Submitted via email to: leslie.d.taylor@usda.gov

April 18, 2022

Douglas McKay
ATTN: Leslie Taylor
Heppner Ranger Station
PO Box 7
Heppner, OR 97836

Re: Ellis Integrated Vegetation Project DEIS

Dear Mr. McKay,

WildEarth Guardians respectfully provides the following comments regarding the draft environmental impact statement (DEIS) for the Ellis Integrated Vegetation Project. The project area covers approximately 110,000 acres of national forest, with nearly the entirety considered for treatment. With the Ellis Integrated Vegetation Project the Forest Service would authorize commercial thinning; small diameter thinning; mechanical fuels treatments; pile, jackpot, and landscape burning; pruning; planting of native vegetation; placement of large wood in meadow streams; road closures and road decommissioning.

WildEarth Guardians (Guardians) is a nonprofit conservation organization with offices in Oregon, Washington, and five other states. Guardians, with more than 175,000 members and supporters across the United States, works to protect and restore the wildlife, wild places, wild rivers, and health of the American West. Guardians and its members have specific interests in the management of the Umatilla National Forest. We believe that thoughtful, careful management of its old and large trees is critical to improve the health of the Forest.

I. The Forest Service's Analysis of the Ellis Integrated Vegetation Project Proposal Cannot Tier to the 2021 Eastside Screens Amendment.

The Forest Service states that the DEIS incorporates by reference, or "tiers," to the Umatilla Forest Plan (Forest Plan) and subsequent amendments, including the January 15, 2021 Decision Notice and Finding of No Significant Impact for the Forest Management Direction for Large Diameter Trees in Eastern Oregon and Southeastern Washington Project (Eastside Screens Amendment or Amendment). DEIS, 2. However, the Eastside Screens Amendment is unlawful and the DEIS cannot be tiered to it.

The Amendment is unlawful because the Forest Service violated both the National Environmental Policy Act (NEPA) and its own regulations in approving it. The Forest Service failed to prepare an environmental impact statement, as required by NEPA, for amendments to six Forest Plans—covering approximately eight million acres of national forest—that will significantly affect the quality of the human environment. The Forest Service also approved the amendments without providing the public an opportunity to appeal or object, which violated its regulations concerning public participation and administrative appeals.

It is arbitrary and capricious for an agency to incorporate the environmental analysis of a broader-scope proposal as part of the analysis of a more specific proposal if the analysis of the broader proposal was never properly approved. When a broader proposal is never properly approved, the action agency by definition has failed to take a "hard look" at the impacts of the broader proposal and neglected to supply a reasoned explanation why the analysis of the broader proposal can tier to a narrower action.

Here, the Forest Service defied its public participation and appeal regulations when Undersecretary for Natural Resources and Environment James Hubbard signed the final decision approving the Eastside Screens Amendment on January 12, 2021. Because the Eastside Screens Amendment was never properly adopted, it is arbitrary and capricious for the Forest Service to tier the Ellis Integrated Vegetation DEIS to the Eastside Screens Amendment EA. Further, any proposed action as part of the Ellis Integrated Vegetation Project that implements or relies on the illegitimate Amendment is not in compliance with the management direction of the Umatilla Forest Plan.

The Forest Service also cannot tier the Ellis Integrated Vegetation DEIS to the Eastside Screens Amendment because it was approved in the absence of an EIS, despite the fact that a change to the Umatilla Forest Plan that permits previously prohibited cutting of large trees will have significant impacts on, *inter alia*, aquatic ecosystems, wildlife habitat, climate change, and ESA-listed species.

The Eastside Screens were implemented to protect dwindling old growth forest on the national forests east of the Cascade Crest in Oregon. Among the Screens was a prohibition on cutting live trees, regardless of species, larger than 21" at diameter breast height (DBH). The Amendment replaces that prohibition with a non-mandatory guideline to "maintain and increase old and late structure forest" and "favor fire tolerant species where appropriate" on the six eastern Oregon forests. Decision Notice for Eastside Screens Amendment at 4. To be more specific, the Eastside Screens Amendment permits the cutting of grand and white fir larger than 21" DBH but smaller than 30" DBH on the Umatilla and other eastern Oregon national forests. The Forest Service states that Alternative 5 of the Ellis Integrated Vegetation Project as proposed would implement the (illegally issued) Eastside Screens Amendment, so the project would permit the cutting of Douglas-fir and grand and white fir up to 30" DBH in size. DEIS at 18.

NEPA requires federal agencies to prepare, consider, and approve an adequate Environmental Impact Statement (EIS) for "any major federal action significantly affecting the quality of the human environment." 42 U.S.C. § 4332(2)(c); 40 C.F.R. § 1501.4(a)(1). To make a supportable determination of non-significance, NEPA documents must consider the direct, indirect, and cumulative environmental impacts of a proposed action. 40 C.F.R. § 1508.8. The agency must take a "hard look" at the consequences of the proposed action and provide a "convincing statement of reasons to explain why a project's impacts are insignificant." *Envtl. Prot. Info. Ctr. v. United States Forest Serv.*, 451 F.3d 1005, 1009 (9th Cir. 2006) (alteration in original) (quoting *Nat'l Parks & Conservation Ass'n v. Babbitt*, 241 F.3d 722, 730 (9th Cir. 2001)). The information considered must be of high quality. 40 C.F.R. § 1500.1(b). Scientific analysis, expert agency comments, and public scrutiny are essential to implementing NEPA. *Id.*

In determining whether an action is "significant" under NEPA, agencies must evaluate the project's significance by analyzing the "context" and "intensity" of the action. 40 C.F.R. 1508.27. The context of an action includes "society as whole (human, national), the affected region, the affected interests, and the locality." *Id*. at § 1508.27(a). Both short-term and long term impacts are important. The regulations also list ten, non-exclusive intensity factors that the agency should consider. *Id*. at § 1508.27(b). These factors include: the degree to which the effects on the environment are highly controversial, highly uncertain, or involve unique and unknown risks; the degree of impact on threatened and endangered species or its critical habitat; and whether the action is related to other actions with individually insignificant but cumulative significant impacts. *Id*.

Among the significant impacts of cutting large Douglas-fir and grand and white fir up to 30" DBH in size as an element of Alternative 5 of the Ellis Integrated Vegetation project are the negative effects on carbon values, snag habitat and aquatic habitats. The Forest Service failed to consider and disclose these effects in the Amendment EA and it has likewise failed to do so in the Ellis Integrated Vegetation DEIS. Large diameter trees are key to the ability of forests to accumulate substantial amounts of carbon needed to mitigate climate change and to maintain ecological integrity in the face of a changing climate. Logging large diameter trees removes natural climate solutions and deprives the ecosystem of much needed large snags and dead wood that provide habitat for a wide array of wildlife species. Large diameter trees are also integral to a variety of crucial aquatic and riparian ecosystem functions and processes. They play central roles in these ecosystems, such as helping to store sediments and nutrients; shape channel morphology and instream habitats and conditions necessary for fish and other aquatic organisms; support groundwater flows, hyporheic flows and groundwater storage. Because the impacts on carbon values and snag and aquatic habitats will be significant but weren't adequately considered in the Amendment EA, tiering the EA to the Ellis Integrated Vegetation DEIS is not rational. Rather than tier to the Amendment EA, the Forest Service could evaluate those impacts independently in the DEIS and approve an amendment to the Umatilla Forest Plan. It has not pursued this option either, so neither the Amendment EA nor the DEIS adequately analyze impacts on carbon values, snag habitats and aquatic habitats.

1. The Project's Cutting of Large Douglas-fir, White Fir and Grand Fir Will Have Significant Effects on Carbon Values

The accumulation of carbon in forest ecosystems is crucial for mitigating ongoing climatic change, with large-diameter trees storing disproportionally massive amounts of carbon in forests worldwide. Globally, forests removed the equivalent of about 30 percent of fossil fuel emissions annually from 2009 to 2018 and while boreal and tropical forests have received a great deal of attention, 44 percent of the carbon removed by forests from 2009 to 2018 is attributed to temperate forests such as the Umatilla (Friedlingstein et al., 20197). Temperate forests of the U.S. consistently offset about 14 percent of the Nation's CO2 emissions and are the largest category of land sinks in the country (EPA, 2020). Forest ecosystems in the U.S. have the potential to continue rapid atmospheric CO2 removal rates in addition to the massive carbon stores they currently hold (Moomaw et al., 2019). Forest carbon accumulation is a central component of a natural climate solutions framework that is receiving substantial attention in the science community and in President Biden's Executive Order 13990. (Griscom et al., 2017; Fargione et al., 2018; Cook-Patton et al., 2020).

Large-diameter trees have an outsized role in the ability of forests to accumulate the substantial amounts of carbon needed to mitigate climate change (Luyssaert et al., 2008; Lutz et al., 2018; Stephenson et al., 2014). Large-diameter trees comprise about half of the mature forest biomass worldwide and on average, 50 percent of the live tree biomass carbon in all types of forests globally is contained in the largest 1 percent of trees (Lutz et al., 2018). However, the value for the U.S. is lower (~30 percent) in the largest 1 percent of trees due to widespread historical logging of large trees (Lutz et al., 2018; Pan et al., 2011). The relationship between large-diameter trees and overall biomass suggests that forests cannot accumulate aboveground carbon to their ecological potential without large trees (Lutz et al., 2018). Recognition of the importance of large-diameter trees in the global forest carbon cycle has led to management recommendations to conserve existing large-diameter trees and those that will soon reach large diameters (Lutz et al., 2018; Lindenmayer et al., 2014).

In any forest, the largest trees relative to the rest of the stand contribute disproportionately to ecological function such as increasing drought-tolerance, reducing flooding from intense precipitation events, altering fire behavior, redistributing soil water, and acting as focal centers of mycorrhizal communication and resource sharing networks (Bull et al., 1997; Brooks et al., 2002; Brown et al., 2004; Luyssaert et al., 2008; Beiler et al., 2015; Lindenmayer et al., 2017). In the U.S. Pacific Northwest ("PNW"), carbon dense old growth forests buffer against increasing temperatures by creating microclimates that shelter understory species from rising temperatures (Frey et al., 2016; Davis et al., 2019). Forests with large-diameter trees tend to have high tree species richness, and a high proportion of critical habitat for endangered vertebrate species, indicating a strong potential to support biodiversity into the future and promote ecosystem resilience to climate change (Lindenmayer et al., 2014; Buotte et al., 2020).

Harvest practices can substantially alter carbon storage and accumulation (Kauppi et al., 2015; Masek et al., 2011; Turner et al., 2011; Krankina et al., 2012; Law et al., 2018). There is a negative relationship between harvest intensity and forest carbon stocks whereby as harvest intensity increases, forest carbon stocks decrease while emissions increase (Hudiburg et al., 2009; Mitchell et al., 2009; Simard et al., 2020). It can take centuries to re-accumulate forest carbon stocks reduced by harvest (Birdsey et al., 2006; McKinley et al., 2011), and climate mitigation targets need to be met in the next few decades.

Carbon storage is an important management objective for National Forest Lands in the U.S. (Depro et al. 2008; Dilling et al., 2013; Dugan et al., 2017; Birdsey et al., 2019). Western U.S. forests, including the Umatilla National Forest, show considerable potential to accumulate additional carbon over the coming century, especially forests within the PNW that are projected to have relatively low to moderate vulnerability to future drought and fire (Buotte et al., 2020). This reinforces the importance of protecting large trees on the Umatilla National Forest to help abate our current trajectory toward massive global change (Fargione et al., 2018; Buotte et al., 2020).

Current research reveals the large carbon stocks associated with large-diameter trees in "eastside forests," and the potential for significant losses in aboveground carbon stocks ("AGC") with large tree logging (Mildrexler et al., 2020). These findings document the important role of large trees in storing carbon in eastside forest ecosystems, and are consistent with previous findings on the disproportionately important role of large trees in the forest carbon cycle (Hudiburg et al., 2009; Stephenson et al., 2014; Lutz et al., 2012; Lutz et al., 2018). The rapid increase in carbon storage with increasing tree diameter emphasizes the importance of preserving mature and old large trees to keep this carbon stored in the forest ecosystem where it remains for centuries (Law et al., 2018; Lutz et al., 2018). Harvest of large-diameter trees—even focused on a specific species (e.g. grand and white fir)—can remove a significant fraction of tree AGC from these ecosystems. While the 21-inch Screen standard was initially conceived to protect remaining late successional and old-growth forest and the native species that depend on these unique ecosystems for survival (Henjum et al., 1994), carbon storage associated with the 21-inch standard on the Umatilla National Forest has been a significant co-benefit of this protective measure (Mildrexler et al., 2020). Logging large Douglas-fir, white fir and grand fir trees under the Ellis Integrated Vegetation proposal would lose these carbon stores, and release large amounts of carbon to the atmosphere. The amount of carbon that remains stored in wood products is insufficient to offset the loss of carbon stored in the forest. Life cycle assessment shows that 65 percent of the wood harvested in Oregon over the past 115 years has been emitted to the atmosphere, 16 percent is in landfills and only 18 percent remains in wood products (Hudiburg et al., 2019). Harvesting the large trees will increase, not decrease, emissions and end centuries of long-term carbon storage in the forests.

Trees over 30 inches DBH in size are rare on the Umatilla and their rarity highlights the relative importance of the sub-30 inch DBH large trees, and the value in allowing these trees to continue growing and replenish the stock of trees over 30 inches DBH that are rare (Mildrexler et al., 2020). This strategy is the most rapid means for accumulating additional quantities of carbon in forests and out of the atmosphere (Moomaw et al., 2019). Ecological restoration that gives protection to large and old trees, reduces surface and ladder fuels, and understory thinning treatments where appropriate with reintroduction of low-intensity fire at intervals (Allen et al., 2002; Brown et al., 2004; Agee and Skinner, 2005; Noss et al., 2006) can achieve the benefits of carbon storage and accumulation in the larger, most fire-resistant trees and reduction of fuel loads and stem density in the smaller diameter trees.

The recent history of high-grade logging on the Umatilla National Forest targeted large and old trees (Henjum, 1994; Rainville et al., 2008). Historical abundances of large trees on the Umatilla National Forest landscape were much greater than today (Kauppi et al., 2015; Hagmann et al., 2013; Wales et al., 2007), and thus would have represented a larger fraction of aboveground biomass than currently found on these forests. While large tree composition may have shifted today relative to European settlement times, these large trees nonetheless continue to perform important functional attributes related to water and climate such as carbon storage, hydraulic redistribution, shielding the understory from direct solar radiation, and providing wildlife habitat. These functional attributes of large trees, irrespective of species, characterize ecosystems through thousands to millions of years (Barnosky et al., 2017), and cannot be quickly replaced.

Preserving carbon stores in large trees also supports important components of biodiversity and is associated with increased water availability (McKinley et al., 2011; Perry and Jones, 2016; Berner et al., 2017; Law et al., 2018; Buotte et al., 2020). Large-diameter snags account for a relatively high proportion of total snag biomass in temperate forests (Lutz et al., 2012). Large hollow trees, both alive and dead, are the most valuable for denning, shelter, roosting, and hunting by a wide range of animals (Bull et al., 2000; Rose et al., 2001). In the Interior Columbia River Basin, grand fir and western larch form the best hollow trees for wildlife uses (Rose et al., 2001). Downed hollow logs serve as important hiding, denning, and foraging habitat on the forest floor (Bull et al., 1997; Bull et al., 2000). Large decaying wood influences basic ecosystem processes such as soil development and productivity, nutrient immobilization and mineralization, and nitrogen fixation (Harmon et al., 1986).

The importance of forest carbon storage is now greatly amplified by a warming climate that must urgently be addressed with reductions in greenhouse gases and natural climate solutions (IPCC, 2018; Ripple et al., 2020). Rather than holding ecosystems to an idealized conception of the past using historical conditions as management targets, a good understanding of the environmental co-benefits associated with large tree protection is needed to inform management strategies that contribute toward solving humanity's most pressing Earth system challenges (Millar et al. 2007; Rockstrom et al., 2009; Barnosky et al., 2017; Ripple et al., 2020).

Replacing large diameter trees with seedlings within the Ellis Integrated Vegetation Project proposal area will create a major carbon loss to the atmosphere during harvest (Harris et al., 2016) and not achieve storage of comparable atmospheric carbon for the indefinite future. Continuing to protect large trees in the Ellis Integrated Vegetation proposal area provides the greatest benefit for carbon, habitat, and biodiversity.

While the effects of climate change were touted throughout the Amendment EA as a reason to log large trees, it failed to analyze the effects of cutting large Douglas-fir, white fir, and grand fir on carbon values including climate mitigation and adaptation and carbon stocks. As outlined above, the impacts of the Ellis Integrated Vegetation project on these values is significant and must be analyzed. A robust analysis of the impacts of the Ellis Integrated Vegetation Project's logging large white and grand fir on carbon values would show that it will likely make the climate issue worse.

2. Cutting Douglas-fir, White Fir, and Grand Fir up to 30" DBH Will Have Significant Effects on Snag Habitat

Logging large trees will deprive the Umatilla's old growth ecosystems of much needed large snags and the critically important role played by snags and dead wood recognized in the 1994 Everett Report (p 23):

> [In]… presettlement forest fires ... [t]rees were killed but not removed by fire and a considerable biomass of dead wood was left standing. Before being incorporated into the soil, these dead trees functioned first as dead shade-moderating site conditions for the establishment of new conifer seedlings, shrubs, and herbs; snags- providing food, roosts, and homes for various birds and small mammals; and down logs- again providing food and shelter, and substrate for arthropods, plants, soil bacteria and fungi, and moisture retention.
>
> Dead trees and down logs play important roles in ecosystems. An important goal of research will be to determine the amount of dead wood that is needed to conserve biological diversity and long-term productivity. An important goal of ecosystem management will be to match management actions to the disturbance ecologies of ecosystems. … [Y]ield expectations for harvested acres should be scaled to accommodate the dead wood needs of ecosystems.
>
> … Large amounts of standing and down dead wood should be left after harvest.
>
> … Under ecosystem management, planned thinning can leave behind important dead and down wood in all of its needed forms.

Significant progress has been made to improve the identification of the appropriate amount of snags and dead wood that should be maintained over time in eastside forests such as the Umatilla, but the Amendment eliminated any clear requirement to meet the quantifiable needs of snag-associated wildlife when designing timber sales. In addition, there is no valid ecological rationale for the Ellis Integrated Vegetation Project's plan to remove Douglas-fir, grand fir, and white fir trees 21-30 inches DBH, given that large shade-tolerant trees provide disproportionate ecological value in terms of cavity habitat. Ponderosa pine are not as cavity prone.

The Ellis Integrated Vegetation Project would shift conifer species composition away from shade-tolerant species like grand fir and white fir and as a result would have significant effects on habitat for species like pileated woodpecker. This point was made in the Franklin/Johnson/Seager Open Review:

> "… the EA addresses habitat under LOS for late-closed and late-open associated wildlife species. This fails to account for conifers species composition, and more importantly, the stand specifics of each conifer species (e.g., DBH, spatial placement) for wildlife habitat requirements. Since different alternatives allow the harvest of different tree species, sizes, and ages, it does not hold that post-treatment stands classified as late-open or late-closed will inherently contain the habitat needed … [L]ate-closed forests without proper conifer species composition providing rapid decay (e.g., grand fir or white fir) will not provide appropriate pileated woodpecker habitat."

3. Cutting Douglas-fir, Grand Fir, and White Fir up to 30" DBH Will Have Significant Effects on Aquatic Habitat

Aquatic and riparian ecosystems are especially vulnerable to negative impacts from the loss of large trees (and the loss of recruitment for large tree structure), both from logging within riparian habitat conservation areas (RHCAs) and from upslope logging. Because the Forest Service incorporated the Amendment EA into the Ellis Integrated Vegetation DEIS, it has failed to adequately disclose or analyze the significant effects that increased logging of large trees would have on these ecosystems.

The Inland Native Fish Strategy ("INFISH") and Pacific Anadromous Fish Strategy ("PACFISH") are management directions related to aquatic resources that have been incorporated into the Umatilla Forest Plan. PACFISH and INFISH do not limit the size of trees harvested within the areas that they apply to RHCAs. The Amendment EA stated that "[s]ince no changes will be made to these aquatic conservation strategies, a No Effect determination applies to all Threatened and Endangered, R6 Sensitive and MIS fish species...in the analysis area." Amendment EA at 69. Essentially, the EA claimed that because there were not proposed changes to INFISH or PACFISH there will be no effects.

This reasoning was arbitrary and capricious and can't be incorporated into the Ellis Integrated Vegetation DEIS. Douglas-fir, white fir and grand fir trees up to 30" DBH can be cut in RHCAs as long as Resource Management Objectives ("RMOs") logging does not retard attainment of RMOs and those objectives are met. This is not good for the health of RHCAs. Logging within RHCAs along streams that are not meeting multiple RMOs has taken place on the Umatilla National Forest. The failure to meet RMOs in streams with commercial logging proposed within their RHCAs is documented in the USFS NEPA analyses for numerous sales. Some of these sales include commercial logging within RHCAs along streams that regularly exceed stream temperature standards for RMOs and state water quality standards.

In areas where there is ample evidence of historic Douglas-fir/white fir/grand fir dominance, silvicultural prescriptions regarding large trees in mixed-conifer forests within RHCAs and in upslope areas often seek to shift species composition towards early seral species and lessen the amount of mature grand/white fir in stands. The proposed action explicitly permits logging of Douglas-fir, white fir, and grand fir greater than 21 inches DBH. As a result, increased logging of larger grand and white fir within RHCAs is expected under the Ellis Integrated Vegetation project.

Riparian forests, aquatic habitats, fish, and water quality will be significantly affected by this proposal as a result of increased logging of large trees in the uplands and within RHCAs. The Amendment EA ignored key issues such as decreased recruitment of large woody debris; likely increases in stream temperature and excess fine sediments; alteration of watershed hydrology due to the increased loss of large trees; and other likely negative effects to aquatic systems. As such, the Ellis Integrated Vegetation DEIS cannot rely on the Amendment EA for incorporation.

Large trees are integral to a variety of crucial aquatic and riparian ecosystem functions and processes on the Umatilla National Forest. They play central roles in these ecosystems, such as helping to store sediments and nutrients; shape channel morphology and instream habitats and conditions necessary for fish and other aquatic organisms; support groundwater flows, hyporheic flows and groundwater storage, and so provide cold water flows into streams; and provide key habitat for numerous species. (Bisson et al., 1987; Frissell et al., 2014; Hicks et al. 1991; Ralph et al.1994; Bilby and Bisson 1998; Spies et al. 2013; Pollock and Beechie 2014). Should the Ellis Integrated Vegetation Project be implemented, the loss of large trees due to logging, and the loss of future recruitment of large trees, would likely have significant effects on the ecosystems.

Conclusion

We appreciate the Forest Service's time and attention considering these substantive comments and urge the agency to forego the Ellis Integrated Vegetation Project until it can ensure that all alternatives comply with the original Eastside Screen prohibiting the cutting of any live tree greater than 21" DBH regardless of species.

Sincerely,

Christoph J Krupp

Chris Krupp, Public Lands Attorney
WildEarth Guardians
10015 Lake City Way NE #414
Seattle, WA 98125
ckrupp@wildearthguardians.org
(206) 417-6363

Cited Literature

Friedlingstein, P., Jones, M. W., O'Sullivan, M., Andrew, R. M., Hauck, J., Peter, G. P. et al. (2019). Global Carbon Budget 2019. Earth Syst. Sci. Data 11, 1783-1838. doi: 10.5194/essd-11-1783-2019.

EPA. (2020). Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018. EPA 430-P-20-001. U.S. Environmental Protection Agency, Washington, D.C., 719 pp.

Moomaw, W. R., Masino, S. A. and Faison, E. K. (2019). Intact forests in the United States: Proforestation Mitigates Climate Change and Serves the Greatest Good. Front. For. Glob. Change 2, 1–27. doi: 10.3389/ffgc.2019.00027.

Griscom, B. W., Adams, J., Ellis, P. W., Houghton, R. A., Lomax, G., Miteva, D. A., et al. (2017). Natural climate solutions. Proc. Natl. Acad. Sci. U.S.A. 114, 11645–11650. doi: org/10.1073/pnas.1710465114.

Fargione, J. E., Bassett S., Boucher T., Bridgham S. D., Conant R. T., Cook-Patton S. C., et al. (2018). Natural climate solutions for the United States. Sci Adv. 4:eaat1869. doi: 10.1126/sciadv.aat186.

Cook-Patton, S. C., Leavitt, S. M., Gibbs, D., Harris, N. L., Lister, K., Anderson-Teixeira, K. J., et al. (2020). Mapping carbon accumulation potential from global natural forest regrowth. Nature 585, 545–550. doi: 10.1038/s41586-020-2686-x.

Luyssaert, S., Schulze, E.-D., Börner, A., Knohl, A., Hessenmöller, D., Law, B. E., et al. (2008). Old-growth forests as global carbon sinks. Nature 455: 213-215.

Lutz, J. A., Furniss, T. J., Johnson, D. J., Davies, S. J., Allen, D., Alonso, A., et al. (2018). Global importance of large-diameter trees. Glob. Ecol. Biogeogr. 27, 849–864. doi: 10.1111/geb.12747.

Stephenson, N. L., Das, A. J., Condit, R., Russo, S. E., Baker, P. J., Beckman, N. J., et al. (2014). Rate of tree carbon accumulation increases continuously with tree size. Nature 507: 90–93.

Pan, Y., Birdsey, R. A., Fang, J., Houghton, R., Kauppi, P. E., Kurz, W. A., et al. (2011). A Large and Persistent Carbon Sink in the World's Forests Science, 333, 988-993. doi: 10.1126/science.1201609.

Lindenmayer, D. B., Laurance, W. F, Franklin, J. F., Likens, G. E., Banks, S. C., Blanchard, W., et al. (2014). New policies for old trees: averting a global crisis in a keystone ecological structure. Conserv. Lett. 7: 61–69. doi: 10.1111/conl.12013.

Bull, E. L., Parks, C. G., Torgersen, T. R. (1997). Trees and logs important to wildlife in the interior Columbia River basin. Gen. Tech. Rep. PNW-GTR-391. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 55 p.

Brooks, J. R., Meinzer, F. C., Coulombe, R., and Gregg, J. (2002). Hydraulic redistribution of soil water during summer drought in two contrasting Pacific Northwest coniferous forests. Tree Physiol. 22, 1107–1117. doi: 10.1093/treephys/22.15-16.1107.

Brown, R. T., Agee, J. K., and Franklin, J. F. (2004). Forest Restoration and Fire: Principles in the Context of Place. Conserv. Bio. 18: 903-912. doi: 10.1111/j.1523-1739.2004.521_1.x.

Beiler, K. J., Simard, S. W. and Durall, D. M. (2015). Topology of Rhizopogon spp. mycorrhizal meta-networks in xeric and mesic old-growth interior Douglas-fir forests. J. Ecol. 103(3): 616-628. doi: 10.1111/1365-2745.12387.

Lindenmayer, D. B., and Laurance, W. F. (2017). The ecology, distribution, conservation and management of large old trees. Biol. Rev. 92, 1434–1458. doi.org/10.1111/brv.12290.

Frey, S. J. K., Hadley, A. S., Johnson, S. L., Schulze, M., Jones, J. A., and Betts, M. G. (2016). Spatial models reveal the microclimate buffering capacity of old-growth forests. Sci. Adv. 2, e1501392. doi: 10.1126/sciadv.1501392.

Davis, K. T., Dobrowski, S .Z., Holden, Z. A., Higuera, P. E., and Abatzoglou, J. T. (2019). Microclimatic buffering in forests of the future: the role of local water balance. Ecography 42, 1–11. doi: 10.1111/ecog.03836.

Buotte, P. C., Law, B. E., Ripple, W. J., and Berner, L. T. (2020). Carbon sequestration and biodiversity co-benefits of preserving forests in the western United States. Ecol. Appl. 30:e02039. doi: 10.1002/eap.2039.

Kauppi, P. E., Birdsey, R. A., Pan, Y., Ihalainen, P., Nöjd., P., and Lehtonen, A. (2015). Effects of land management on large trees and carbon stocks. Biogeosciences 12: 855 – 86. doi: 10.5194/bg-12-855-2015.

Masek, J. G., Cohen, W. B., Leckie, D., Wulder, M. A., Vargas, R., de Jong, B., et al. (2011). Recent Rates of Forest Harvest and Conversion in North America. J. Geophy. Res. 116, G00K03. doi: 10.1029/2010JG001471.

Turner, D. P., Ritts, W. D., Yang, Z., Kennedy, R. E., Cohen, W. B., Duane, M. V., et al. (2011). Decadal trends in net ecosystem production and net ecosystem carbon balance for a regional socioecological system. For. Ecol. Manage. 262, 1318–1325. doi: org/10.1016/j.foreco.2011.06.034.

Krankina, O. N., Harmon, M. E., Schnekenburger, F. S., and Sierra, C. A. (2012). Carbon balance on federal forest lands of Western Oregon and Washington: The impact of the Northwest Forest Plan. For. Ecol. Manage. 286, 171-182. doi: 10.1016/j.foreco.2012.08.028.

Law, B. E., Hudiburg, T. W., Berner, L. T., Kent, J. J., Buotte, P. C., and Harmon, M. (2018). Land use strategies to mitigate climate change in carbon dense temperate forests. Proc. Nat. Acad. Sci. 115(14):3663-3668. doi: org/10.1073/pnas.1720064115.

Hudiburg, T., Law, B., Turner, D. P., Campbell, J, Donato, D. C., and Duane, M. (2009). Carbon dynamics of Oregon and Northern California forests and potential land-based carbon storage. Ecol. Appl. 19:163–180. doi: 10.1890/07-2006.1.

Mitchell, S. R., Harmon, M. E., and O'Connell, K. E. B. (2009). Forest fuel reduction alters fire severity and long-term carbon storage in three Pacific Northwest ecosystems. Ecol. Appl. 19,643–55. doi: 10.1890/08-0501.1.

Simard, S. W., Roach, W. J., Defrenne, C. E., Pickles, B. J., Snyder, E. N., Robinson, A., et al. (2020). Harvest intensity effects on carbon stocks and biodiversity are dependent on regional climate in Douglas-fir forests of British Columbia. Front. For. Glob. Change. doi: 10.3389/ffgc.2020.00088.

Birdsey, R., Pregitzer, K., and Lucier, A. (2006). Forest carbon management in the United States: 1600-2100. J. Environ. Qual. 35: 1461-1469.

McKinley D. C., Ryan, M. G., Birdsey, R. A., Giardina, C. P., Harmon, M. E., Heath, L. S., et al. (2011). A synthesis of current knowledge on forests and carbon storage in the United States. Ecol. Appl. 21:1902–24. doi: 10.1890/10-0697.1.

Depro, B. M., Murray, B. C., Alig, R. J. and Shanks, A. (2008). Public land, timber harvests, and climate mitigation: Quantifying carbon sequestration potential on U.S. public timberlands. For. Ecol. Manage. 225: 1122-1134.

Dilling L., Birdsey R., and Pan, Y. (2013). "Opportunities and challenges for carbon management on U.S. public lands," in Land use and the carbon cycle: advances in integrated science, management and policy, eds D. G. Brown, D. T. Robinson, N. H. F. French, and B. C. Reed. (Cambridge, UK: Cambridge Press), 455–476.

Dugan A. J., Birdsey R., Healey S. P., Pan Y., Zhang F., Mo G., et al. (2017). Forest sector carbon analyses support land management planning and projects: assessing the influence of anthropogenic and natural factors. Clim. Change 144:207–20. doi: 10.1007/s10584-017-2038-5.

Birdsey, R. A., Dugan, A. J., Healey, S. P., Dante-Wood, K., Zhang, F., Mo, G., et al. (2019). Assessment of the influence of disturbance, management activities, and environmental factors on carbon stocks of U.S. national forests. Gen. Tech. Rep. RMRS-GTR-402. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 116 pages plus appendices.

Mildrexler, D.J., L.T. Berner, B.E. Law, R.A., Birdsey, and W. R. Birdsey, and W.R., Moomaw. (2020). Large trees dominate carbon storage in forests east of the Cascade Crest in the U.S. Pacific Northwest. Front. For. Glob. Change. In review.

Lutz, J. A., Larson, A. J., Swanson, M. E., and Freund, J. A. (2012). Ecological importance of large-diameter trees in a temperate mixed-conifer forest. PLoS One, 7, e36131. doi: 10.1371/journal.pone.0036131.

Henjum, M. G., Karr, J. R., Bottom, D. L., Perry, D. A., Bednarz, J. C., Wright, S. G., et al. (1994). Interim Protection for Late Successional Forest, Fisheries and Watersheds: National Forests East of the Cascade Crest, Oregon and Washington. Wildlife Society, Bethesda, MD.

Hudiburg, T.W, Law, B. E., Moomaw, W. R., Harmon, M. E., and Stenzel, J. E. (2019). Meeting GHG reduction targets requires accounting for all forest sector emissions. Environ. Res. Lett. 14: 095005. doi: 10.1088/1748-9326/ab28bb.

Allen, C. D., Savage, M. S., Falk, D. A., Suckling, K. F., Swetnam, T. W., Schulke, T., et al. (2002). Ecological restoration of southwestern ponderosa pine ecosystems: a broad perspective. Ecol. Appl. 12:1418-1433. doi:10.1890/1051-0761(2002)012[1418:EROSPP]2.0.CO;2.

Agee, J. K., and Skinner, C. N. (2005). Basic principles of forest fuel reduction treatments. For. Ecol. Manage. 211: 83–96. doi:10.1016/j.foreco.2005.01.034.

Noss, R. F., Franklin, J. F., Baker, W. L., Schoennagel, T., and Moyle, P. B. (2006). Managing fire-prone forests in the western United States. Front. Ecol. Environ. 4, 481-487. doi: 10.1890/1540-9295(2006)4[481:MFFITW]2.0.CO;2.

Rainville R., White, R. and Barbour, J. (2008). Assessment of timber availability from forest restoration within the Blue Mountains of Oregon. Gen. Tech. Rep. PNW-GTR-752. Portland, OR: USDA, Forest Service, Pacific Northwest Research Station. 65 p.

Hagmann, R. K., Franklin, J. F., and Johnson, K. N. (2013). Historical structure and composition of ponderosa pine and mixed-conifer forests in south-central Oregon. For. Ecol. Manag. 304, 492-504. doi: 10.1016/j.foreco.2013.04.005

Wales, B. C., Suring, L. H., and M. A. Hemstrom. (2007). Modeling potential outcomes of fire and fuel management scenarios on the structure of forested habitats in northeast Oregon, USA. Landscape Urban Plan. 80:223-236. doi: 10.1016/j.landurbplan.2006.10.006.

Barnosky, A. D., Hadly, E. A., Gonzalez, P., Head, J., Polly, P. D., Lawing, A. M., et al. (2017). Merging paleobiology with conservation biology to guide the future of terrestrial ecosystems. Science 355, eaah4787. doi: 10.1126/science.aah4787.

Perry, T. D., and Jones, J. A. (2016). Summer streamflow deficits from regenerating Douglas fir forests in the Pacific Northwest, USA, Ecohydrology doi: 10.1002/eco.1790.

Bull, E. L., Akenson, J. J. and Henjum, M. J. (2000). Characteristics of black bear dens in trees and logs in northeastern Oregon. Northwestern Naturalist 81:148-153. doi: 10.2307/3536825.

Rose, C. L., Marcot, B. G., Mellen, T. K., Ohmann, J. L., Waddell, K. L., Lindely, D. L., et al. (2001). "Decaying wood in Pacific Northwest forests: Concepts and tools for habitat management" Pages. in Wildlife–Habitat Relationships in Oregon and Washington, eds Johnson D. H., O'Neil T. A. (Corvallis: Oregon State University Press), 580-623.

Harmon, M. E., Franklin, J. F., Swanson, F. J., Sollins, P., Gregory, S. V., Lattin, J. D., et al. (1986). Ecology of coarse woody debris in temperate ecosystems. Adv. Ecol. Res. 15:133-302. doi: 10.1016/S0065-2504(03)34002-4.

IPCC (2018). "Summary for policymakers," in Global Warming of 1.5oC, An IPCC Special Report, eds V. Masson Delmotte, P. Zhai, H.-O. P. - Rtner, D. Roberts, J. Skea, P. R. Shukla, et al. (Geneva: World Meteorological Organization), 32.

Ripple, W. J., Wolf, C., Newsome, T. M., Barnard, P., and Moomaw, W. B. (2020). World Scientists' Warning of a Climate Emergency, BioScience 70(1), 8–12, doi: org/10.1093/biosci/biz088.

Millar, C. I., Stephenson, N. L., and Stephens, S. L. (2007). Climate change and forests of the future: managing in the face of uncertainty. Ecol. Appl. 17(8):2145-2151. doi: 10.1890/06-1715.1.

Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin, III, F. S., Lambin, E., et al., (2009). Planetary boundaries: exploring the safe operating space for humanity. Nature 461, 472–475.

Harris, N. L., Hagen, S. C., Saatchi, S. S., Pearson, T. R. H., Woodall, C. W., Domke, G. M., et al. (2016). Attribution of net carbon change by disturbance type across forest lands of the conterminous United States. Carbon Balance Manag. 11, 24; doi: 10.1186/s13021-016-0066-5.

Everett et al 1994. Eastside Forest Ecosystem Health Assessment . Volume I: Executive Summary. General Technical Report PNW-GTR-317.

https://www.jstor.org/stable/3809474?seq=1. "Foundations of Forest Wildlife Habitat Management Habitat through Disturbance and Silviculture. August 2020. Lecture 1 Questions and Answers: https://nctc.fws.gov/topic/online-training/webinars/forest-ecology-andmanagement.html *citing* Evelyn L. Bull, Richard S. Holthausen and Mark G. Henjum 1992.

Roost Trees Used by Pileated Woodpeckers in Northeastern Oregon. The Journal of Wildlife Management. Vol. 56, No. 4 (Oct., 1992), pp. 786-793. https://www.jstor.org/stable/3809474?seq=1.

Bisson, P; Bilby, R.; Bryant, M.; Dolloff, C.; Grette, G.; House, R.; Murphy, M.; Koski, K.; and Sedell, J. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present, and future. Pages 143-190. Streamside management: forestry and fishery interactions. University of Washington.

Frissell, C.; Baker, R.; DellaSala, D.;Hughes, R.; Karr, J.; McCullough, D.; Nawa, R.; Rhodes, J.; Scurlock, M.; and Wissmar, R. 2014. Conservation of aquatic and fishery resources in the Pacific Northwest: Implications of new science for the aquatic conservation strategy of the Northwest Forest Plan. Prepared for the Coast Range Association.

Hicks, B., Beschta, R., and Harr, D. (1991). Long-term changes in streamflow following logging in western Oregon and associated fisheries implications. Water Resources Bulletin, (27):2.

Ralph, S.; Poole, G.; Conquest, L.; and Naiman, R. 1994. Stream channel morphology and woody debris in logged and unlogged basins of western Washington. Canadian Journal of Fisheries and Aquatic Sciences 51(1), 37-51.

Bilby, R. and Bisson, P 1998. Function and distribution of large woody debris. Pages 324-326 River ecology and management: Lessons from the Pacific coastal ecoregion.

Spies, T.; Pollock, M.; Reeves, G.; and Beechie, T. 2013. Effects of riparian thinning on wood recruitment: A scientific synthesis. Science Review Team, Northwest Fisheries Science Center.

Pollock, M. and Beechie, T. 2014. Does Riparian Forest Thinning Enhance Forest Biodiversity? The Ecological Importance of Downed Wood. Journal of American Waters Resource Association (JAWRA) 50(3): 543-559. DOI: 10.1111/jawr.12206.