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Comments: Please accept the following comments from Oregon Wild concerning the FSM 2470, Silvicultural Practices #Directives-4178, https://usfs-public.app.box.com/s/zwkitt7txo6w4zsemafgx43xtvkbasf4/file/1619838201536. 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).

I never found the actual webpage for this proposal. The project link in the FedReg did not work and still does not work. It would have been nice to see a red-lined version of the draft manual, so we could focus my comments a bit more.

Our comments cover a lot of territory. The agency might think that some of the issues we raise are outside the scope of the Silvicultural Manual, but we would point out that many things in the proposed manual (e.g., regen, salvage, replanting, tree genetics, old growth "stewardship") are de facto policy choices, the agency just isn't transparent about it.

Be Humble. Manage Forests as Ecosystems, Not Tree Farms.

The Silvicultural Manual reveals an unwarranted over-confidence in our ability to implement an "orderly silviculture program of work" and obtain predictable results, especially in a time of extreme climate uncertainty. The Manual needs to be redraft with more humility and more respect for species that are adapted to dynamic landscapes, and natural processes that have shaped our forests for millennia, through many climatic transitions.

Forests have naturally established and proceeded through natural stages of succession, and they can continue to do so. Aggressive interventions are not usually warranted. Nature is messy. The Forest Service needs to tolerate the stages of forest development that look messy to human eyes but are part of the natural process. This includes dense forests, burned forests, beetle-killed forests, natural mortality in mature and old-growth forests, etc. These are not new phenomena. These are part of the natural order.

Foresters and silviculturists are typically trained to control and manipulate nature. This agricultural model of forest management is not appropriate, especially while our forests are busy adapting to global climate change. The Silvicultural Manual must reflect a more ecological model of forests.

Silvicultural Prescriptions must be inter-disciplinary. This Manual must recognize that every forest management action has consequences affecting soil, water quality, habitat, carbon storage, cultural values, etc. Silvicultural Prescriptions must therefore be created through an interdisciplinary process, not just a forester working in isolation. This must be made explicit in this FSM amendment.

Prescriptions (and NEPA Analyses) Must be Site Specific

Detailed Silvicultural prescriptions must be disclosed in NEPA documents.

The concept of management of our natural resources through "prescription generalization" by type and/or by regions is no longer acceptable because of the wide variability of a given type and the range of demands upon our resources. Rather we need to think literally in terms of acre-by-acre management. The Forest Service agrees that acre-by-acre management is highly desirable.

USFS 1972. FOREST SERVICE RESPONSE TO RECOMMENDATIONS OF FORESTRY DEANS [ABOUT CLEARCUTTING] Made to the Council on Environmental Quality. June 1972. http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/12011/FOR_SER_RES_TO_REC_OF_FOR_DEA.pdf

NEPA requires that environmental analysis be specific enough to ensure informed decision-making and meaningful public participation.110 The Project EIS's omission of the actual location of proposed timber harvest and road construction within the Project Area falls short of that mandate. [hellip] The Project EIS at issue here [hellip] does not delineate harvest units, let alone identify planned activities within them and describe their impacts on localized cognizable values. Nor does the Project EIS allow the public to identify where specific harvest activities will occur in relation to various cognizable values on Prince of Wales Island.119 [hellip] [T]he EIS falls short of NEPA's directive to "contain[] a reasonably thorough discussion of the significant aspects of the probable environmental consequences" for each alternative.142 This approach, coupled with the lack of site-specific information in the Project EIS, detracts from a decisionmaker's or public participant's ability to conduct a meaningful comparison of the probable environmental impacts among the various alternatives. [hellip] The Project EIS identified a total acreage of potential timber harvest, but not the distribution of the specific acreage authorized by each alternative within these areas. This omission is meaningful given the duration and scale of the project.146 Despite "additional parameters that limit the ultimate selection of units and activities,"147 such as mitigation measures contained in the Activity Cards,148 the Project EIS's structure creates ambiguity about the actual location, concentration, and timing of timber harvest and road construction on Prince of Wales Island.149 By doing so, the Project EIS fails to provide a meaningful comparison of alternatives. By authorizing an integrated resource management plan but deferring siting decisions to the future with no additional NEPA review,150 the Project EIS violates NEPA. The Forest Service has not yet taken the requisite hard look at the environmental impact of site-specific timber sales on Prince of Wales over the next 15 years. The Forest Service's plan for condition-based analysis may very well streamline management of the Tongass and decrease the amount of falldown acreage associated with each timber sale;151 however, it does not comply with the procedural requirements of NEPA, which are binding on the agency.152 "NEPA favors 'coherent and comprehensive up-front environmental analysis to ensure . . . that the agency will not act on incomplete information, only to regret its decision after it is too late to correct."153

SE Alaska Conservation Council v. U.S. Forest Serv. (D. Alaska 2020). Case No. 1:19-cv-00006-SLG. March 11, 2020. https://earthjustice.org/sites/default/files/files/40-order-grantingmsj_3-11-20.pdf.

If the Forest Service is going to do site-specific silvicultural prescriptions as required, then they should also do site-specific NEPA analysis. Forest Service attempts to use "conditions based management" have been widely criticized. EPA has commented critically of conditions-based NEPA analysis:

Site Specificity and Programmatic NEPA

Based upon available information, the Forest appears to be using a condition-based management approach for the Project. NEPA requires a "hard look" at potential environmental impacts of a proposed action and public disclosure of those impacts prior to implementation. The impacts associated with the Proposed Action will vary based on site-specific conditions including: vegetation community composition, soil-types, slopes, proximity to residences, proximity to aquatic resources, proximity to Class I airsheds, road construction needs, road maintenance status, volume and type of material burned, equipment used, volume of truck traffic, sensitive species habitat, etc., and those site-specific conditions are varied across the Hungry Creek landscape. Because conditions vary throughout the planning area, the impacts would be expected to vary as well. Individual treatment project design, impact assessment and determination of needed BMPs and mitigation will occur post-FONSI, years after the public comment period on this EA.1 This lack of site-specificity hampers informed decision-making as part of the NEPA process, and therefore meaningful public participation on the individual treatment projects, both important for understanding the potential for significant impacts and determining mechanisms for avoiding them.

McCoy, Melissa 2023. EPA Comments on the Dixie National Forest Hungry Creek EA. 8-28-2023.

Mature and Old-Growth Conservation

The proposed Silvicultural Manual purports to address old growth forests, but it barely mentions this important topic.

Proposed policy at FSM 2471.03 should require silvicultural prescriptions to address both mature and old growth stewardship.

The Silvicultural Manual should recognize that logging old forests to save them is fraught. Mature and old-growth forests are relatively more resilient to wildfire and other disturbances, and a lot of the silvicultural solutions often used by the agency have significant trade-offs that must carefully considered. For instance, logging mature and old-growth can make fire hazard worse, not better. Logging opens the canopy which makes the stand hotter/drier/windier, transfers hazardous fine fuels form the canopy to the ground where they are more available for combustion in surface fires, and maybe most significantly the open canopy stimulates the growth of surface and ladder fuels necessitating future entries that are more expensive. See, below section on the limited effectiveness (or even counter-productivity) of logging for fuel management.

On April 22, 2022 President Biden issued an executive order declaring a policy to conserve mature and old-growth forests on federal land and to manage forests to retain and enhance carbon storage. The agencies should immediately implement these policies.

Sec. 1. Policy.

Strengthening America's forests, which are home to cherished expanses of mature and old-growth forests on Federal lands, is critical to the health, prosperity, and resilience of our communities [hellip]. Forests provide clean air and water, sustain the plant and animal life fundamental to combating the global climate and biodiversity crises, and hold special importance to Tribal Nations. [hellip] Conserving old-growth and mature forests on Federal lands [hellip] is critical to protecting these and other ecosystem services provided by those forests. [hellip] We can and must take action to conserve, restore, reforest, and manage our magnificent forests [hellip] It is the policy of my Administration, [hellip] to [hellip] conserve America's mature and old-growth forests on Federal lands [hellip]

[hellip]

Sec. 2. Restoring and Conserving the Nation's Forests, Including Mature and Old- Growth Forests.

My Administration will manage forests on Federal lands, which include many mature and old-growth forests, to promote their continued health and resilience; retain and enhance carbon storage; conserve biodiversity [hellip]

Biden, J. 2022. Executive Order #14072 on Strengthening the Nation's Forests, Communities, and Local Economies. APRIL 22, 2022. PRESIDENTIAL ACTIONS https://www.whitehouse.gov/briefing-room/presidential-actions/2022/04/22/executiveorder-on-strengthening-the-nations-forests-communities-and-local-economies/ (emphasis added). The official policy of the federal government is to conserve mature and old-growth forests on federal land and that policy should be implemented here and now.

The National Old-Growth Amendment (NOGA) takes some modest steps to address conservation of old growth but does far too little to address the need to conserve mature forests, which are in desperate need of conservation because (1) old growth forest are too rare to serve their important ecological functions (e.g., water quality, hydrologic stability, biodiversity, climate stability), and mature forest helps meet some of the functions of old growth, and (2) mature forests serve as replacement cohorts for old growth that will succumb to natural and unnatural disturbance.

We urge the Forest Service to 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.

Mature forests are the stage of forest development immediately before old growth. The features that mark the transition from an immature to mature forest are unique to each forest type, underscoring the complexity of defining mature and old-growth forests. In general, mature forests contain more complexity in size and tree arrangement than younger forests but lack larger tree sizes and complex tree arrangement found in old growth.

USFS 2023. Forest Service Climate Risk Viewer (Beta 0.2.0) Mature & Old-Growth Forests.
https://storymaps.arcgis.com/collections/87744e6b06c74e82916b9b11da218d28?item=8

Jerry Franklin & Norm Johnson recently explained that there's no good reason to log mature forest, even in the matrix:

[hellip] primeval older forests are now grossly underrepresented in Oregon's forested landscapes, and they provide important ecological services and have high social value. They should be permanently protected.

Since adoption of the NWFP, we have learned much about the ecological role of these mature natural forests. Westside Douglas fir forests undergo significant structural and functional changes during their second century of life. Much of their evolution into fully developed old growth involves natural thinning processes, including death of some larger trees. Production foresters abhor the mortality of such trees as wasted harvestable timber. Viewed ecologically, however, their death creates gaps in the forest canopy that allow development of multiple canopy layers and enriched understories, which foster significant biological diversity.

Among tree species, Douglas fir is a long-distance runner rather than a sprinter, and at 100 years its growth has just begun to hit its stride. High rates of growth continue throughout the second century of these forests resulting in massive additional accumulations of wood and captured atmospheric carbon. Stocks of dead wood (snags and logs) are rebuilt and add significantly to carbon storage because of their slow rate of decay, helping to combat climate change and providing critical wildlife habitat.

Mature natural forests fulfill many of the same ecological roles as fully developed old-growth forests, such as providing habitat for endangered species like the spotted owl. They help reduce impacts of rain-on-snow storms that can lead to extensive floods in Western Oregon drainages. Ultimately, of course, mature forests become the replacements for old-growth forests that are inevitably lost to wildfire and wind, as occurred last September in wildfires in Western Oregon and Washington.

There are no ecological justifications for harvesting more than 2,000 acres of mature forest in the Flat Country Project. Such activities terminate the natural developmental processes that are at work in these stands, forcing the forest to "start over" on its way to becoming old growth.

One Forest Service justification for the proposed harvest is that the mature forests are "too dense" and "overstocked." However, these judgments are based on measures of desirable tree density developed for managing wood production plantations! Such measures have no relevance to the natural developmental processes underway in primeval mature forests.

The Forest Service also argues that harvesting mature forests is necessary to provide early successional habitat [mdash] the rich community of shrubs, forbs and grasses that naturally develop along with tree seedlings after wildfire or other disturbances. As longtime advocates for such habitat, we know that the wildfires of 2020 will provide significant areas of early successional habitat if the Forest Service does not salvage logs and aggressively replant them.

Jerry Franklin and Norm Johnson 2021. Protect older natural forests in the western Cascades. Guest Viewpoint. Eugene Register Guard. 4-27-2021. https://www.registerguard.com/story/opinion/columns/2021/04/27/guest-view-protect-oldernatural-forests-western-cascades-jerry-franklin-norm-johnson/7385736002/ citing Franklin & Johnson 2021. ArcGIS Storymap. Protect Older Natural Forests in the Western Cascades https://dlj.maps.arcgis.com/apps/MapJournal/index.html?appid=e9eb7176553d42a0a84a9e1f56e25950

"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.

NRDC (2023) provides a nice science summary of the biodiversity benefits of conserving mature and old-growth forests, including as climate refugia. https://www.climateforests.org/post/biodiversity-co-benefits-of-mature-forests ("Mature and old-growth forests and trees provide diverse habitat for wildlife and vegetation to a degree that younger forests cannot. Older trees develop unique features that support complex habitats, often serving as biodiversity hotspots. Mature forests are far less prevalent across the U.S. than they once were and are the increasingly scarce preferred habitat for a myriad of imperiled species. Conversely, relative to mature forests, there is generally no shortage of young forests, undermining justifications for logging to convert mature stands to an earlier successional state. Logging of mature and old-growth trees in the United States removes these remaining cornerstones of ecosystem integrity, compounding the ongoing biodiversity crisis.").

Old forests provide a wide range of ecological functions and processes describe here:

Functions of old growth forest ecosystems are many and include (Watson et al., 2018; Buotte et al., 2020; Price et al., 2020; Ripple et al., 2020):

[bull] CARBON SEQUESTRATION AND STORAGE

[bull] PROVISION OF HABITAT

[bull] CONSERVATION OF BIODIVERSITY

[bull] CONSERVATION OF UNIQUE AND AT-RISK SPECIES

[bull] MAINTENANCE OF HYDROLOGIC FUNCTION AND FISH HABITAT

[bull] NUTRIENT CYCLING

[bull] REGULATION OF CLIMATE

[bull] BUILDING SOIL

BC Old-Growth Forest Ecology website, Accessed March 28, 2022.
https://oldgrowthforestecology.org/ecological-values-of-old-growth-forests/ecological-processes-and-functions/

Conserving forests is one of the most effective and lowest-cost options for managing atmospheric carbon dioxide, and mature and old-growth forests do this job most effectively. Protecting and expanding them does not require expensive or complex energy-consuming technologies, unlike some other proposed climate solutions.

Allowing mature and old-growth forests to continue growing will remove from the air and store the largest amount of atmospheric carbon in the critical decades ahead. The sooner logging of these forests ceases, the more climate protection they can provide.

Law & Moomaw 2024. Old forests are critically important for slowing climate change and merit immediate protection from logging. The Conversation. Jan. 19, 2024. https://theconversation.com/old-forests-are-critically-important-for-slowing-climate-changeand-merit-immediate-protection-from-logging-220771

Some unique ecological phenomena only occur in old growth forests, such as canopy soil accumulation and microhabitat development within the canopy of large trees. Jessica Murray, A. Peyton Smith, Myrna Simpson, Keylor Mu[ntilde]oz Elizondo, Jacqueline A. Aitkenhead-Peterson, Bonnie Waring 2023. Climate, as well as branch-level processes, drive canopy soil abundance and chemistry. Geoderma, Volume 438, 2023, https://doi.org/10.1016/j.geoderma.2023.116609 (open access). ("Canopy soils (arboreal Histosols; Fig. 1) are found in temperate and tropical biomes and play a critical role in the forest ecosystems where they are found, supporting plant diversity and contributing to nutrient and water cycling (Gotsch et al., 2016). Canopy soils are composed of nutrient-rich particulate organic matter and develop over time through the retention and decomposition of host tree and epiphytic plant litter on tree branches and in tree crotches in wet forests. They associate with epiphytic plant communities that represent up to 25% of vascular plant diversity in tropical forests (Nieder et al., 2001), forming canopy communities that provide critical habitat and forage for animals (Nadkarni and Matelson, 1989,Paoletti et al., 1991). Canopy soils host unique microbial assemblages (Dangerfield et al., 2017) and have high fungal biomass per unit organic matter compared to forest floor soils (Rousk and Nadkarni, 2009). Canopy soils have been observed to store up to 264% of their dry weight in water (K[ouml]hler et al., 2007) and can therefore play an important role in rainwater interception, reducing surface runoff and nutrient leaching on the forest level (Gotsch et al., 2016). Relative to forest floor soils, canopy soils contain high concentrations of carbon (C), nitrogen (N), and phosphorus (P) as well as cations such as magnesium, potassium, and calcium (Cardel[uacute]s et al., 2009, Hofstede and Wolf, 1993, Nadkarni et al., 2004, Victoriano-Romero et al., 2020). Canopy soils derive carbon and nutrients not only from within the forest ecosystem (e.g. from host tree or epiphyte litter) but also allochthonous sources such as those fixed from the atmosphere by epiphytic bryophytes (Matson et al., 2015) or deposited in dust or rain (Hietz et al., 1999). [hellip] The limited information available about canopy soils indicates their abundance may increase with stand age and moisture (Gotsch et al., 2017, Nadkarni et al., 2004, Werner et al., 2012).").

Large trees provide a wide variety of important values that are scarce due to decades of logging on public and private lands. Scientists wrote to the Forest Service explaining -

Primary forests and large, old trees, both living and dead, provide irreplaceable benefits to society that are essential to forestalling the loss of biodiversity and climate change related environmental emergencies. Those forests and trees have elevated conservation status, needing to reach maturation in order to achieve their ecological potential in supporting associated biodiversity, contributing to carbon storage and myriad ecosystem servicesii.[EC1] Trees greater than 18 inches dbh (>45 cm) have been declining in forests at all latitudesiii. With that decline occurring, occurring, the following values of large trees are of utmost importance in preserving:

? Large, old trees are among the most massive terrestrial organisms on Earth. They are bio-cultural elements of a natural inheritance that is declining globallyiv

? The size of a tree increases over time accumulating keystone features that provide large internal cavities and canopy structures for wildlife not present in younger trees.

? Large, old trees, including snags and downed wood, are needed for nesting, roosting, foraging, denning, and other habitat elements that support numerous lichens, epiphytes, up to 30% of all vertebrates in some forestsv, and invertebrates, many of which are rare, endemic, or endangeredv.

? Large, old trees anchor soils through their massive root systems, stabilize slopes, and provide shading and habitat (logs) for aquatic speciesvi.

? Large, old trees provide nutrients and soil carbon, are associated with high levels of plant varieties, play critical roles in hydrological cycles, and are "blueprints" for restorationvii.

? Large, old trees store a disproportionate amount of carbon with greater leaf surface area for CO2 absorption, and massive carbon-storing tree trunks and rootsviii. For instance, a recent global study found half of carbon in living above ground biomass is stored in the largest 1% diameter treesix.

? Large, old trees provide stable microclimates and mitigate soil desiccationx.

? Mycorrhiza fungal networks are more connected and carbon rich as forests age with large trees serving as central nodes in the networksxi.

? Large, old trees are especially valuable when killed individually or in large patches by natural disturbance processes such as insects, forest pathogens, wind storms, and wildfirexii that generate "complex early seral forestsxiii."

DellaSala et al 2020. Open Letter to The Forest Service on the Importance of Large, Old Trees and Forests. https://drive.google.com/file/d/1oRTRDNoQSngZKXnwz04lITABz85AqS0D/view citing -

ii Lindenmayer, D.B. et al 2012. Global decline in large trees. Science 338:1305-1306. Lindenmayer, D.B. et al. 2013. New policies for old trees: averting a global crisis in a keystone ecological structure. Conservation Letters 7:61-69. Brandt, P et al 2014. Multifunctionality and biodiversity: ecosystem services in temperate rainforests of the Pacific Northwest. Biol Conserv. 169:362-371

iii Lindenmayer, D.B., W.F. Laurance, J.F. Franklin. 2012. Global decline in large old trees. Science 338:1305-06.

iv Lutz, J A et al 2018. Global importance of large diameter trees. Global Ecol Biogeogr:1-16

v Lindenmayer, D.B., et al. 2012. Ibid

vi Reeves, G.H. et. al. 2006. The aquatic conservation strategy of the Northwest Forest Plan. https://www.fs.usda.gov/treesearch/pubs/27229

vii Mackey, B 2014. Counting trees, carbon, and climate change. The Royal Statistical Society:19-23. Frey, S J K et al 2016. Spatial models reveal the microclimatic buffering capacity of old-growth forests. Sci Adv 2016:e1501392.

viii Mackey, B 2014. Counting trees, carbon, and climate change. The Royal Statistical Society:19-23. Frey, S J K et al 2016. Spatial models reveal the microclimatic buffering capacity of old-growth forests. Sci Adv 2016:e1501392.

ix Lutz, J.A. et al. 2018. Ibid

x Frey, S J K et al 2016. Ibid

xi Maser, C., et al. 2008. Trees, truffles, and beasts: how forests function. Rutgers University Press, NJ. Davis, K. T., et al. 2019a. Microclimatic buffering in forests of the future: the role of local water balance. Ecography 42:1-11.

xii Franklin, J.F. et al. 2000. Threads of continuity. Conservation Biology in Practice 1:9-16.

xiii Swanson, M.E. et al. 2011. The forgotten stage of forest succession: early-successional ecosystems on forested sites. Frontiers in Ecology and Environment 9:117-125.

In 2022, a consortium of conservation and academic experts explained -

Why Mature Forests are Considered Important in Protection Strategies

[hellip]

The following are important characteristics of mature forests where old-growth characteristics are emerging:

[bull] As forests mature, structural features become increasingly developed and the maturation process is associated with greater ecosystem benefits and biodiversity

[bull] Most dominant/co-dominant trees reach the culmination of mean annual increment (CMAI or Age of Biological Maturity) at 60-80 years depending on site conditions - foresters use CMAI to know when to log a forest for profit. CMAI means that the annual growth rate of trees slows down as trees age - therefore, they are mature.

[bull] Structure- large trees, vertical/horizontal layering, snags/logs, canopy branching begin to show up in mature forests at about 80 years or so across most forest types

[bull] Complex soils with well-developed mycorrhizal connections show up at this age

[bull] Processes - gap phase dynamics, predator-prey food webs, pollination, nutrient cycling are at an advanced stage at this age

[bull] Functions - climate buffering, water regulation, ecosystem services are all the more advanced as forests mature in 80 years or so

[bull] Setting the protection (from logging) threshold >80 years is reasonable for a national standard for all federal mature forests- the Northwest Forest Plan in the Pacific Northwest is an example of mature forest defined at 80

years when the emergence of structure, processes, functions are approaching old growth characteristics.

DellaSala et al 2022. 'Mapping Mature Forests in Conterminous USA' Project
https://www.matureforests.org/importance-of-mature-forests; https://www.matureforests.org/about-contacts

Birdsey et al (2023) showed that mature forests on the National Forests store significant carbon, and have the potential to store much more, yet they remain vulnerable to logging.

The approach and methodology developed here are designed to inform policy makers about federally managed mature forests and their large and vulnerable C stocks and high rates of accumulation of carbon from the atmosphere. [hellip] Our study further corroborates that large areas of mature federal forests are significant carbon sinks that lack protection. [hellip]We also note an important distinction that rates of carbon accumulation tend to be higher in younger forests while the largest amounts of stored carbon are found in mature forests. Protecting these carbon sinks and avoiding losses of carbon from logging would require a policy shift to focus more on the potential role of federal forests in climate mitigation (DellaSala et al., 2022a). [hellip] For operational land management practices, it is often easier to apply a diameter limit in timber operations by species than an age limit by forest type, because as noted previously it can be challenging to determine a precise stand age, whereas measuring tree diameter is simple and accurate [hellip] [W]e found that the unprotected carbon stock in larger trees in mature stands ranged from 36 to 68% of the total carbon in tree biomass [hellip] The unprotected annual carbon accumulation in tree biomass of larger trees in mature stands ranged from 12 to 60% of the total accumulation in all trees. The potential climate impact of avoiding emissions from logging larger trees and mature forests is thus significant.

Birdsey RA, DellaSala DA, Walker WS, Gorelik SR, Rose G and Ram[iacute]rez CE (2023) Assessing carbon stocks and accumulation potential of mature forests and larger trees in U.S. federal lands. Front. For. Glob. Change 5:1074508. doi: 10.3389/ffgc.2022.1074508.
https://www.frontiersin.org/articles/10.3389/ffgc.2022.1074508/full

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 "captures mortality" 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. https://web.archive.org/web/20061008082841/http://www.coastrange.org/documents/forestreport.pdf. Jerry Franklin says the 80-year cut-off for logging under the Northwest Forest Plan came from the discovery that after the 1902 Yacolt burn in SW Washington, forests that naturally regenerated with a legacy of abundant dead wood and vegetation complexity developed into suitable spotted owl habitat after 80 years. K. Norm Johnson says protection of stands older than 80 years "is so pivotal to everything that has happened to this day. There's no more important criteria under the Northwest Forest Plan than that one." Scott, Aaron 2020. Timber Wars podcast, Episode 5. https://www.opb.org/article/2020/09/22/timber-warsepisode-5-the-plan/.

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. "Effects of Riparian Thinning on Marbled Murrelets and Northern Spotted Owls." 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.

1997 Marbled Murrelet Recovery Plan, page 143

"Consistent with the Forest Plan Record of Decision, thinning within Late-Successional Reserves should be restricted to stands younger than 80 years.... 3.2.1.2 Protect 'recruitment' nesting habitat to buffer and enlarge existing stands, reduce fragmentation, and provide replacement habitat for current suitable nesting habitat lost to disturbance events. Stands (currently 80 years old or older) that will produce suitable habitat within the next few decades are the most immediate source of new habitat and may be the only replacement for existing habitat lost to disturbance (e.g., timber harvest, fires, etc.) over the next century. Such stands are particularly important because of the vulnerability of many existing habitat fragments to fire and wind and the possibility that climate change will increase the effects of the frequency and severity of natural disturbances. Such stands should not be subjected to any silvicultural treatment that diminishes their capacity to provide quality nesting habitat in the future. Within secured areas, these "recruitment" stands should not be harvested or thinned."

Skeena Watershed Council in British Columbia note that "Old growth forests are now a nonrenewable 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."

"[W]e 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 Mart[iacute]nez, 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 (Sillett 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 - 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, https://www.fs.fed.us/rm/pubs_journals/2018/rmrs_2018_lutz_j001.pdf.

Conservation of mature and old-growthtrees 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 and 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.

"The more structurally complex the forest, the more big trees, the more vertical layers - the cooler it was," 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't have nearly the understory material - small trees, shrubs, ground cover - as more complex stands. Nor do these single-age plantations have a lot of big trees - unlike old growth stands.

"We think one of the mechanisms causing this is thermal inertia," Betts says. "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."

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-climatechange/ 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. The buffering provided by mature and old-growth forests is relatively stable even in a dynamic climate regime, so "To maintain microrefugia in a rapidly changing climate, conservation of old-growth and other structurally complex forest habitat is critical" Christopher Wolf, David M. Bell, Hankyu Kim, Michael Paul Nelson, Mark Schulze, Matthew G. Betts, Temporal consistency of undercanopy thermal refugia in old-growth forest. Agricultural and Forest Meteorology, Volume 307, 15 Sept 2021, 108520, ISSN 0168-1923, https://doi.org/10.1016/j.agrformet.2021.108520. See also Xiyan Xu, Anqi Huang, Elise Belle, Pieter De Frenne, And Gensuo Jia 2022. Protected areas provide thermal buffer against climate change. SCIENCE ADVANCES. 2 Nov 2022. Vol 8, Issue 44. DOI: 10.1126/sciadv.abo01. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9629704/pdf/sciadv.abo0119.pdf ("Protected forests can effectively cool the land surface. The latitudinal gradient of the cooling effects of protected forests on LST [land surface temperature], i.e., decreasing cooling effects from the tropics to the poles, is similar to the spatial pattern of cooling effects of forest cover on land surface (21). This spatial pattern is also supported by ground observations of air temperatures measured within and outside forest canopies, indicating that the below-canopy microclimate is buffered by tree canopies. The buffering effect of forests on subcanopy microclimate tends to be greater than the magnitude inferred from LST that represents the temperature at the top of the canopy. Subcanopy air temperatures are even lower, most likely because of the shading and light interception of the canopy structure (20). However, the effect is much stronger than the mean effect of forests (protected and nonprotected) on LSTs compared to open land (grasslands and croplands). The cooling effects are high in tropical and temperate forests, [hellip] The buffering effect of PAs [protected areas] on increased temperatures therefore stabilizes the impacts of climate change at the global level. It is generally recognized that nature conservation contributes to global climate targets by preventing carbon emission from land-use change and by enhancing carbon removal from the atmosphere (12, 14). Here, we show that the effectiveness of PAs in stabilizing the local climate cannot be ignored. The stabilized climate in regions of high PA coverage is particularly important for providing climate change refugia and protecting species and communities from the negative impacts of climate change (45), whereas land-use change and disturbances result in greater warming that modifies habitats and threatens species. The buffering effects of PAs along a latitudinal gradient, i.e., stronger buffering at higher latitudes, are particularly important for species and communities at higher latitudes, where climate warming is more pronounced than that at lower latitudes. [hellip] The buffering effects of PAs on local microclimate are mainly achieved through the moderation of energy budgets by natural intact vegetation. Natural and seminatural vegetation, particularly forests, have much higher ET and surface roughness due to dense and tall canopies than croplands, where the land surface is cooled down by turbulent heat loss (32). [hellip] We find higher LAI [leaf area index] in PAs than NPAs [non-protected areas], which results in lower aerodynamic resistance and enhances turbulent heat transfer from the land surface to the atmosphere, thereby cooling the land surface (47) in temperate forests, tropical forests, grasslands, and savannas (fig. S8B). The cooling effect of land cover with higher LAI through aerodynamic resistance plays a major role in cooling the land surface compared to other biophysical effects (48).").

Another study showed that as the climate warms forests, especially natural forests, become an increasingly important refuge for mammals. Tourani et al 2023. Maximum temperatures determine the habitat affiliations of North American mammals. PNAS December 4, 2023. 120 (50) e2304411120 https://doi.org/10.1073/pnas.23044111, https://www.pnas.org/doi/pdf/10.1073/pnas.2304411120.

Mature forests are relatively resistant and resilient to wildfire -

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-refugein-areas-at-risk-of-severe-fire/; https://www.fs.usda.gov/pnw/news-releases/old-growthforests-may-provide-valuable-biodiversity-refuge-areas-risk-severe-fire. Notably, mature forests are less resilient after logging due to hotter/dryer microclimate, logging slash, and stimulated growth of surface and ladder fuels. The Stella Project FEIS said "Larger trees, such as ponderosa pine and Douglas-fir, develop a thick bark that insulates the cambium from damaging heat. Even if the bark is considerably scorched, the cambium can remain undamaged. In addition, the crowns of larger trees are more elevated, thus protecting the buds and foliage from heat scorch." Rogue River Siskiyou National Forest. 2021. Stella Restoration Project Final EIS. https://usfs-public.app.box.com/v/PinyonPublic/file/934132398930.

Lesmeister et al (2021)--

We examined the relationship between fire severity and suitable nesting forest in 472 large wildfires (> 200 ha) that occurred in the northern spotted owl range during 1987- 2017. [hellip] Averaged over all fires, the interior nesting forest burned at lower severity than edge or non-nesting forest. These relationships were consistent within the low severity, very frequent, and mixed severity, frequent fire regime areas. [hellip] Over the 30-year study, we found a strong positive trend in the proportion of wildfires that burned at high severity in the non-nesting forests, but not in the suitable nesting forest types. Conclusions: Under most wildfire conditions, the microclimate of interior patches of suitable nesting forests likely mitigated fire severity and thus functioned as fire refugia (i.e., burning at lower severity than the surrounding landscape). With changing climate, the future of interior forest as fire refugia is unknown, but trends suggest older forests can dampen the effect of increased wildfire activity and be an important component of landscapes with fire resiliency.

Lesmeister, D.B., Davis, R.J., Sovern, S.G. et al. Northern spotted owl nesting forests as fire refugia: a 30-year synthesis of large wildfires. fire ecol 17, 32 (2021). https://doi.org/10.1186/s42408-021-00118-z; https://fireecology.springeropen.com/counter/pdf/10.1186/s42408-021-00118-z.pdf.

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[mdash]in addition to protecting habitat[mdash]could enhance biodiversity persistence in the face of climate warming.

Matthew G. Betts, Ben Phalan, Sarah J. K. Frey, Jos[eacute]e 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://onlinelibrary.wiley.com/doi/pdf/10.1111/ddi.12688. Supported by Kim, H., McComb, B. C., Frey, S. J. K., Bell, D. M., & Betts, M. G. (2022). Forest microclimate and composition mediate long-term trends of breeding bird populations. Global Change Biology, 00, 1- 14. https://doi.org/10.1111/gcb.16353, https://onlinelibrary.wiley.com/doi/pdf/10.1111/gcb.16353. ("We provide the first empirical evidence that complex forest structure and vegetation diversity confer microclimatic advantages to some animal populations in the face of climate change. Conservation of old-growth forests, or their characteristics in managed forests, could help slow the negative effects of climate warming on some breeding bird populations via microclimate buffering and possibly insurance effects.") 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/ ("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").

Research in European forests have found similar climate buffering effects -

The researchers also discovered that forests have so far done a remarkable job of buffering plants against the broader climate change going on outside them.

Temperature measurements revealed that forests often have significantly different temperatures from what weather stations - always placed far from trees - record. In summer, for example, they are on average 4[deg]C cooler. This is not only because thick canopies keep out the light, but also because evapotranspiration of water through the leaves and into the atmosphere sucks heat out of the forest, and the vegetation keeps out breezes that would mix warm air into the cool.

Climate models don't take into account this buffering, despite the fact that two thirds of the world's species live in forests and forest processes such as carbon and nutrient cycling depend on temperature, says Professor Pieter de Frenne, a bioscientist also at Ghent University [hellip]

Aisling Irwin 2020. Forest darkness helps stave off effects of nitrogen pollution - but this is set to change. Horizon - EU Research and Innovation Magazine. 01 October 2020. https://horizonmagazine.eu/article/forest-darkness-helps-stave-effects-nitrogen-pollution-set-change.html. The microclimate buffering effects of mature forest become increasingly valuable as time passes because climate change is expected to increase rates of disturbance and make mature forests more scarce. See also, Christopher Wolf, David M. Bell, Hankyu Kim, Michael Paul Nelson, Mark Schulze, Matthew G. Betts,

Temporal consistency of undercanopy thermal refugia in old-growth forest. Agricultural and Forest Meteorology, Volume 307, 15 Sept 2021, 108520, ISSN 0168-1923, https://doi.org/10.1016/j.agrformet.2021.108520. ("To maintain microrefugia in a rapidly changing climate, conservation of old-growth and other structurally complex forest habitat is critical, [hellip]").

The extreme heart dome of 2021 also demonstrated the value of conserving mature forests. Still & Talberth. 2022. Deforestation, Forest Degradation, Heat Waves and Drought - Evidence from the Pacific Northwest heat dome of 2021. https://sustainable-economy.org/wpcontent/uploads/2022/03/Deforestation-and-heat-waves-FINAL.pdf ("[bull] At the western Oregon region of interest, the mean, maximum, and minimum land surface temperature was always higher on the deforested and degraded lands. During the heat dome event, the undisturbed forest was 5.5 [ordm]C cooler (94.8 [ordm]F vs. 104.7 [ordm]F).

[bull] At the NEON sites in Washington and relative to the undisturbed old growth forest, the degraded (plantation) site was hotter (~4.5 [ordm]C), lost more water, was less efficient at photosynthesis, and experienced a more dramatic impact to carbon cycling, flipping from a sink to a source during the heat dome event.

[bull] The results suggest that as heat and drought intensify with climate change, maintaining the extent of undisturbed forest and reducing the extent of deforested and degraded lands may be important for mitigating the effects of heat waves, conserving water supplies, and reducing wildfire risk.").

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 ("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 (2-16m) 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 2-16 m strata - conditions that owls actually avoid.") 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'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 ("Highlights - [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 "old-growth forests". 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)."). 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)-

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 (Bu[eacute]e 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 Bu[eacute]e 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.

SEE LETTER SUBMISSION: Table 1 Scale dependent change in forest interior area from 2001 to 2006

These fragmentation effects are clearly evident in the Pacific Northwest.

SEE LETTER SUBMISSION: Figure 2 Net change in forest area from 2001 to 2006

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.

[hellip] an extensive literature demonstrate[es] the benefits of intact forests over degraded forest systems. These benefits range from greater carbon sequestration and resilience to disturbance through to genetic benefits, lower wildfire risk and more stable hydrological services. Intact forests also provide homes, livelihoods and cultural importance for millions of Indigenous and local people, and are strong magnets for tourism.

The value of old forests must not be minimized by promises of forest restoration. Conversion of already-cleared land to timber plantation will, of course, bring some carbon sequestration and habitat services. And more-concerted efforts to genuinely restore forests beyond simple plantation use are hugely necessary and welcome. But even well-executed forest restoration cannot fully regain the functions of old forests over time scales that will compensate for the biodiversity and climate ramifications of their loss.

Old forests are not replaceable. Nat Ecol Evol 6, 653 (2022). https://www.nature.com/articles/s41559-022-01806-y.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 "this beautiful place should not be destroyed by logging."

Uneven-aged management

The proposed Silvicultural Manual recommends setting a maximum tree size in uneven-aged stands. This is ecologically flawed, and represents an example of outdated agricultural thinking about forests. The largest and oldest trees have disproportionate value, and should be retained, not removed.

It is much more ecologically desirable to thin from below, not thin from above.

Regeneration Harvest Methods

Regen harvest and plantation forestry need to be reconsidered in light of global climate change and the expected increase in fire frequency, and the fact that dense planted stands pose an increased fuel hazard and increased risk of stand loss. Simply put, plantation forestry may no longer be sustainable. Removing most or all of the trees from a site, replanting new stands that are at heightened risk of severe fire, and expecting to come back in [x] decades to harvest may no longer be a viable forestry practice, since tree farms are likely to be subject to loss before they reach economic viability.

All regeneration harvest methods, including clearcutting, shelterwood, seed tree, etc. are inconsistent with natural processes, and create novel stand structures are generally unsuitable habitat. Such harvest methods must be closely scrutinized for ecological appropriateness.

Past management emphasized converting natural forests to tree farms, which resulted in numerous serious social and environmental problems (e.g., polluted streams, excessive peak flows during storms, low summer stream flow, loss of old growth forests, endangered fish and wildlife, social conflict, loss of public trust by the federal agencies, loss of scenic and recreational values, community instability from boom-bust economics, etc.). See 1993 FEMAT Report. https://www.blm.gov/or/plans/nwfpnepa/FEMAT-1993/1993_%20FEMAT_Report.pdf.

Regen does not mimic natural disturbance. The Silvicultural plan and NEPA analysis need to consider the potentially significant cumulative effects on ecosystems and hydrologic systems from widespread logging in the project area and surrounding watersheds.

Foresters like to think that regen logging mimics natural processes like fire, but this is far from the case, because logging removes so much more biomass than fire. Fire leaves abundant legacies that offer some late successional habitat value, even in the young stands that dominate in the decades after fire. This is not the case with regen logging which removes much more biomass and disproportionally removes the large legacy components. This causes a much more abrupt spatial and temporal transition/ fragmentation between young and old forests. Logging also causes much more significant soil disturbance, especially compaction and displacement, from roads, landings, skidding and yarding logs, and unusually hot slash fires. This spreads weeds, harms the below-ground ecosystem, degrades site productivity, and causes erosion. Regen combined with replanting and roads also causes very atypical hydrologic disruption, including artificial peak flows immediately after the first several storms following logging, and artificial low flows during summer for several decades following establishment of dense tree plantations.

Regen logging does not mimic natural disturbance because it removes the vast majority of the habitat structure, such as snags and large down wood, that early seral wildlife depend on. Eighty five percent of vertebrates tied to edges and early seral forest in the western Cascades need dead wood. C. Friesen 2010. Early Seral Forests - A Conservation Conundrum. http://www.ecoshare.info/uploads/ccamp/Early-Seral-Forest-Friesen.ppt; http://ecoshare.info/projects/central-cascade-adaptive-management-partnership/synthesispapers-tools/

"Key attributes" of high quality early seral habitat include "exceptionally high quantities of large dead wood," a condition that is not provided by commercial timber harvest that exports the vast majority of wood from the site. "[P]rompt reforestation and few legacies is unlikely to approximate the role of naturally generated early-seral conditions" M.E. Swanson Mark E. Swanson, Nichole M. Studevant, John L. Campbell, Daniel C. Donato. 2014. Biological associates of early-seral pre-forest in the Pacific Northwest. Forest Ecology and Management 324 (2014) 160-171. http://www.sierraforestlegacy.org/Resources/Conservation/Biodiversity/BD-Swanson-etal-EarlySeral2014.pdf.

Plantations are fake forests because they lack the integrity of real forests. ... Real forests are much more complex at all levels of biological organization: genetic (genomes are highly variable compared to nursery "stock"), native species richness, and ecosystem processes[mdash]the latter both above and below ground. ... Moreover, real forests are grossly under-valued for myriad ecosystem benefits and biodiversity values that they provide to society, as pressures to log them continue to mount. ...

Dominick A DellaSala 2019. "Real" vs. "Fake" Forests: Why Tree Plantations Are Not Forests. Reference Module in Earth Systems and Environmental Sciences 2019. https://doi.org/10.1016/B978-0-12-409548-9.11684-7

The agency must avoid any suggestion that natural disturbance reset stand age to zero, or that regen logging mimics stand replacing disturbance. This is an oversimplification of forest ecology. First of all, forests are products of their history. There really is no such thing as a zero-aged stand, because every forest is a product of disturbance while retaining some memory of its past in the form of legacy structures; surviving organism; onsite and nearby seed banks, seed sources, mycorrhizal inoculum, spores, and propagules, that are genetically "family" to the disturbed forest, etc. If the agency treats disturbed forests as a "blank slate" with no history, then they will effectively be erasing their history and their ecological memory.

Natural disturbance recruits large amounts of dead wood that provide valuable habitat for diverse wildlife. Of the many wildlife species that use early seral forest, 85% use dead wood at some life stage. Friesen, C.A. 2007. Early Seral Forest: A conservation Conundrum. http://www.ecoshare.info/uploads/ccamp/Early-Seral-Forest-Friesen.ppt Unfortunately, regen harvest removes virtually all of the most valuable large wood depriving wildlife of the rich structural complexity they would normally enjoy after a natural disturbance.

The presence of coarse woody debris is critical for biodiversity conservation. [hellip] In general, post-fire forest ecosystems include the presence of large numbers of snags and downed woody debris. This dead material provides important habitat elements for many species of plants and animals, while also storing a great deal of carbon (MacDonald 1993; Fleming and Freedman 1998; Freedman et al. 1996). Clearcut harvesting of natural forests results in the removal of most of the aboveground woody biomass from the site because trees are the commodity being harvested. [hellip] Because clearcut harvesting concentrates on the removal of biomass, it fails to produce large-dimension snags and coarse-woody debris in intensively managed forests, [hellip] Although both harvesting and wildfire kills trees, only fire leaves them as dead standing biomass. [hellip] The fire-killed snags and woody debris cast partial shade, which ameliorates the surface microclimate and may enhance the survival of pine seedlings (Fraser and Farrar 1953; Cayford and McRae 1983; Carleton and MacLellan 1994). [hellip] Some studies have suggested that the cover and richness of the understorey vegetation of a natural forest may never fully recover from clearcutting. [hellip] Wildfires reduce the presence of some hosts that assist the spread of pests and pathogens while clearcutting may promote them. [hellip] [E]xclusion of fire from such ecosystems, along with forestry practices that leaves young infected trees in the residual stand, leads to increased abundance of this parasite. In contrast, fire eliminates Dwarf mistletoe. [hellip] Numerous studies have determined the potential removals of nutrients with conventional and whole-tree clearcuts [hellip] The data show that clearcutting removes large amounts of biomass and nutrients from the site, and that these are equivalent to a substantial fraction of the site capita of these materials. [hellip] During a wildfire, biomass capital of the stand is lost by combustion, as is that of nitrogen through the oxidation of organic compounds and the release of gaseous NO and NH_3. In intense wildfires these losses of biomass and nitrogen can be comparable in magnitude to what would be removed by the clearcutting of comparable stands. Unlike wildfire, however, clearcutting also removes large amounts of phosphorus, potassium, calcium, and magnesium contained in the tree biomass; these materials are mostly conserved in situ during a wildfire. [hellip] Clearcut harvesting with heavy equipment can cause severe soil compaction along skidding lanes and it can also disrupt soil profiles by churning [hellip] Permanent roads are not generally associated with wildfire management or suppression (although temporary access routes may be constructed while fighting some wildfires). An extensive road network is, however, necessary for timber harvesting and subsequent stand management. Roads affect biodiversity in many ways. Roads directly remove natural habitat, alter drainage and stream dynamics, cause erosion, introduce edge effects, fragment contiguous ecosystems, alter species movements, and act as corridors for the introduction of non-native species [hellip]. Road density is a useful indicator of ecological threat [hellip] [I]t is erroneous to assume that forest harvesting plays the same ecological role as wildfire.

D.J. McRae, L.C. Duchesne, B. Freedman, T.J. Lynham, and S. Woodley, 2001. Comparisons between wildfire and forest harvesting and their implications in forest management. Environ. Rev. 9. 223-260 (2001); DOI: 10.1139/er-9-4-223.

Modelling by Harris (2000) suggests that since snags are ephemeral and need to be continually replaced, 12 or more green trees need to be retained for every snag we want to maintain over the life of the stand. Harris, R.B. 2000. Estimating large snag recruitment needs in regeneration timber harvests. Western Journal of Applied Forestry. 15: 140-146.
http://www.cas.umt.edu/facultydatabase/FILES_Faculty/1152/Harris%202000%20LargeSnagRecruitment%20Western%20J.%20Appl.%20For.pdf. This paper also highlights the concern that without numerical guides, managers could erroneously assume that they are maintaining adequate numbers of snags across the landscape even though they are retaining too few green trees to achieve that goal.

SEE LETTER SUBMISSION: Disturbance and biomass change (live, snag, down)

Ohmann, JL, MJ Gregory, HM Roberts, RE Kennedy, Z Yang, J Braaten, SL Powell, WB Cohen, V Kane, J Lutz. 2012. Mapping change in live and dead forest biomass with Landsat time-series, remeasured plots, and nearest-neighbor imputation. ForestSat 2012: Corvallis, OR; September 2012.
http://lemma.forestry.oregonstate.edu/export/presentations/ohmann_etal_2012_forestsat.pps

Although many existing silvicultural systems have been designed to mimic stand-scale natural disturbances, McRae et al. (2001) and Palik et al. (2002) remind us that natural disturbances are inherently different from those of silviculture. One difference, of course, relates to the amount of carbon removed from the site when harvesting a forest. Removals tend to be much greater with harvesting than for fire, for example. Fire tends to create a complex mosaic of forest types and ages on the landscape. Forest harvesting, as commonly practiced, tends to simplify forest composition and structure.

Crow, T.R. and A.J. Perera. 2004. Emulating natural landscape disturbance in forest management - an introduction. Landscape Ecology 19: 231-233. http://www.firescience.gov/projects/01-1-3-43/project/01-1-3-43_01_1_3_43_Deliverable_02.pdf

In terms of sedimentation, it is the forest roads that may have the most significant impact because of the constant source of sediment they can provide over the life time of the road network. When all attributes are considered it appears that [clearcutting] does not emulate wildfire and may have a more detrimental impact on headwater systems in both the short and long-term. [hellip] Overall, the results suggest that harvesting does not emulate wildfire, particularly [clearcutting]. [hellip] It is important for forest managers to consider the complex affects that harvest treatments can have on headwater systems if they are going to successfully practice ecosystem management and achieve sustainable forest management. It is also important for managers to understand that there are many other attributes to be considered. In particular, the ability of harvest treatments to emulate wildfire in regards to peak flows, organic matter inputs, large woody debris recruitment, channel morphology, and stream biota response. Due to the inability to statistically analyse these attributes they were not incorporated into the scope of this paper.

Nitschke C.R. 2005. Does forest harvesting emulate fire disturbance? A comparison of effects on selected attributes in coniferous-dominated headwater systems. Forest Ecology and Management 214 (2005) 305-319.
http://www.sierraforestlegacy.org/Resources/Conservation/FireForestEcology/FireScienceResearch/FuelsManagement/FM-Nitschke05.pdf

From a wildlife perspective, stand-replacing fires and timber harvesting both represent major disturbances which significantly alter habitats [hellip] Despite their similarities, fire and logging differ in several of the habitat conditions they procure for wildlife. Wildfires, especially when severe, generate large amounts of standing (eventually downed) dead trees including large ones which represent an important habitat and food source for many wildlife species (Drapeau et al. 2002; Pedlar et al. 2002). [hellip] [T]he spatial variability of fire severity creates various amounts of green or mixed-severity stands over the burned landscape (e.g., Kafka, Gauthier, and Bergeron 2001; Smyth et al. 2005), which represent important refuge sites for some wildlife species (Norton and Hannon 1997; Tittler and Hannon 2000; Lance and Phinney 2001; Tittler, Hannon, and Norton 2001). Contrarily, clearcut harvesting removes most of the large live trees, leaves few standing deadwood, and retains variable amounts of non-commercial trees and understory vegetation. [hellip] All studies directly comparing bird assemblages in burned and harvested stands reported an important divergence in bird assemblages, especially for the first years following disturbance (Hutto 1995; Schulte and Niemi 1998; Hobson and Schieck 1999; Imbeau, Savard, and Gagnon 1999; Schieck and Hobson 2000; Morissette et al. 2002; Simon, Schwab, and Otto 2002). One of the most striking differences lies in the abundance of the snag-associated guild in post-fire stands. [hellip] [H]igh snag densities are clearly missing in harvested stands (Schulte and Niemi 1998; Pedlar et al. 2002; Simon, Schwab, and Otto 2002). Concordantly, Imbeau, Savard, and Gagnon (1999) found no resident and cavity-nesting species in recent clearcuts, where little retention (green or dead trees) has been left on site. Similarly, Hobson and Schieck (1999) found very distinct assemblages between burned and harvested forests, a difference that was partly explained by the dominance of several snag-associated species. These major differences in the abundance of snag-associated species are of particular importance considering that several of these have been identified as the most sensitive to the long-term effects of forestry (Imbeau, M[ouml]nkk[ouml]nen, and Desrochers 2001). [hellip] The magnitude of the initial divergence and eventual convergence in bird communities between fire and harvesting may greatly depend on the level of residual vegetation (Schieck and Hobson 2000). Schieck and Hobson (2000) found that bird assemblages from larger patches within disturbed stands supported more species from older forests than smaller ones. In contrast, bird communities from smaller patches (within cut blocks vs. burned stands) mainly reflected the surrounding post-disturbance communities, therefore showing the same initial divergence in bird assemblages between post-fire and post-harvest stands reported by Hobson and Schieck (1999). Nonetheless, over time these small patch communities also became more similar to those inhabiting mature fire origin forests and hence converged as succession proceeded (although some differences still persisted up to 60 years after disturbance). [hellip] Early after disturbance, most stand-level attributes differ between harvesting and wildfire. Structurally, young post-fire stands are characterized by more snags and less downed woody debris than young post-harvest stands. [hellip] Biodiversity elements significantly differ between burned and logged sites. Early after disturbance, significant differences in understory vascular and non-vascular community composition are commonly reported. Faunal assemblages, be they mammals, invertebrates, or birds, all seem to respond differently initially to harvesting- and wildfire-induced disturbances. [hellip] At the stand scale, while most forest attributes are different early after disturbance between burned and logged stands, the majority of these converge a few decades after fire. A few exceptions are to be noted, though. [hellip] [W]hile faunal communities do become less different as time passes, late in succession some species present in burned stands are either significantly less abundant or absent in similarly aged logged stands. [hellip] Post-fire salvage logging affects ecological processes, biological legacies, and the abundance of species commonly encountered only after fire. Removal of fire-killed trees can affect tree regeneration, understory composition, the abundance and distribution of dead wood, wildlife habitat, and soil properties. [hellip] At the landscape scale, the most important difference between fire and harvesting regimes is the distribution of stand age classes. The proportion of stands older than the rotation period (usually 100 yrs) tends toward zero under a fully regulated harvesting regime, while it is around 37% under a fire regime of similar rotation period. This results in a significant loss of over-mature forests in managed landscapes, potentially affecting organisms that are often associated with such stands.

NCASI. 2006. Similarities and differences between harvesting- and wildfire-induced disturbances in fire-mediated Canadian landscapes. Technical Bulletin No. 924. Research Triangle Park, N.C.: National Council for Air and Stream Improvement, Inc. http://landscape.zoology.wisc.edu/People/Simard/NCASI924.pdf

Many bird species benefit from fire that leaves a rich mix of plants and complex structure of snags and dead wood, but regen harvest removes the complex structure and truncates the early seral vegetation by planting conifers. The quality of habitat that results after fire often depends on the successional stage of the forest pre-disturbance, because much of this structure is carried over after the fire into the future forest. Logging removes most of the trees and with it the structural legacies that bind the past and future forests. Dick Hutto said:

In a new paper, we show that fire effects cannot be accurately assessed through a simple comparison of recently burned and unburned forest plots. This is because the same species that show negative responses through simplistic comparisons of burned and unburned forests reveal strong POSITIVE responses to more restricted combinations of successional stage and fire severity. With 10 years of post-fire data, we show that the majority of bird species (60%) benefit from fire (as evidenced by greater abundances in burned forest patches belonging to a particular successional stage/fire severity combination than in forest patches that have been long unburned). With data from even longer times-since-fire (say, 15, 20, or 30 years after fire), the percentage of species that clearly benefit from fire is probably closer to 80%!

Describing Richard L. Hutto, and David A. Patterson 2016. Positive effects of fire on birds may appear only under narrow combinations of fire severity and time-since-fire. International Journal of Wildland Fire. http://dx.doi.org/10.1071/WF15228

Regen harvest (and associated roads) on slopes above streams also increases landslide risk and modifies the composition of future landslides to increase adverse sediment and decrease beneficial wood recruitment.

NATURAL landslides are important sources of wood and sediment for salmon

1. Provide 60% of wood source in coastal systems

2. Provide diverse stream structures

[hellip]

2. Landslides from roads and management are DIFFERENT than natural slides in that those road-related types contribute excessive sediment and relatively low amounts of essential large wood to streams

3. Need to manage for quality, NATURAL landslides

Gordie Reeves 2017. Climate Modeling Results. Elk River Watershed Restoration Planning Project Public Presentation Notes. Port Orford, February 02, 2017 http://a123.g.akamai.net/7/123/11558/abc123/forestservic.download.akamai.com/11558/www/nepa/105036_FSPLT3_3949335.pdf.

Regeneration and Heavy Thinning Increase Fire Hazard.

Fire hazard is a primary concern of the public and political leaders and our forests need to be managed with that in mind. Silvicultural Plans must account for the fact that timber harvest often increases fire hazard, in particular regen harvest and heavy thinning.

Zald & Dunn (2018) conducted a careful study of the effects of forest management on fire severity in SW Oregon and found that plantation forestry tends to increase fire severity under a wide range of weather conditions.

ABSTRACT: [hellip] In 2013, the Douglas Complex burned over 19,000 ha of Oregon & California Railroad (O&C) lands in Southwestern Oregon, USA. O&C lands are composed of a checkerboard of private industrial and federal forestland (Bureau of Land Management, BLM) with contrasting management objectives, providing a unique experimental landscape to understand how different management practices influence wildfire severity. Leveraging Landsat based estimates of fire severity (Relative differenced Normalized Burn Ratio, RdNBR) and geospatial data on fire progression, weather, topography, pre-fire forest conditions, and land ownership, we asked (1) what is the relative importance of different variables driving fire severity, and (2) is intensive plantation forestry associated with higher fire severity? Using Random Forest ensemble machine learning, we found daily fire weather was the most important predictor of fire severity, followed by stand age and ownership, followed by topographic features. Estimates of pre-fire forest biomass were not an important predictor of fire severity. Adjusting for all other predictor variables in a general least squares model incorporating spatial autocorrelation, mean predicted RdNBR was higher on private industrial forests (RdNBR 521.85 [plusmn] 18.67 [mean [plusmn] SE]) vs. BLM forests (398.87 [plusmn] 18.23) with a much greater proportion of older forests. Our findings suggest intensive plantation forestry characterized by young forests and spatially homogenized fuels, rather than pre-fire biomass, were significant drivers of wildfire severity. This has implications for perceptions of wildfire risk, shared fire management responsibilities, and developing fire resilience for multiple objectives in multi-owner landscapes.

[hellip]

SEE LETTER SUBMISSION: Table 2 RdNBR, Figure 3

[hellip]

RESULTS

[hellip] RdNBR was consistently higher in young forests on both ownerships. RdNBR declined rapidly on BLM forests between stand ages of 20 and 80 yr old, and remained roughly level in older forests. In contrast, RdNBR in private forests declined linearly with age across its range, although private lands had few forests greater than 100 yr old. [hellip]

DISCUSSION

[hellip] After accounting for fire weather, topography, stand age, and pre-fire biomass, intensively managed private industrial forests burned at higher severity than older federal forests managed by the BLM. Below we [hellip] argue that younger forests with spatially homogenized continuous fuel arrangements, rather than absolute biomass, was a significant driver of wildfire severity [hellip]

Fire weather was a strong top-down driver of fire severity, while bottom-up drivers such as topography and pre-fire biomass were less important. [hellip] [B]ottom-up drivers of fire severity can be overwhelmed by top-down climatic and weather conditions when fires burn during extreme weather conditions [hellip] Fire severity was consistently higher on private lands across a range of fire weather conditions for the majority of days of active fire spread (Appendix S1: Fig. S3), leading us to conclude that while fire weather exerted top-down control on fire severity, local forest conditions that differed between ownerships remained important, even during extreme fire weather conditions. [hellip]

Variation in pre-fire forest conditions across ownerships were clearly a significant driver of fire severity, and we believe they operated at multiple spatial scales. Private industrial forests were dominated by young trees, which have thinner bark and lower crown heights, both factors known to increase fire-induced tree mortality (Ryan and Reinhardt 1988, Dunn and Bailey 2016). At the stand scale, these plantations are high-density single cohorts often on harvest rotations between 30 and 50 yr, resulting in dense and relatively spatially homogenous fuel structure. In contrast, public forests were dominated by older forests that tend to have greater variability in both tree size and spatial pattern vs. plantations (Naficy et al. 2010), arising from variable natural regeneration (Donato et al. 2011), post-disturbance biological legacies (Seidl et al. 2014), and developmental processes in later stages of stand development (Franklin et al. 2002). Fine-scale spatial patterns of fuels can significantly alter fire behavior, and the effects of spatial patterns on fire behavior may increase with the spatial scale of heterogeneity [hellip]

Management-driven changes in fuel spatial patterns at tree and stand scales could also reconcile differences in prior studies that have found increases (Odion et al. 2004, Thompson et al. 2007) and decreases (Prichard and Kennedy 2014) in fire severity with intensive forest management. [hellip] [F]orests [that] have lower productivity compared to those studied in the Klamath ecoregion, with more open canopies and longer time periods to reach canopy closure after harvest, [ ] likely results in more heterogeneous within stand fuel spatial patterns.

LIMITATIONS

[hellip] we relied on pre-fire biomass and stand age as proxies for fuel, in part because Landsat and other passive optical sensors have limited sensitivity to vertical and below-canopy vegetation structure (Lu 2006). Accurate and spatially complete quantitative information of forest surface and canopy fuels were not available for the Douglas Complex. More broadly, there are significant limitations to spatial predictions of forest structure and fuels using GNN and other methods that rely on passive optical imagery such as Landsat (Keane et al. 2001, Pierce et al. 2009, Zald et al. 2014), which is why we relied on the more accurately predicted age and pre-fire biomass variables as proxies. Surface and ladder fuels are the most important contributors to fire behavior in general (Agee and Skinner 2005), and surface fuels have been found to be positively correlated to fire severity in plantations within the geographic vicinity of the Douglas Complex (Weatherspoon and Skinner 1995). [hellip]

MANAGEMENT IMPLICATIONS

[hellip] [W]e believe our results have implications across a much broader geographic area. First, it brings into question the conventional view that fire exclusion in older forests is the dominant driver of fire severity across landscapes. [hellip] [I]n the landscape we studied, intensive plantation forestry appears to have a greater impact on fire severity than decades of fire exclusion. Second, higher fire severity in plantations potentially flips the perceived risk and hazard in multi-owner landscapes, because higher severity fire on intensively managed private lands implies they are the greater source of risk than older forests on federal lands. These older forests likely now experience higher fire severity than historically due to decades of fire exclusion, yet in comparison to intensively managed plantations, the effects of decades of fire exclusion in older forests appear to be less important than increased severity in young intensively managed plantations on private industrial lands.

Furthermore, our findings suggest challenges and opportunities for managing intensive plantations in ways that reduce potential fire severity. Increasing the age (and therefore size) of trees and promoting spatial heterogeneity of stands and fuels is a likely means to reducing fire severity [hellip] [However] there may be strong economic limitations to increased rotation ages and non-commercial thinning in young intensive plantation forests. [hellip] [T]he economic viability of such alternative management regimes remains poorly understood. Optimization models integrating spatial allocation of fuel treatments and fire behavior with economic models of forest harvest and operations could be used to determine if alternative management activities in plantations are economically viable. If alternative management activities are not economically viable, but wildfire risk reduction is an important objective on lands adjacent to industrial forestlands, strategic land purchases or transfers between ownership types may be required to achieve landscape level goals.

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-wildfireseverityyoung-plantation.html

Another recent study also found that mature forests are more resilient to high-severity fire.

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.

Lesmeister et al (2021)--

We examined the relationship between fire severity and suitable nesting forest in 472 large wildfires (> 200 ha) that occurred in the northern spotted owl range during 1987-2017. [hellip] Averaged over all fires, the interior nesting forest burned at lower severity than edge or non-nesting forest. These relationships were consistent within the low severity, very frequent, and mixed severity, frequent fire regime areas. [hellip] Over the 30-year study, we found a strong positive trend in the proportion of wildfires that burned at high severity in the non-nesting forests, but not in the suitable nesting forest types. Conclusions: Under most wildfire conditions, the microclimate of interior patches of suitable nesting forests likely mitigated fire severity and thus functioned as fire refugia (i.e., burning at lower severity than the surrounding landscape). With changing climate, the future of interior forest as fire refugia is unknown, but trends suggest older forests can dampen the effect of increased wildfire activity and be an important component of landscapes with fire resiliency.

Lesmeister, D.B., Davis, R.J., Sovern, S.G. et al. Northern spotted owl nesting forests as fire refugia: a 30-year synthesis of large wildfires. fire ecol 17, 32 (2021). https://doi.org/10.1186/s42408-021-00118-z; https://fireecology.springeropen.com/counter/pdf/10.1186/s42408-021-00118-z.pdf.

NRDC (2023) provide a nice science summary of the fire resistance and resilience of mature and old-growth forests. https://www.climate-forests.org/post/mature-trees-are-fire-resistant ("Tree resistance to wildfire increases over many decades. Key adaptations include increasing bark thickness, shedding lower branches, increasing height, and developing more open crowns. Together, adaptations like these make it difficult for fire to ignite tree boles or climb into flammable canopies, in larger, older trees, particularly in fire-adapted forest types. When ignited, fires tend to spread more slowly though the patchy and heterogeneous fuels of mature forests compared to the continuous and homogeneous fuels typically found in young tree farms. [hellip] At the stand level, mature and old-growth forests often function as fire-resilient refugia. Stands dominated by older trees tend to have increased shade and humidity, cooler temperatures, and reduced wind speeds that retain moisture and enhance stand-level fire resistance. Due to higher levels of moisture associated with older forests, they require much more fire energy and exposure to ignite and typically, there is proportionately less biomass available to burn. This trend has been observed repeatedly in U.S. forests, especially in the Pacific Northwest. As a result of these and other adaptations, older trees and the stands dominated by them generally have a relatively small effect on overall fire behavior across landscapes. Older trees can contribute to burn duration, burning for longer periods if they ignite. However, mature trees rarely contribute significantly to the rate of fire spread. Mature trees, as a group, are more resistant to fire than their younger counterparts. And weather[mdash]not older trees[mdash]often plays a determinative role in fire intensity [hellip]").

Stone et al (2008) reviewed the conditions before and after the 2003 Cooney Ridge fire in Montana and found that ...

Much more private land burned severely compared to public land [See Figures 3 and 4 below]. Heavily logged areas and tree plantations have been known to burn more extensively than intact forests (Brown 2002). Much of the private land within the fire perimeter had been recently heavily logged for timber extraction, not for the purpose of fire hazard reduction. ... Private lands in this area were recently harvested with large clear cuts.... A much lower proportion of the public land had been recently harvested.

SEE LETTER SUBMISSION: Figure 3 Burned Area Remote Classification Map, Figure 4 Proportional Area % burned in the Cooney Ridge Fire by ownership

More research is needed to understand the relationship between ownership practices and severity. At the Cooney Ridge fire, patches of unburned vegetation and low severity remained after the fire, while much more of the private land burned uniformly with high severity. These results indicate that more diversified public lands management helped produce a much more diverse fire mosaic, thus better protecting this forested landscape. By comparison most private forested land burned with moderate to high severity, under likely similar weather conditions as on the public land. Our results show that, perhaps counter intuitively, heavy harvest can increase subsequent fire severity.

Carter Stone, Andrew Hudak, Panelope Morgan 2008. Forest Harvest Can Increase Subsequent Forest Fire Severity. PSW-GTR-208, pp 525-534. https://www.fs.fed.us/psw/publications/documents/psw_gtr208en/psw_gtr208en_525-534_stone.pdf, In Gonz[aacute]lez-Cab[aacute]n, Armando, tech. coord. 2008. Proceedings of the second international symposium on fire economics, planning, and policy: a global view. Gen. Tech. Rep. PSW-GTR-208, Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. 720 p. https://www.fs.fed.us/psw/publications/documents/psw_gtr208en/

"Large blocks of old-growth forests - rather than large contiguous blocks of young growth or highly simplified forests - are the best scenario for reducing catastrophic wildfire." Jerry Franklin, David Perry, Reed Noss, David Montgomery, Christopher Frissell. Simplified Forest Management To Achieve Watershed And Forest Health: A Critique. National Wildlife Federation. https://web.archive.org/web/20061008082841/http://www.coastrange.org/documents/forestreport.pdf.

BLM admits that "regeneration harvest [hellip] would result in a young stand and a high density young stand structural stage that would the shift the relative stand-level fire hazard from moderate to high for up to 50 years [hellip]" Butte Falls Resource Area, Medford BLM 2024. South Clark timber sale EA, p 89. https://eplanning.blm.gov/eplanning-ui/project/2021843/570

"[F]orest managers can and do reduce fire risk in young plantations by piling and burning the debris left after clearcutting, but the plantations become very susceptible to fire as they fill in. Fuel reduction is not warranted in old-growth forests whose large trees and shaded microclimates make them resistant to fire. Millions of acres of old-growth were clearcut in the 20th century and replaced with plantations. More plantations mean higher fire risk [hellip]" Tom Spies, emeritus scientist with the USDA Forest Service's Pacific Northwest Research Station. Look to wildfires history to better prepare for next one. Sept 20, 2020 op-ed in The Oregonian. https://www.oregonlive.com/opinion/2020/09/opinion-look-to-wildfires-history-to-betterprepare-for-next-one.html.

Evers C, Holz A, Busby S, Nielsen-Pincus M. Extreme Winds Alter Influence of Fuels and Topography on Megafire Burn Severity in Seasonal Temperate Rainforests under Record Fuel Aridity. Fire. 2022; 5(2):41. https://doi.org/10.3390/fire5020041, https://www.mdpi.com/2571-6255/5/2/41/pdf. (Reviewing the 2020 Labor Day fires in the Western Cascades, the authors found " [hellip] both vegetation structure and topography significantly affect burn severity patterns even under extreme fuel aridity and winds. Early-seral forests primarily concentrated on private lands, burned more severely than their older and taller counterparts, over the entire megafire event regardless of topography. Meanwhile, mature stands burned severely only under extreme winds and especially on steeper slopes. [hellip] The most important factors explaining high burn severity across all five megafires combined (both burn periods) were canopy height, followed by weather period (i.e., winds), [hellip] Vegetation structure (especially canopy height) was the strongest predictor of high burn severity and was strongly related to two important thresholds. First, the likelihood of high burn severity increased markedly in stands shorter than 20 m and was particularly high below 10 m for P1 [severe fire weather] and especially P2 [moderate fire weather] (Figure 2B). The likelihood of short-stature vegetation (ca. 5 m) burning at high severity compared to 30 m in P1 was ca. 40% higher and 750% higher in P2. Second, open canopy vegetation, especially below 40% cover, was at substantially higher risk of burning at high severity during both periods, and particularly so for P2. [hellip] Canopy height and canopy cover had one of the most pronounced interactions both within and across periods, both of which had a notable and compounding effect on severity below specific thresholds (e.g., canopy heights < 10 m; canopy cover < 40%; Figure 3A). These compounding effects were pervasive and had an overriding effect on other variables. For instance, the effect of slope on severity in P1 was overwhelmed in stands lower than 10 m in canopy height (Figure 3C,G). [hellip] The probability of high-severity burn remained elevated for low-stature forests while mature stands were likely protected by thicker bark, shadier conditions [37], increased canopy-base height [79], and lower canopy bulk density [80,81]. Early successional vegetation (<40% canopy cover) burned more severely than closed-canopy forests. Streams and the moist, deep soils of the canyon bottom [20,82,83] lowered the likelihood of high severity fire during P2 [hellip] Inconsistent with hypothesis H1, forest structure (particularly canopy height) was the single most important predictor of high-burn severity during P1, [hellip] ")

The graphics below show that tall canopies (i.e., mature forest) significantly reduces the probability of high burn severity (vertical axis) in both extreme (red line) and moderate (blue line) fire weather conditions, but especially in moderate fire weather conditions. In addition, higher canopy cover also reduced the probability of high burn severity, especially during moderate fire weather. This finding directly contradicts the rationale often used to justify fuel reduction logging.

SEE LETTER SUBMISSION: Canopy height (m), Canopy cover (%)

Levine, Jacob I.; Collins, Brandon M.; Steel, Zachary L.; de Valpine, Perry; Stephens, Scott L. 2022. Higher incidence of high-severity fire in and near industrially managed forests. Frontiers in Ecology and the Environment online early. https://doi.org/10.1002/fee.2499 ("... [W]e assembled and analyzed a large dataset of 154 wildfires that burned a combined area of more than 971,000 ha in California. We found that where fires occurred, the odds of high-severity fire on "private industrial" lands were 1.8 times greater than on "public" lands"[hellip] [T]hese results indicate that prevailing forest management practices on private industrial timberland may increase high-severity fire occurrence, [hellip])

Steel, Z.L., Jones, G.M., Collins, B.M., Green, R., Koltunov, A., Purcell, K.L., Sawyer, S.C., Slaton, M.R., Stephens, S.L., Stine, P. and Thompson, C. (2022), Mega-disturbances cause rapid decline of mature conifer forest habitat in California. Ecological Applications. Accepted Author Manuscript e2763. https://www.fs.usda.gov/rm/pubs_journals/2022/rmrs_2022_steel_z001.pdf ("Areas with high initial canopy cover and without tall trees were most vulnerable to canopy cover declines [due to wildfire] [hellip] The effect of large tree height on relative canopy cover decline was negative [hellip] indicating the presence of large, tall trees had a moderating effect on disturbance. [hellip]")

S. G[oacute]mez-Gonz[aacute]lez, A. Miranda, J. Hoyos-Santillan, A. Lara, P. Moraga, J.G. Pausas, 2024. Afforestation and climate mitigation: lessons from Chile, Trends in Ecology & Evolution, Volume 39, Issue 1, 2024, Pages 5-8, ISSN 0169-5347, https://doi.org/10.1016/j.tree.2023.09.014. ("Afforestation as established in Chile increases the amount and continuity of fuel, which could lead to larger and more severe fires under warming conditions. [hellip] These mega-fires have multiple socioeconomic consequences, including the abrupt emission of large amounts of greenhouse gases.")

Thinning Prescriptions

We urge you to prescribe variable spacing for all thinning projects. The great benefits in terms ecosystem processes far outweigh any minor loss of future timber value. The 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. According to the 2003 Draft SEIS for survey and manage, "Matrix was also expected to provide for ecologically diverse early-successional conditions and planned timber harvest." (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.

A concern with evenly spaced thinnings is that the uniformly open canopy will encourage a homogenous understory dominated by a few species instead of a patchy and heterogeneous understory

Liane R. Davis, and Klaus J. Puettmann, Gabriel F. Tucker. 2007. Overstory Response to Alternative Thinning Treatments in Young Douglas-fir Forests of Western Oregon. Northwest Science 81(1). 2007.

Salvage Must be Considered Ecologically

Salvage logging is an outdated practice with long-term adverse consequences. Silvicultural prescriptions must account for these adverse effects and the Forest Service should consider all the reasons NOT to salvage trees after disturbance.

Consider and disclose reasons NOT to remove snags

Science tells us that natural forests develop after disturbance with abundant structural legacies. These legacy features include snags and down wood which play a wide variety of valuable ecological services for the developing forest, including but not limited to:

* nutrient uptake, storage, and release
* water uptake, storage, and release
* mycorrhizal colonization
* wildlife habitat, in particular for primary cavity species which are recognized as a "keystone" element of healthy forests
* allowing some forest species to linger in burned forests after disturbance and to recolonize burned forests sooner after disturbance, thereby shortening the period during which burned stands are unsuitable for wildlife
* providing food for insects that in turn feed a wide variety of other wildlife such as birds and bats
* favorable sites for seed germination and establishment
* mechanical thinning of the regenerating stand due to the process of snag fall
* shade and cover for everything from seedlings to big game
* perches, nest, and den structures.

In general, the larger the piece size, the longer they tend to last. But salvage logging removes those very elements that are most valuable for wildlife and most difficult to replace. An excellent description of the diverse ecosystem services provided by dead trees often removed by salvage logging is provided by 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.

Since this project involves post-fire commodity extraction (also often referred to erroneously as "salvage" logging) please carefully disclose and weigh the economic and environmental tradeoffs the associated with salvage logging. The Silvicultural Prescription (and the NEPA analysis) analysis must include a site-specific analysis of the many reasons NOT to do post-fire commodity extraction, including but not limited to:

* adverse impacts to soil, such as erosion, compaction, displacement, litter disturbance, nutrient depletion; loss of chemical buffering; loss of soil organic matter; loss of burrowing wildlife that help aerate soils; reduction of nitrogen fixing plants that boost soil fertility; loss of slope and snow stabilizing effects which could lead to mass wasting or eliminate mechanisms that may mitigate mass wasting;
* loss of down wood functions s such as trapping sediment and aiding water infiltration, and creating microsites favorable for germination and establishment of diverse plants, and habitat for diverse wildlife;

SEE LETTER SUBMISSION: With Lake McDonald 4,300 feet below, Byrd digs a hole to plant seedling among dead trees

https://www.yesmagazine.org/environment/2020/03/11/climate-change-montana-forest/

SEE LETTER SUBMISSION: Management implications

https://www.nrfirescience.org/event/wildfire-effects-microclimate-conditions-and-seedling-regeneration-northern-rockies-mixed

* loss of decaying wood and depletion of the "savings account for nutrients and organic matter" which affects site productivity through the removal of dead trees which store nutrients and slowly release them to the next stand. Mara[ntilde][oacute]n-Jim[eacute]nez, S., Fern[aacute]ndez-Ondo[ntilde]o, E., and J. Castro. 2013. Charred wood remaining after a wildfire as a reservoir of macro- and micronutrients in a Mediterranean pine forest. International Journal of Wildland Fire. http://dx.doi.org/10.1071/WF12030 ("Partially charred wood represented a considerable pool of nutrients, due to both the relatively high concentrations and to the great amount of biomass still present after the fire. Potential contributions of the charred wood were particularly relevant for N and micronutrients Na, Mn, Fe, Zn and Cu, as wood contained 2-9 times more nutrients than the soil. Postfire woody debris constitutes therefore a valuable natural element as a potential source of nutrients, which would be lost from ecosystems in cases where it is removed")
* Recent studies indicate that wood may release nutrients more rapidly than previously thought through a variety of decay mechanisms mediated by means other than microbial decomposers, i.e. fungal sporocarps, mycorrhizae and roots, leaching, fragmentation, and insects;
* Charred trees produce a pulse of charcoal delivered into long-term storage in the soil which offers numerous benefits related to nutrient retention, below-ground biological activity, and water holding capacity. "Post-fire salvage logging [hellip] can impact soil charcoal levels. Removing burned trees removes a lot of char that would otherwise fall to the ground and become incorporated into soil over time." Wilson, Kelpie 2015. Biochar for Forest Restoration in the Western United States - September 18, 2015 http://greenyourhead.typepad.com/files/biochar_for_forest_restoration_wba.pdf. See also Maestrini, B., E. C. Alvey, M. D. Hurteau, H. Safford, and J. R. Miesel (2017), Fire severity alters the distribution of pyrogenic carbon stocks across ecosystem pools in a Californian mixed-conifer forest, J. Geophys. Res. Biogeosci., 122, doi:10.1002/2017JG003832; Wei, X., Hayes, D. J., Fraver, S., & Chen, G. (2018). Global pyrogenic carbon production during recent decades has created the potential for a large, long-term sink of atmospheric CO2. Journal of Geophysical Research: Biogeosciences, 123. https://doi.org/10.1029/2018JG004490 ("PyC [pyrogenic carbon] production from fires may represent approximately 0.2-0.6% of annual global net primary production (Huston & Wolverton, 2009). Though this percentage is relatively small, we emphasize that PyC is more recalcitrant than original biomass (Bird et al., 2017), meaning that it accumulates in terrestrial and marine ecosystems. ... PyC from fires may be a significant sink of atmospheric CO2 when considered over longer time periods ... [F]ires represent a large carbon source to the atmosphere by releasing CO2 and other gaseous

carbon compounds; however, they also create PyC in the form of charred material that remains on site or small particles that are transported far from the site of origin (Bird et al., 2015; Cotrufo et al., 2016). Because PyC is more recalcitrant to decay than original biomass, the accumulated PyC may serve as a potentially growing, stable carbon sink that is distributed globally.");
* loss of nutrients from live trees that are determined to be "dying." Surviving trees produce serve as refugia for animals, facilitate tree regeneration, invertebrates, and mycorrhizae; produce litter fall; and help cycle nutrients which are all extremely valuable in the post-fire landscape;
* loss of wood that serves to buffer soil chemistry and prevent extreme changes in soil chemistry;
* water quality degradation;
* loss of water storage capacity in down logs;
* altered timing of storm run-off which could lead to peak flows that erode stream banks and scour fish eggs;
* delaying the pace of vegetative recovery and reducing the quality/diversity of the vegetation community;
* dead trees serve as a natural fence that protects young seedlings from browse by cattle and big game. This is one way that young aspen and other valuable species can get their start;
* spread of invasive weeds through soil disturbance and extensive use of transportation systems;
* loss of legacy structures that can carry species, functions, and processes over from one stand to the next;
* loss of terrestrial and aquatic habitat (mostly snags and down logs) potentially harming at least 93 forest species (63 birds, 26 mammals, and 4 amphibians) that use snags for nesting, roosting, preening, foraging, perching, courtship, drumming, and hibernating, plus many more species that use down logs for foraging sites, hiding and thermal cover, denning, nesting, travel corridors, and vantage points for predator avoidance;
* Depletion of large wood structures in streams that can cause: 1) simplification of channel morphology, 2) increased bank erosion, 3) increased sediment export, 4) decreased nutrient retention, 5) loss of habitats associated with diversity in cover, hydrologic patterns, and sediment retention;
* commercial salvage usually removes the largest trees, but this will disproportionately harm wildlife because: (1) larger snags persist longer and therefore provide their valuable ecosystem services longer and then serve longer as down wood too, and (2) most snag-using wildlife species are associated with snags >14.2 inches diameter at breast height (dbh), and about a third of these species use snags >29.1 inches dbh.
* Truncation of symbiotic species relations and loss of biodiversity. Sixteen species are primary cavity excavators and 35 are secondary cavity users; 8 are primary burrow excavators and 11 are secondary burrow users; 5 are primary terrestrial runway excavators and 6 are secondary runway users. Nine snag-associated species create nesting or denning structures and 8 use created structures.
* Reduced avian and terrestrial species diversity which affects plant and invertebrate diversity. Since different wildlife help disperse different sets of seeds and invertebrates, reduced wildlife diversity can significantly affect pace of recovery and the diversity of the regenerating stand. Snag- associated wildlife play a greater role in dispersal of invertebrates and plants, while down wood-associated wildlife play a greater role in dispersal of fungi and lichens. Down wood-associated species might contribute more to improving soil structure and aeration through digging, and to fragmenting wood which increases surface area encouraging biological action that releases nutrients.
* loss of partial shade that helps protect the next generation of forest;
* loss of cover quality and fawning areas for big game;
* loss of future disturbance processes such as falling snags that help thin and diversify the next generation of forest;1

1 JAMES [EC2] A. LUTZ AND CHARLES B. HALPERN. 2006. TREE MORTALITY DURING EARLY FOREST DEVELOPMENT: A LONG-TERM STUDY OF RATES, CAUSES, AND CONSEQUENCES. Ecological Monographs, 76(2), 2006, pp. 257-275. This study showed that mortality from mechanical damage ("crushing disturbance") from falling limbs and trees and snow loads can be a more significant factor than suppression mortality. See also, Brown, Martin J.; Kertis, Jane; Huff, Mark H. 2013. Natural tree regeneration and coarse woody debris dynamics after a forest fire in the western Cascade Range. Res. Pap. PNW-RP-592. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 50 p. "Snag fall and fragmentation added so much wood to the ground[mdash]thousands of meters of log length per

hectare[mdash]that it probably constitutes a significant ecological disturbance in itself, a kind of rain of logs.")

* increased human activity and human access that can increase fire risk;
* increased fine fuels on the forest floor that can cause an increase in fire hazard;
* loss of seed sources, and
* loss of diversity of vegetation and microsite conditions.
* The fact that regional standards for snags and down wood fail to incorporate the most recent science indicating that more snags and down wood (especially large snags and logs) are required in order to maintain species viability and sustain site productivity.
* Arguments in support of the "reburn hypothesis" are specious. (1) partial reburn may be completely natural and desirable in some cases to consume some fuel and diversify the regenerating forest, and (2) salvage logging will cause a pulse of fine fuels on the ground and actually increase the reburn risk/hazard above natural levels, and (3) fuels that fall to the ground over time will to some extent decay as they fall.
* Uncertainty calls for a cautious approach.

Compare these adverse impacts of salvage logging to the few scant reasons to salvage (e.g., economic recovery of fiber).

Prevention of reburn must not be used as a justification for post-fire logging, without carefully documenting the rationale and providing references to published scientific studies (not just hypotheses and speculation and anecdotes). Also, the Forest Service must explain whether logging will increase or decrease the risk of reburn in terms of fuels profiles over various time horizons, ignition sources, etc. Salvage logging increases fine and mid-size fuels in the short-term by leaving treetops, branches, and needles on site. Fine and mid-size surface fuels also occur in unsalvaged areas, but accumulate gradually over time. It is unlikely that fuels in an unsalvaged area would reach the same magnitude as in the post-salvage scenario because decomposition breaks down new material accumulates. As noted by scientists interviewed by the Oregonian, "There would be less risk by leaving dead trees standing where they gradually would decay while keeping their tinder above the reach of flames." Michael Milstein. "Scorched forests best left alone, study finds." The Oregonian, Jan 6, 2006.

Please consider at least one non-commercial, restoration-only alternative that invests in restoration and recovery of the fire area by, for instance, eliminating livestock grazing, emphasizing native species recovery, not building any new roads, stabilizing soils disturbed by the fire suppression effort, decommissioning unneeded roads.

Also, consider an alternative modeled on the recommendations of the Beschta report. Specifically:

* prohibit post-fire logging AND roadbuilding on all sensitive sites, including: severely burned areas (areas with litter destruction), on erosive soils, on fragile soils, in roadless/unroaded areas, in riparian areas, on steep slopes, and any site where accelerated erosion is possible. We would add: Late-Successional and Riparian Reserves, and protective land allocations or designations including Botanical and Scenic River Areas;
* protect all live trees;
* protect all old snags over 150 years old;
* protect all large snags over 20 inches dbh;
* protect at least 50% of each size class of dead trees less than 20 inches dbh.

See Beschta RL, Frissell CA, Gresswell R, Hauer R, Karr JR, Minshall GW, Perry DA, and Rhodes JJ. 1995. Wildfire and Salvage Logging: recommendations for ecologically sound postfire salvage logging and other post-fire treatments on Federal lands in the West. Corvallis, OR: Oregon State University. Available at: http://www.fireecology.org/science/Beschta_Report.pdf.

Salvage is not Restoration.

Salvage is a Tax on Ecosystem Structure/Function/ Process.

Salvage should be considered silviculturally appropriate only after the significant adverse effects have been considered.

An article from respected scientists in one of the world's leading science journals said: [hellip] [N]atural disturbances are key ecosystem processes rather than ecological disasters that require human repair. Recent ecological paradigms emphasize the dynamic, nonequilibrial nature of ecological systems in which disturbance is a normal feature and how natural disturbance regimes and the maintenance of biodiversity and productivity are interrelated [hellip] Salvage harvesting activities undermine many of the ecosystem benefits of major disturbances. [hellip] [R]emoval of large quantities of biological legacies can have negative impacts on many taxa. For example, salvage harvesting removes critical habitat for species, such as cavity-nesting mammals, [and] woodpeckers, [hellip] Large-scale salvage harvesting is often begun soon after a wildfire, when resource managers make decisions rapidly, with longlasting ecological consequences[hellip].

Lindenmayer, Franklin, Hunter, Noss, et al., 2005. ECOLOGY: Salvage Harvesting Policies After Natural Disturbance, Science 2004 303: 1303.
http://www.eebweb.arizona.edu/courses/ecol406r_506r/lindenmayer&noss-2005-effectslogging4.pdf

[hellip] retaining canopy cover, even from standing snags, moderates microclimate conditions. Management actions that remove standing dead trees could further increase microclimate extremes, with the potential to impact seedling survival and regeneration.

Northern Rockies Fire Science Network 2022. WILDFIRE EFFECTS ON MICROCLIMATE CONDITIONS AND TREE REGENERATION IN MIXED CONIFER FORESTS. Research Brief 15 | September 2022. https://www.nrfirescience.org/sites/default/files/2022-12/NRFSN_ResearchBrief15_Microclimate_and_Seedling_Regeneration_Final_0.pdf citing Wolf, K. D., P. E. Higuera, K. T. Davis, and S. Z. Dobrowski. 2021. Wildfire impacts on forest microclimate vary with biophysical context. Ecosphere 12(5):e03467. 10.1002/ecs2.3467. https://esajournals.onlinelibrary.wiley.com/doi/pdfdirect/10.1002/ecs2.3467. (".. our results suggest that retention of standing dead trees and postfire vegetation recovery would attenuate the impacts of fire on microclimate [hellip]").

In a January 3, 2014 letter to the Forest Service following the Rim Fire, several scientists said:

We are also concerned that your proposal under-estimates the cumulative impacts of postfire logging and its potential effects on ecological integrity and forest health. In particular, the proposal seems to violate the National Forest System Land Management Planning Rule of 2012 (36 CFR Part 219) that directs the Forest Service to maintain the ecological integrity of a planning area as it relates to "the completeness of wholeness of an ecosystems composition, structure, function, and connectivity." Postfire logging is inconsistent with the intent of the planning rule as it would greatly diminish ecological integrity of important postfire wildlife habitat while removing habitat for at-risk species, as noted.

[hellip]

Current studies also have concluded that complex early seral habitat, created by higher-severity fire, has declined substantially since the era of fire suppression . Yet there are no forest plan provisions to protect this habitat. Thus, in closing, there is a consensus of scientific opinion that post-fire logging and artificial conifer plantation establishment is one of the most ecologically damaging activities that could occur after mixed-severity fire.

DellaSala, Hanson, Bond, Hutto, Halsey. 1-3-2014 letter to the USFS regarding Rim Fire salvage. http://www.californiachaparral.org/images/rimfirescientistsignonletter12_13_2013.pdf

In September 2015, over 260 scientists sent a joint letter to Congress and the President highlighting the ecological value of post-fire landscapes, the significant adverse effects of salvage logging, and opposing bills that would encourage post-fire logging.

[hellip] numerous scientific studies tell us that even in the patches where forest fires burn most intensely, the resulting wildlife habitats are among the most ecologically diverse on western forestlands and are essential to support the full richness of forest biodiversity.

Post-fire conditions also serve as a refuge for rare and imperiled wildlife species that depend upon the unique habitat features created by intense fire. These include an abundance of standing dead trees, or "snags," which provide nesting and foraging habitat for woodpeckers and many other plant and wildlife species responsible for the rejuvenation of a forest after fire.

The post-fire environment is rich in patches of native flowering shrubs that replenish soil nitrogen and attract a diverse bounty of beneficial insects that aid in pollination after fire. [hellip]

This post-fire renewal, known as "complex early seral forest," or "snag forest," is quite simply some of the best wildlife habitat in forests, and is an essential stage of natural processes that eventually become old-growth forests over time. This unique habitat is not mimicked by clearcutting, as the legislation incorrectly suggests. Moreover, it is the least protected of all forest habitat types, and is often as rare, or rarer, than old-growth forest, [hellip]

After a fire, the new forest is particularly vulnerable to logging disturbances that can set back the forest renewal process for decades. Post-fire logging has been shown to eliminate habitat for many bird species that depend on snags, compact soils, remove biological legacies (snags and downed logs) that are essential in supporting new forest growth, and spread invasive species that outcompete native vegetation and, in some cases, increase the flammability of the new forest.

While it is often claimed that such logging is needed to restore conifer growth and lower fuel hazards after a fire, many studies have shown that logging tractors often kill most conifer seedlings and other important re-establishing vegetation and actually increases flammable logging slash left on site. Increased chronic sedimentation to streams due to the extensive road network and runoff from logging on steep slopes degrades aquatic organisms and water quality.

We urge you to consider what the science is telling us: that post-fire habitats created by fire, including patches of severe fire, are ecological treasures rather than ecological catastrophes, and that post-fire logging does far more harm than good to public forests.

DellaSala, Hanson et al (2015) Open Letter to U.S. Senators and President Obama from Scientists Concerned about Post-fire Logging and Clearcutting on National Forests. http://www.geosinstitute.org/images/stories/pdfs/Publications/Fire/SciLetterOpposingPostfireLoggingBillsSept2015.pdf; https://web.archive.org/web/20151015005302/http://www.geosinstitute.org/press-room-sp/press-releases/1228-260-scientists-oppose-post-fire-logging-bills.html.

The ICBEMP analysis showed that traditional salvage logging that removes large trees is not compatible with ecosystem management.

Can salvage timber sales be compatible with ecosystem-based management?

[hellip] Our findings suggest that this type of harvesting is not compatible with contemporary ecosystem-based management. Ecosystem-based management would emphasize removing smaller green trees with greater attention to prevention of mortality rather than removal of large dead trees.

Quigley, Thomas M., tech. ed. 1996; The Interior Columbia Basin Ecosystem Management Project: Scientific Assessment.) Gen. Tech. Rep. PNW-GTR-382, https://www.fs.usda.gov/pnw/pubs/pnw_gtr382.pdf; Page 178.

Salvage logging and replanting will convert a structurally complex landscape into a simplified and biologically depraved landscape. Unsalvaged, naturally regenerated, young stands are one of the rarest forest types in the Pacific northwest, and their biodiversity rivals that of old-growth forests.

Indeed, naturally developed early-successional forest habitats, with their rich array of snags and logs and nonarborescent vegetation, are probably the scarcest habitat in the current regional [Pacific Northwest] landscape.

Lindenmayer, David B. and Jerry F. Franklin. 2002. Conserving Forest Biodiversity: A Comprehensive Multiscale Approach. Island Press. Washington, DC: 69. See also, DellaSala, D.A., J.E. Williams, C. Deacon-Williams, and J.F. Franklin. 2004. Beyond smoke and mirrors: a synthesis of fire policy and science. Conservation Biology, Pages 976-986. Volume 18, No. 4, August 2004.
http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/17521/Beyond%20smoke%20and%20mirrors.pdf

A post-fire study in the Klamath Region looked at forests 20 years after wildfire, salvage logging, replanting found --

* Management had no impact on Douglas-fir regeneration, the main species of concern in the region.
* Managed sites had more homogeneous stand structure with fewer snags than unmanaged sites.
* Aspect overwhelmed management's ability to influence composition and conifer regeneration.

Maria J. Lopez Ortiz, Terry Marcey, Melissa S. Lucash, David Hibbs, Jeffrey P.A. Shatford, Jonathan R. Thompson. 2019. Post-fire management affects species composition but not Douglas-fir regeneration in the Klamath Mountains. Forest Ecology and Management. Volume 432, 15 January 2019, Pages 1030-1040. https://doi.org/10.1016/j.foreco.2018.10.030

"There has been a loss of diverse young forests on all ownerships. [hellip] Conservation of diverse young forests has received little attention in forest policy."

Janet Ohmann; Science Findings, Issue 56; Seeing the trees for the forest: mapping vegetation biodiversity in coastal Oregon forests; (September 2003). http://www.fs.fed.us/pnw/sciencef/scifi56.pdf.

The agency should carefully review the post-fire science summary prepared by the World Wildlife Fund in 2006.

In general traditional forestry has viewed fire as bad and dead trees as a waste. These views have skewed public policies about post-fire logging. However, current scientific understanding recognizes that disturbance and dead trees are in fact critical to forest health. Of the approximately thirty scientific papers on post-fire logging and additional government reports published to date, not a single one indicates that logging provides benefits to ecosystems regenerating post-disturbance. In general, post-fire logging impedes regeneration when it compacts soils, removes "biological legacies" (e.g., large dead standing and downed trees), introduces or spreads invasive species, causes soil erosion when logs are dragged across steep slopes, and delivers sediment to streams from logging roads. Further, a large body of science on disturbance ecology (e.g., recent books on Mt. St Helens and studies in the Yellowstone Ecosystem and elsewhere) indicate that when natural disturbance events are preceded and/or followed by land management activities they often impair the recovery of forest ecosystems.

Dominick A. DellaSala 2006. POST-FIRE LOGGING SUMMARY OF KEY STUDIES AND FINDINGS. World Wildlife Fund, February 2006. https://forestlegacies.org/wp-content/uploads/2010/08/PostfireSummaryOfKeyFindings.pdf

The agency often cites Franklin and Agee. 2003 "Forging a Science-Based National Forest Fire Policy," Issues in Science and Technology Online. Fall 2003. http://web.archive.org/web/20071215154828/http://www.issues.org/issues/20.1/franklin.html to support "active management" after fire. This paper simply does not support aggressive salvage logging. In fact, it has very short discussion of post fire logging that includes the following:

Management of postburn areas, including timber salvage, needs to incorporate the concept of biological legacies. Salvaging dead and damaged trees from burns involves the ecology of a place, not simply economics and fuels. In addition to effects on postfire wildlife habitat, there are also effects of salvage logging on soils, sediments, water quality, and aquatic organisms. Significant scientific information exists on this topic as well as on biological legacies.

Biological legacies differ by orders of magnitude in natural forests, a fact that should guide restoration programs. Where stand-replacement fires are characteristic, such as with lodgepole pine and Pacific Coast Douglas fir forests, massive areas of standing dead and down trees are usual; salvage operations generally are not needed and do not contribute to ecological recovery, even though they do provide economic return. On the other hand, uncharacteristic stand-replacement fires in dry forests can produce uncharacteristic levels of postfire fuels, including standing dead and down trees. Removing portions of that particular biological legacy may be appropriate as part of an intelligent ecological restoration program, and not simply as salvage. (emphasis added)

The Franklin and Agee piece also makes clear that salvage logging must be considered in an ecological restoration framework and all adverse impacts of the logging must be considered. A truly ecological post-fire plan would involve:

* rehabilitating fire fighting impacts (e.g. minimize erosion and block OHV use, reestablish native plant communities),
* significant road closures to protect watershed values and avoid the knee-jerk removal of hazard trees,
* culvert removal or replacement to provide for passage of fish sediment and woody debris,
* a long-term plan for managing fuels in the future,
* plans to avoid as much as possible impacts from seeding (e.g. weeds and competition with native plant communities), planting (dense plantations), logging (e.g. loss of snag habitat, loss of cover, etc.)

At most this paper supports removal of a portion of the uncharacteristic fuels. The only fuels that would be "uncharacteristic" and the small trees that grew up as a result of fire suppression. If the tree was there before fire suppression, than it should remain after a stand replacing fire. Only small fuels should be removed. This intent is clear from Jerry Franklin's work on The Klamath Tribes' Forest Management Plan.

Specific principles to guide removal of trees, snags, and logs from burned sites are as follows:

[hellip]

2) Trees (live and dead) and down wood will be retained in sufficient quantities to provide for wildlife and ecological needs, including long-term structural enrichment of the site.

However, this goal does have to be evaluated in the context of whether the post-fire levels of snags and down wood are within the characteristic range for the plant association; i.e., where pre-burn stands had uncharacteristic stand densities for that plant association. General guidelines for retention of trees (live and dead) and down wood within the wildfire area are as follows: Retain amounts and distributions of trees as would be characteristic of the pre-burn (historical) landscape [hellip]

[hellip]

Large snags persist for the longest period, and are most difficult to replace. Consequently, snag and log retention will focus on the largest (21"+ DBH) pieces in the post-burn landscape.

[hellip]

The retention standards should be checked to make sure that they will provide amounts and distributions of snags and down wood that will meet requirements for species at risk, sensitive species, and other species of special interest to the Tribes (such as mule deer). If they will not meet the species requirements, adjust the retention standards accordingly. There is an important caveat: this may not be done if providing for a particular species requires maintaining uncharacteristic levels of post-fire fuels over a significant portion of the burned landscape.

As noted above, proposed levels of snag and down wood retention will be evaluated to determine that they will not result in fuel loadings that are above characteristic levels for the plant association. Where they do, the goal will be to adjust retention to characteristic levels. In such a case retention of the large snags and down wood will be the standard since these structures contribute less to fuels on a cubic foot basis, persist longer, and provide habitat for more species.

(emphasis added)

K. Norm Johnson, Jerry Franklin, Debora Johnson. The Klamath Tribes' Forest Management Plan. Dec 2003. http://web.archive.org/web/20040103034821/http://www.klamathtribes.org/forestplan.htm pp 108-109.

Hutto (2005) says:

"Personally, I've come to think we need to change our thinking on salvage logging. There are other values in the forest. In fact, a burned area is probably the most sensitive place you could be working in. The public really hasn't caught on to this yet. People still want to get the cut, get the trees they see as wasting away. They want the economic value. We talk about forest restoration after a fire, but it just got restored. That's what fire does. We know that, but we can't seem to get the message out. Until you start thinking like a black-backed woodpecker, you just ain't going to get it."

Richard L. Hutto, Ph.D., Director of the Avian Science Center and Professor of Ornithology and Ecology at the University of Montana, from Birds in the black: Through following avian wildlife, a UM scientist has discovered that burned forests play a critical role in the health and diversity of the Western landscape By MICHAEL JAMISON of the Missoulian August 11, 2005.

Hutto and others have been surveying birds in the Black Mountain fire area and nearly 20 other 2003 fire sites from Glacier National Park down to the Bitterroot, some of which have been salvage-logged. Nearly all woodpeckers have proven absent from salvaged areas, Hutto says, and all other bird species are less abundant in those spots than in areas left unlogged following fires.

"I can't think of any other land-use practice where it's uniformly negative, at least in terms of birds," Hutto says. "That's why I end up thinking that a burned place should be lower on our priority list for logging[mdash]because it's so sensitive."

Hutto's research is some of the first post-fire work that's been done in areas broader than one forest or one salvage-logging job, which may help it yield insightful facts for policymakers as they struggle to find a balance for post-fire salvage logging nationwide.

Jessie McQuillan. 2006. Still life, with woodpeckers. Missoula Independent. 6/22/2006. http://missoulanews.bigskypress.com/missoula/still-life-with-woodpeckers/Content?oid=1137343

"More than 10 years ago, and again two years ago, I joined eight other scientists to explore whether forests might be restored by logging soon after a fire. We had among us a wealth of knowledge across a wide range of fields. We pored over several decades of research but found nothing to show that fire-adapted forests might be improved by logging in the wake of a fire.

In fact, we found just the opposite: Most plants and animals in these forests are adapted to periodic fires; they have a remarkable way of recovering - literally rising from the ashes.

These forests have evolved with fire. Periodic fires have been part of a normal cycle lasting thousands of years. Logging a burned forest damages the soil, carrying away nutrients, robbing seedlings of moisture and clogging nearby streams. Trees in a burned landscape, both dead and alive, continue to provide homes for wildlife after a fire and form the building blocks of new forests."

Karr, James. 2005 Nature doesn't benefit from logging fire-damaged lands | The News Tribune, Tacoma, WA. ftp://ftp2.fs.fed.us/incoming/r5/Klamath/Mt.HebronRestoration/MountHebron.Records/MtHebronRestoration.ProjectRecord/D.%20ScopingComments.Analysis/ArtleyAttachment9.FullArticles/Pub10.Karr2005.Tribune.pdf

[I]n the absence of research specifically addressing the impact of large-scale salvage, I believe there is sufficient evidence to suggest that the risk to nontimber values decreases as the amount of retention increases at either the stand or landscape level (or in some cases both).

Jim Snetsinger, Chief Forester. Guidance on Landscape- and Stand-level Structural Retention in Large-Scale Mountain Pine Beetle Salvage Operations. December 2005. http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/stewardship/cf_retention_guidance_dec2005.pdf.

A review of 116 research articles, dating from 1960 to 2002, which examined bird-forestry relationships in managed forests across North America found that [mdash]

[hellip] The response of birds to forestry practices has been mixed and highly species-specific, but in general, net change in community richness following timber harvest was negligible. Among silvicultural practices, uneven-aged management (e.g., selection harvest) appears to be the most favorable for birds. In contrast, snag removal was highly deleterious, with >80 percent of studies reporting net species loss; net gain was never reported....

[hellip] What seems to be particularly detrimental to forest avifauna is removal of snags. When prescriptions involved manipulation of snag densities, either by removing (Kilgore 1971, Scott 1979, Dingledine and Haufler 1983, Scott and Oldemeyer 1983, Schreiber and deCalesta 1992), retaining (Dickson et al. 1983, Zarnowitz and Manuwal 1985, Stribling et al. 1990, Schreiber and deCalesta 1992, Welsh et al. 1992), or creating (McPeek et al. 1987) snags, bird numbers were typically found to be positively correlated with snag density. Unlike even-aged and unevenaged management practices, removal of snags never resulted in more species increasing in abundance than decreasing. The importance of snags to birds is well known (Davis et al. 1983 and references therein, Bull et al. 1997, references above), not only to cavity nesters, but also songbirds (Sallabanks et al. 2002) that may use snags for nesting, perching, foraging, singing, and scanning for predators. [hellip] Since large

remnant snags and "defective" residual green trees provide much of the snag habitat for cavity-nesters in early- to mid-successional stands, particularly on private lands (Ohmann et al. 1994), retention of these structures will be important for maintaining populations of cavity- and snag-using avian species in managed forests. Snag retention and/or creation were the most commonly listed management recommendations from studies included in our review. We concur that leaving snags wherever possible is another important way that foresters can improve or maintain avian habitat quality within managed forest landscapes.

Rex Sallabanks and Edward B. Arnett. Accommodating Birds in Managed Forests of North America: A Review of Bird-Forestry Relationships. PSW-GTR-191.
http://www.fs.fed.us/psw/publications/documents/psw_gtr191/Asilomar/pdfs/345-372.pdf.

Part of the natural post-fire recovery process is that beetles eat some trees parts and excrete nutrient-rich frass which enhances the growth of surviving and newly established plants. New science indicates that salvage should be avoided or delayed and snags must be retained well-distributed in order to realize the nutrient-cycling benefits of beetle frass.

Beetle droppings[mdash]known in the scientific world as frass[mdash]are crucial to forests recovering from fire. The tiny piles of droppings, found at the bases of trees, resemble cones of sawdust, and they help nourish the forest floor by increasing microbial activity in the soil. This process can also determine which kinds of trees grow back.

"This means that rather than being considered a pest or a nuisance, these beetles are in fact very important to helping burned forests recover," Cobb said. He is concerned, though, because salvage logging is taking the beetles out of the forest before they can do their job; the insects lay their eggs in the dead trees, and the larvae are subsequently destroyed when the wood is processed at sawmills. "That population is being removed from the salvage site and that takes away the mechanism by which the nutrients are returned to the soil."

Salvage logging should be delayed after a fire to allow the beetles to complete their life cycle, Cobb said.

Betkowski, Bev. 2007. Beetle dung helps forests recover from fire. University of Alberta. Public release date: 3-Dec-2007. http://www.uofaweb.ualberta.ca/rso/news.cfm?story=69803 citing Tyler Cobb. 2007. Boreal Mixed-wood Beetles and the Cumulative Ecological Consequences of Disturbance. PhD Dissertation. University of Alberta. Spring 2007.

Scientists raised concerns about salvage logging after fires in B.C.

"When trees are removed from a newly burned landscape, birds and mammals lose the last remnants of habitat," she adds. "Salvage logging decreases forest biodiversity and changes ecological processes of post-fire forest regeneration. Mosaics of regenerating forest are changed through the removal of standing and downed trees, which would naturally remain on the landscape following fire."

Hodges notes while BC's logging industry is heavily regulated, harvesting differs between normal harvests and post-fire logging. More frequent wildfires mean an increase in postfire salvage logging.

"Salvage logging is often done urgently as harvesters attempt to get burned timber to market before the wood deteriorates," she says. "Salvage logging is also done at larger scales and intensities than a standard harvest. This post-fire harvest means wildlife species that can manage after a wildfire do not rebound as quickly from this second disturbance."

UBCO researchers concerned about prey and predator species in post-fire logging areas - Salvage harvesting damages vital habitat for wildlife species. https://scienmag.com/ubco-researchers-concerned-about-prey-and-predator-species-in-post-fire-logging-areas/; https://news.ok.ubc.ca/2020/09/23/ubco-researchers-concerned-about-important-prey-and-predator-species-in-post-fire-logging-areas/

Simon Thorn et al 2020. Estimating retention benchmarks for salvage logging to protect biodiversity. NATURE COMMUNICATIONS | (2020) 11:4762 | https://doi.org/10.1038/s41467-020-18612-4, https://www.nature.com/articles/s41467-020-18612-4.pdf ("Many naturally disturbed forests are subsequently subjected to post-disturbance salvage logging, particularly in the temperate and boreal zones. Salvage logging is commonly justified to recover economic capital, reduce the risk of insect outbreaks, and decrease fire hazard. It is sometimes also justified on the basis that it contributes to ecosystem recovery. Salvage logging is conducted in all forest types, and is common even in areas that are otherwise excluded from logging, such as national parks. By extracting timber and other tree biomass from large areas, salvage logging can impair ecosystem services6 and affect the biodiversity of deadwood-dependent species. Salvage logging can have more profound effects on biodiversity than natural disturbance or logging alone due to the additive and interacting effects of the two disturbances. This has been exemplified by studies on changes in communities of birds and vascular plants. Currently, unlogged early-successional forests following stand-replacing natural disturbances are among the most uncommon habitats in many regions of the world [hellip] The increasing frequency and extent of natural disturbances have generated intense debates about the appropriateness of widespread, high-intensity salvage logging. Hence, the retention of key structures in salvage logging operations (so-called biological legacies), and the partial exclusion of naturally disturbed forests from salvage logging, are increasingly discussed as measures to halt the loss of forest biodiversity. However, while benchmarks for a specific number of trees to be excluded from overall logging operations are common measures in modern retention forestry, such benchmarks are rare for salvage logging of naturally disturbed forests [hellip] We apply this statistical approach to a global dataset of studies with sampling units selected randomly from both naturally disturbed and salvage logged areas to estimate logging benchmarks for naturally disturbed forests, namely a) the portion of naturally disturbed forest that must be spared from salvage logging to maintain 90% of the species richness associated with naturally disturbed and not salvage logged forest; and conversely b) the portion of species richness associated with naturally disturbed forest that remains when 50% of the area of a disturbed forest is salvage logged [hellip] Using a global multi-taxa dataset, we estimate retention benchmarks needed for biodiversity conservation in naturally disturbed forests. We find that, across all investigated disturbance types, an average of 75% of the disturbed area needs to be unlogged to maintain 90% of the disturbed forest's unique species. [hellip] preservation of all species unique to unlogged naturally disturbed areas requires the retention of on average 100% of the disturbed area, [hellip] The benchmarks reported in our study are based on the number of species unique to unlogged, naturally disturbed forests. Hence, the overall increase or decrease in species richness with increasing extent of salvage logging depends both on the loss of species unique to unlogged naturally disturbed forests and on the simultaneous colonization of species typically found in salvage-logged forests."). Note: The Deschutes LRMP, M15-9 says "Dead, down trees will be managed to maximized biological diversity."

11 Reasons Why Burned Forests are Beautiful

1. Severely burned forests provide rich habitats.

2. Severely burned forests are rich in bird life.

3. Severely burned forests support a wonderful variety of insects.

4. Severely burned forests still have lots of living trees, it just takes time for them to say hello.

5. Natural regeneration is everywhere.

6. If left alone, severely burned forests are fun to watch as they explode with new life over the years.

7. Shrubs and trees live together in harmony.

8. Severely burned forests provide habitat where it might be least expected! [e.g., bird nesting in root wads]

9. Severely burned forests still have patches of green.

10. The usual alternative to letting severely burned forests alone is an ecological disaster. [e.g. clearcut salvage and replanting and herbicides on private land]

11. Severe fire is a natural part of forest ecosystems.

California Chapparal Institute. 2014.
http://hosted.verticalresponse.com/652874/13cc17b39e/289104753/39addbbd1d/

Reforestation - Allow More Natural Recovery

The proposed FSM says "an area that is considered suitable for timber production, natural recovery is not an appropriate prescription." This should be amended to allow natural regeneration in a much wider variety of circumstances.

Complex/diverse forests better address climate change than simplified plantations.

... [R]educing emissions from deforestation and degradation may also yield co-benefits for adaptation by maintaining biodiversity and other ecosystem goods and services, while plantations, if they reduce biological diversity may diminish adaptive capacity to climate change (e.g., (Chum et al., 2011). Primary forests tend to be more resilient to climate change and other human-induced environmental changes than secondary forests and plantations (Thompson et al., 2009). The impact of plantations on the carbon balance is dependent on the land-use system they replace, while plantation forests are often monospecies stands, they may be more vulnerable to climatic change (see IPCC WGII Chapter 4) ... Adaptation measures in return may help maintain the mitigation potential of land-use systems. ... Forest and biodiversity conservation, protected area formation, and mixed-species forestry-based afforestation are practices that can help to maintain or enhance carbon stocks, while also providing adaptation options to enhance resilience of forest ecosystems to climate change (Ravindranath, 2007) ...

IPCC AR5, Working Group III, Mitigation of Climate Change, Chapter 11 Agriculture, Forestry and Other Land Use (AFOLU) (Final Draft 2014) pp 46-47. https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter11.pdf.

Intact forests have considerably lower long-term TAC [temporal autocorrelation in the state of the system] (that is, higher forest resilience) than managed forests (0.13 and 0.21, respectively; Fig. 2a). This finding reinforces the expectation that intact forests have a higher capacity to withstand external perturbations thanks to their typically higher structural complexity and species richness. [hellip] intact forests show a lower correlation between GPP [gross primary productivity] and TAC than managed forests (Fig. 2c), probably because resilience is on average higher in intact ecosystems (Fig. 2a) and therefore probably less critical for productivity. [hellip] , about 70% of both managed and intact forests are experiencing a positive trend in GPP at present, but in 50% of these areas (about 36% in absolute terms), this occurs in combination with a positive trend in TAC (Fig. 2f, dark red patterns). This implies that a considerable fraction of forest area is increasing primary productivity while also experiencing a declining resilience, therefore leading to an expanding but more vulnerable forest sink. The widespread observations of rising tree mortality, as well as observations of the growing terrestrial carbon sink, confirm the co-occurrence of such antagonistic processes in response to global change. [hellip] We found that tropical, temperate and arid forests underwent a decline in resilience probably related to the concomitant increase in water limitations and climate variability. On the contrary, benefits induced by climate warming and CO2 fertilization have outweighed such negative effects in much of the boreal biome, ultimately leading to an increase in forest resilience. [hellip] We estimate that about 23% of intact undisturbed forests have already reached their critical threshold for an AD [abrupt decline] and are experiencing a concomitant further degradation of resilience. Considering the expected transition from a CO2-fertilization-dominated period to a warming/ drying-dominated period, the observed negative trajectories of forest resilience suggest potential critical consequences for key ecosystem services, such as carbon sequestration

Forzieri, G., Dakos, V., McDowell, N.G. et al. Emerging signals of declining forest resilience under climate change. Nature (2022). https://doi.org/10.1038/s41586-022-04959-9; https://www.nature.com/articles/s41586-022-04959-9.pdf.

A 2020 study found that natural regeneration can capture more carbon more quickly and more securely than plantations. Cook-Patton, S.C., Leavitt, S.M., Gibbs, D. et al. Mapping carbon accumulation potential from global natural forest regrowth. Nature 585, 545-550 (2020). https://doi.org/10.1038/s41586-020-2686-x. See also, FRED PEARCE 2020. Natural Debate: Do Forests Grow Better With Our Help or Without? Yale Environment 360. SEPTEMBER 24, 2020 https://e360.yale.edu/features/natural-debate-do-forests-grow-better-with-our-help-or-without

[W]e tested the hypothesis that species-rich forests show greater temporal stability of C capture, and are more resistant to drought, than monodominant plantations. Carbon stocks in monodominant teak (Tectona grandis) and Eucalyptus (Eucalyptus spp.) plantations were 30-50% lower than in natural evergreen forests, but differed little from moist-deciduous forests. Plantations had 4-9% higher average C capture rates (estimated using the Enhanced Vegetation Index - EVI) than natural forests during wet seasons, but up to 29% lower C capture during dry seasons across the 2000-18 period. In both seasons, the rate of C capture by plantations was less stable across years, and decreased more during drought years (i.e., lower resistance to drought), compared to forests. Thus, even as certain monodominant plantations could match natural forests for C capture and storage potential, plantations are unlikely to match the stability - and hence reliability - of C capture exhibited by forests, particularly in the face of increasing droughts and other climatic perturbations.

Anand M Osuri, Abhishek Gopal, T R Shankar Raman, Ruth S DeFries, Susan C Cook-Patton and Shahid Naeem. 2020. Greater stability of carbon capture in species-rich natural forests compared to species-poor plantations. Environmental Research Letters. Accepted Manuscript online 6 December 2019. https://doi.org/10.1088/1748-9326/ab5f75; https://iopscience.iop.org/article/10.1088/1748-9326/ab5f75/pdf.

Regen will replace more-resilient larger mature forests with less-resilient small young trees.

Physiological sensitivity to climate also varies with tree size. The relative sensitivity of leaf stomata to high evaporative demand is greater in young than old ponderosa pine (Irvine et al., 2004), and young trees are more susceptible to soil water deficits due to shallower rooting and their greater vulnerability of their roots to broken water columns (Domec et al., 2004). Over the course of dry summers, 20%, 45% and 47% of water used by young, mature and old pine trees in sandy soils is extracted from below 80 cm depth (Irvine et al., 2004). Hydraulic redistribution from deep soil layers will be missed, along with the added storage capacity, if models that assume 1 m soil depth.

[hellip] During the extreme drought years of 2001 and 2002, old ponderosa pine trees in Oregon showed only a small decline in water transport efficiency to leaves (11-24%) whereas in mature pine, the efficiency declined by 46%, and for young pine, by 80% (Irvine et al., 2004). The ability of young pine to open their stomata more widely than older trees, increases the rate that water flows through a unit of their sapwood. As a result, younger trees risk the breakage of a larger proportion of their water columns, which may account for the high mortality in a young ponderosa pine plantation in California (Goldstein et al., 2000).

Law, B.E., Waring, R.H. 2015. Review and synthesis - Carbon implications of current and future effects of drought, fire and management on Pacific Northwest forests. Forest Ecology and Management 355 (2015) 4-14. http://people.forestry.oregonstate.edu/richard-waring/sites/people.forestry.oregonstate.edu.richard-waring/files/publications/Law%20and%20Waring%202015.pdf

Simon Lewis et al (2019) urge greater emphasis on restoring and protecting natural forests as a climate mitigation strategy.

To stem global warming, deforestation must stop. And restoration programmes worldwide should return all degraded lands to natural forests [mdash] and protect them. More carbon must be stored on land, while recognizing competing pressures to deliver food, fuel, fodder and fibre.

We call on the restoration community, forestry experts and policymakers to prioritize the regeneration of natural forests over other types of tree planting [mdash] by allowing disturbed lands to recover to their previous high-carbon state. This will entail tightening definitions, transparently reporting plans and outcomes and clearly stating the trade-offs between different uses of land.

...

Natural-forest restoration is clearly the most effective approach for storing carbon. But clashing priorities are sabotaging carbon storage potential.

...

Today's forest-restoration schemes must increase their carbon sequestration potential to meet global climate commitments. We suggest four ways in which this could happen.

First and foremost, countries should increase the proportion of land that is being regenerated to natural forest.

...

Second, prioritize natural regeneration in [forests] which all support very high biomass forest compared with drier regions. ...

...

Third, build on existing carbon stocks. Target degraded forests and partly wooded areas for natural regeneration; focus plantations and agroforestry systems on treeless regions

...

...

Fourth, once natural forest is restored, protect it. ...

Simon L. Lewis, Charlotte E. Wheeler, Edward T. A. Mitchard & Alexander Koch. 2019.

Restoring natural forests is the best way to remove atmospheric carbon

Plans to triple the area of plantations will not meet 1.5 [deg]C climate goals. Plans to triple the area of plantations will not meet 1.5 [deg]C climate goals. New natural forests can ... Nature 568, 25-28. 2 April 2019. https://www.nature.com/magazine-assets/d41586-019-01026-8/d41586-019-01026-8.pdf.

"... precisely because reforestation takes a very long time, it should be taboo today to cut down mature, species-rich forests, which are large carbon reservoirs and a valuable treasure trove of biological diversity."

Stefan Rahmstorf. 2019. Can planting trees save our climate? RealClimate - Climate science from climate scientists, 16 July 2019. http://www.realclimate.org/index.php/archives/2019/07/can-planting-trees-save-our-climate/

Managing for diverse tree species (instead of uniform plantations) enhances carbon and nitrogen retention. Chen et al (2023) found "An analysis of Canada's National Forest Inventory provides strong evidence that the build-up of soil carbon and nitrogen on a decadal timescale increased with improved tree diversity in natural forest ecosystems." Chen, X. et al. 2023. Tree diversity increases decadal forest soil carbon and nitrogen accrual. Nature https://doi.org/10.1038/s41586-023-05941-9.

Choi et al. (2024) showed that complex canopies typoical of mature and old-growth forests are more reistant and resilient to moderate disturbances which may become more common due to the changing climate.

"Since [moderate-severity disturbances are] more common, they're probably playing a larger role in the ecosystem than we might have appreciated before," said Brady Hardiman, associate professor of forestry and natural resources and environmental and ecological engineering in Purdue University's College of Agriculture. "At any given time, a huge fraction of the forested landscape is undergoing or regrowing from a moderate-severity disturbance, which took out some of the trees but not all of them. The forest is not regrowing from scratch."

[hellip]

Forest canopy structural dimensions include height, openness, density and complexity. Previous research by Hardiman and others has documented that structurally complex canopies absorb more light and that their complexity is linked to important ecosystem functions. These include nutrient cycling, providing shelter and nutrients to organisms, and biodiversity.

[hellip]

The researchers analyzed the differences between press and pulse disturbances, discrete events compared to those that occur over a longer period. The co-authors looked for patterns in changes to canopy structure following disturbances. They found that forests with canopy structures of more complexity seemed better able to withstand and recover from the disturbances.

Steve Koppes 2024. Complex tree canopies help forests recover from moderate disturbances. 2024 News. Purdue Univeristy. February 6, 2024. https://ag.purdue.edu/news/2024/02/complex-tree-canopies-help-forests-recover-from-moderate-disturbances.html citing Choi, D. H., LaRue, E. A., Atkins, J. W., Foster, J. R., Matthes, J. H., Fahey, R. T., Thapa, B., Fei, S., & Hardiman, B. S. (2023). Short-term effects of moderate severity disturbances on forest canopy structure. Journal of Ecology, 111(9), 1866-1881. https://doi.org/10.1111/1365-2745.14145.

A climate simulation study in Europe found that "... Norway spruce was most resilient to climate change when planted in mixed-species stands. Our results are consistent with the growing evidence from empirical and experimental studies on the positive effects of mixed forests under climate change (Bauhus et al. 2017; Jactel et al. 2018)." Honkaniemi, J., Rammer, W. & Seidl, R. 2020. Norway spruce at the trailing edge: the effect of landscape configuration and composition on climate resilience. Landscape Ecol (2020), pp 1-16.

https://doi.org/10.1007/s10980-019-00964-y https://link.springer.com/content/pdf/10.1007%2Fs10980-019-00964-y.pdf.

It is also much cheaper to allow diverse young forests to regenerate naturally than to do artificial planting. Pedro H.S. Brancalion, Paula Meli, Julio R.C. Tymus, Felipe E.B. Lenti, Rubens M. Benini, Ana Paula M. Silva, Ingo Isernhagen, Karen D.Holl 2019. What makes ecosystem restoration expensive? A systematic cost assessment of projects in Brazil. Biological Conservation. Volume 240, December 2019, 108274. https://doi.org/10.1016/j.biocon.2019.108274

Minimize Replanting in Order to Promote Complex Early Seral

There is a growing recognition of the ecological importance of complex early seral habitat which typically exists after a disturbance and before young conifers re-establish dominance. Replanting therefore truncates succession to the detriment of complex early seral habitat. The agency should be willing to accept delayed conifer re-establishment. Slow progress toward conifer dominance is not a failure of forestry, but a benefit to biodiversity.

We urge the agency to carefully consider how replanting can be adjusted to minimize and mitigate adverse effects on complex early seral habitat, for instance:

* consider relying on natural regeneration;
* replant only where natural seed sources are far away;
* leave unplanted "skips" within planting areas;
* plant in a highly variable, clumpy, gappy pattern;
* plant at low density, so that future thinning entries are not needed;
* plant diverse species and diverse genetic stock (especially important considering climate change);
* minimize soil disturbance and avoid weeds;
* retaining complex dead wood structure (retain all snags, leave dead/down wood in patches, leave some fuel piles unburned, etc.).

Science shows that natural regeneration is adequate to restock conifers even in large high severity burn patches. Hanson CT and Chi TY (2021) Impacts of Postfire Management Are Unjustified in Spotted Owl Habitat. Front. Ecol. Evol. 9:596282. doi: 10.3389/fevo.2021.596282. ("In our analysis the percentage of plots lacking conifer regeneration decreased significantly with larger plot sizes, a finding contrary to previous studies which assumed vast "deforested" areas in wildland fires, a bias created by small plot size. We found higher conifer regeneration closer to live-tree edges, but we consistently found natural post-fire conifer regeneration at all distances into interior spaces of large high-severity fire patches, including >300 m from the nearest live trees. Distance from live-tree edges did not affect pine dominance in post-fire regeneration.").

New science shows that automatic tree planting after fire can be counter-productive.

[hellip] the results of this study suggest that some earlier replanting efforts may not have been needed, such as a 2010 replanting at the site of the 2008 Gnarl Ridge Fire on Mt. Hood. "That was probably unnecessary," says Busby. "What we saw in the field and modeling work that we did suggest that the natural regeneration in that area was sufficient, and it's possible the replant has compounded tree density in a negative manner for forest resistance to fire, drought, insects and pathogens."

Results and techniques from this study can now be used by forest managers as a new tool to pinpoint where natural tree regeneration is likely or unlikely to occur after fires. This will prevent overplanting, which can be needlessly expensive and actually place forests at increased risk of future fires.

Summer Allen June 9, 2022. PORTLAND STATE STUDY SHOWS HOW 'GREEN ISLANDS' HELP FORESTS

REGENERATE AFTER FIRE. https://www.pdx.edu/news/portland-state-study-shows-how-green-islands-help-forests-regenerate-after-fire.

This project should be adjusted to reflect the growing recognition of the ecological and social value of complex early seral habitats which are promoted by delayed re-establishment and dominance of conifers after disturbance.

Complex early seral habitat, with diverse vegetation, as well as retaining some structure remaining after previous entries, often provides important ecological value to a wide variety of wildlife including big game, birds, insects, small animals, plants and wildflowers, butterflies, etc.

Complex early seral habitats are now relatively uncommon as a result of many decades of timber dominant forestry, with regeneration harvest, fire suppression, salvage logging, and conifer replanting.

This project could be made more beneficial to the creation of complex early seral habitat by dropping areas from planting entirely when they have a nice existing complement of diverse vegetation. Please minimize efforts to control competing native vegetation.

Another option is to replant at very low densities or in a very clumpy-patchy-gappy pattern to allow existing non-conifer vegetation more time in the sun. Try to avoid homogenizing tree densities.

The agency should be willing to accept delayed conifer re-establishment. Slow progress toward conifer dominance is not a failure of forestry, but a boon to biodiversity.

The diversity and complexity of naturally established early seral forests are both resilient to climate change and help store a lot of carbon. Bernard T. Bormann, Robyn L. Darbyshire, Peter S. Homann, Brett A. Morrissette, Susan N. Little. 2015. Managing early succession for biodiversity and long-term productivity of conifer forests in southwestern Oregon. Forest Ecology and Management 340 (2015) 114-125 https://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/55627/MorrissetteBrettForestryManagingEarlySuccession.pdf ("Fifteen years of growth of shrubs and hardwood trees in the Early-seral plantation was remarkable, resulting in total aboveground biomass increment (18 Mg/ha/yr) double that of the Douglas-fir plantations.")

To help get your creative juices flowing on this interesting and developing topic please review and consider the following resources:

Jerry Franklin - Early seral forest: a diminishing resource? http://www.slideshare.net/ecoshare/jerry-franklin-early-seral-forest-a-diminishing-resource.

K. Norman Johnson - Policies to Encourage Diverse, Early Seral Forest in Oregon: What Might We Do? http://www.slideshare.net/ecoshare/k-norman-johnson-policies-to-encourage-diverse-early-seral-forest-in-oregon-what-might-we-do.

Exploring What is a 'Good' Forest Opening and is the Future a concern? January 30, 2007. http://ecoshare.info/projects/central-cascade-adaptive-management-partnership/workshops/early-seral-forest-2007/. AND http://www.slideshare.net/ecoshare/presentations.

Daniel C. Donato, John L. Campbell & Jerry F. Franklin 2011. Multiple successional pathways and precocity in forest development: can some forests be born complex? Journal of Vegetation Science. (2011) http://onlinelibrary.wiley.com/doi/10.1111/j.1654-1103.2011.01362.x/pdf.

Churchill, D.J., M.C. Dalhgreen, A.J. Larson, and J.F. Franklin. 2013. The ICO approach to restoring spatial pattern in dry forests: Implementation guide. Version 1.0. Stewardship Forestry, Vashon, Washington, USA. https://web.archive.org/web/20130330181038/http://www.cfc.umt.edu/ForestEcology/files/ICO_Manager_Guide.pdf and

Derek J. Churchill, Andrew J. Larson, Matthew C. Dahlgreen, Jerry F. Franklin, Paul F. Hessburg, and James A. Lutz. 2013. Restoring forest resilience: From reference spatial patterns to silvicultural prescriptions and monitoring. Forest Ecology and Management 291 (2013) 442-457. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5428873.pdf

M. G. BETTS, J. C. HAGAR, J. W. RIVERS, J. D. ALEXANDER, K. MCGARIGAL, AND B. C. MCCOMB. 2010. Thresholds in forest bird occurrence as a function of the amount of early-seral broadleaf forest at landscape scales. Ecological Applications, 20(8), 2010, pp. 2116-2130. http://www.fsl.orst.edu/flel/pdfs/Betts%20et%20al%202010%20Ecol%20Apps.pdf.

Li, W., Guo, W., Pasgaard, M., Niu, Z., Wang, L., Chen, F., Qin, Y., Qiao, H., & Svenning, J. (2024). Unmanaged naturally regenerating forests approach intact forest canopy structure but are susceptible to climate and human stress. One Earth. https://doi.org/10.1016/j.oneear.2024.05.002. ("[hellip] unmanaged naturally regenerating forests develop a canopy structure approaching that of intact forests, much more so than managed naturally regenerating and planted forests. [hellip] Notably, safeguarding the persistence of global naturally re-growing forests becomes an urgent necessity.").

Replanting may not be necessary where birds and other wildlife serve essential roles in post-disturbance seed dispersal.

Seed dispersal mutualisms with scatter-hoarders play a crucial role in population dynamics of temperate large-seeded trees. These behaviors shape seed dispersal patterns, which can be applied to conservation of populations, communities, and even ecosystems dominated by large-seeded trees. We draw on a growing body of literature to describe the ecological context and consequences of scatter-hoarding as a seed dispersal mechanism. We synthesize the quantitative literature on the interaction between members of the avian family Corvidae (crows, ravens, jays, magpies, and nutcrackers) and nut-bearing trees such as pines (Pinus spp.) and oaks (Quercus spp.) to examine unique aspects of avian scatter-hoarders as seed dispersers. During the scatter-hoarding process, seed selectivity, transportation distance, hoarding frequency, and cache placement affect seed dispersal effectiveness, a measure of the quantity and quality of dispersal. Case studies from around the world highlight the role of corvid seed dispersal in population dynamics of trees, and how the birds' scatter-hoarding behavior can be facilitated for the restoration of oak- and pine-dominated habitats.

Mario B. Pesendorfer, T. Scott Sillett, Walter D. Koenig, and Scott A. Morrison (2016) Scatter-hoarding corvids as seed dispersers for oaks and pines: A review of a widely distributed mutualism and its utility to habitat restoration. The Condor: February 2016, Vol. 118, No. 2, pp. 215-237. http://dx.doi.org/10.1650/CONDOR-15-125.1

If reforestation of recently-burned areas remains an important goal, relatively cool/wet sites should be prioritized first because seedling survival in these areas is likely to be greatest, now and into the future. Within these wetter areas, planting units should be limited to locations where available seed sources are most distant (Stevens-Rumann and Morgan 2019). ... In addition, prioritizing plantings in wetter years would be likely to benefit treatment success ...

Veblen & Rodman 2019. Modeling the Influence of Climate and Local Site Factors on Post-Fire Regeneration in the Southern Rocky Mountains. JFSP PROJECT ID: 17-2-01-4 November 2019. https://www.firescience.gov/projects/17-2-01-4/project/17-2-01-4_final_report.pdf.

Replanting intended to accelerate the establishment and dominance of conifers will adversely affect a variety of birds associated with broadleaf, early-seral vegetation. See M. G. BETTS, J. C. HAGAR, J. W. RIVERS, J. D. ALEXANDER, K. MCGARIGAL, AND B. C. MCCOMB. 2010. Thresholds in forest bird occurrence as a function of the amount of early-seral broadleaf forest at landscape scales. Ecological Applications, 20(8), 2010, pp. 2116-2130. http://www.fsl.orst.edu/flel/pdfs/Betts%20et%20al%202010%20Ecol%20Apps.pdf.

Li, Wang et al. 2024. Unmanaged naturally regenerating forests approach intact forest canopy structure but are susceptible to climate and human stress. One Earth, Volume 7, Issue 6, 1068 - 1081. https://www.cell.com/one-earth/abstract/S2590-3322(24)00213-6 ("We show that canopy structure in unmanaged naturally regenerating forests more closely resemble intact forests than managed naturally regenerating forests and planted forests").

In October 2013, 250 scientists signed a letter urging greater attention to the conservation of complex early seral forests and natural recovery after fire. These scientists conclude that the

"current state of scientific knowledge, [hellip] indicates that [salvage logging] would seriously undermine the ecological integrity of forest ecosystems on federal lands. [hellip] This post-fire habitat, known as 'complex early seral forest,' is quite simply some of the best wildlife habitat in forests and is an essential stage of natural forest processes. Moreover, it is the least protected of all forest habitat types and is often as rare, or rarer, than old-growth forest, due to damaging forest practices encouraged by post-fire logging policies. While there remains much to be discovered about fire in our forests, the scientific evidence indicates that complex early seral forest is a natural part of historical fire regimes in nearly every conifer forest type in the western U.S. (including ponderosa pine and mixed-conifer forests) [hellip] Numerous studies also document the cumulative impacts of post-fire logging on natural ecosystems, including the elimination of bird species that are most dependent on such conditions, compaction of soils, elimination of biological legacies (snags and downed logs) that are essential in supporting new forest growth, spread of invasive species, accumulation of logging slash that can add to future fire risks, increased mortality of conifer seedlings and other important re-establishing vegetation (from logs dragged uphill in logging operations), and increased chronic sedimentation in streams due to the extensive road network and runoff from logging operations."

Della Sala, D. et al (2013) Open Letter to Members of Congress from 250 Scientists Concerned about Post-fire Logging. October 30, 2013.
http://geosinstitute.org/images/stories/pdfs/Publications/Fire/Scientist_Letter_Postfire_2013.pdf or
http://www.scribd.com/doc/181401520/Open-Letter-to-Members-of-Congress-from-250-Scientists-Concerned-about-Post-fire-Logging-October-30-2013

The agency must prepare a programmatic EIS to comprehensively disclose and consider:

a. The natural range of variability and existing rarity of complex young forests (e.g., young forests that are unsalvaged after disturbances). Since large snags are outside the natural range of variability across the landscape, the agency must retain all large snags to start moving the landscape toward the natural range of variability, or the agency must carefully justify in the Silvicultural Prescription (and the NEPA analysis) every large snag it proposes to remove. See Jerome J. Korol, Miles A. Hemstrom, Wendel J. Hann, and Rebecca A. Gravenmier. Snags and Down Wood in the Interior Columbia Basin Ecosystem Management Project. PNW-GTR-181. http://www.fs.fed.us/psw/publications/documents/gtr-181/049_Korol.pdf. This paper estimates that even if we apply enlightened forest management on federal lands for the next 100 years, we will still reach only 75% of the historic large snag abundance measured across the interior Columbia Basin, and most of the increase in large snags will occur in roadless and wilderness areas.

b. Daniel C. Donato, John L. Campbell & Jerry F. Franklin 2012. FORUM Multiple successional pathways and precocity in forest development: can some forests be born complex? Journal of Vegetation Science 23 (2012) 576-584 http://people.forestry.oregonstate.edu/john-campbell/sites/people.forestry.oregonstate.edu.john-campbell/files/Donato_2012_JVS.pdf

SEE LETTER SUBMISSION: Figure 3

c. The ecological values (such as wildlife habitat) associated with snags, dead wood, and complex young forests. 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;

d. Given the regional deficit of young complex forests and the fact that many species, such as woodpeckers and secondary cavity users, appear to be adapted to exploit the structure and resources available within disturbed forests, the agencies should comprehensively consider and disclose the direct and indirect effects of salvage logging on species associated with young complex forests. The Forest Service has numerous Management Indicator Species whose populations have not been monitored, so the agencies lack the information necessary to show that the salvage logging program will maintain species viability.

e. The effects of salvage logging on the development of complex forest habitat; "The early post-disturbance period of forest ecosystem development - pre-tree-canopy closure - is profoundly important!" because it is heterogeneous, light-energy rich, structure rich, biodiversity rich, and process rich. "Removal of legacies is most profound long-term impact" because of the "Importance of Coarse Wood:

* Habitat for species
* Organic seedbeds (nurse logs)
* Modification of microclimate
* Protection of plants from ungulates
* Sediment traps
* Sources of energy & nutrients
* Sites of N-fixation
* Special source of soil organic matter
* Structural elements of aquatic ecosystems"

Jerry Franklin - What is a 'Good' Forest Opening? - Powerpoint
http://courses.washington.edu/esrm315/Lectures/FranklinEarlySuccession.pdf

f. All the new science related to salvage logging and dead wood, including but not limited to: Beschta R.L., J.J. Rhodes, J.B. Kauffman, R.E. Gresswell, G.W. Minshall, J.R. Karr, D.A. Perry, F.R. Hauer, and C.A. Frissell, 2004. Postfire management on forested public lands of the western USA. Cons. Bio. Vol 18 No. 4, page 957-967. https://www.sierraforestlegacy.org/Resources/Conservation/FireForestEcology/SalvageLoggingScience/Salvage-Beschta04.pdf.

g. "Conservation of diverse young forests has received little attention in forest policy." USDA PNW Research Station. Science Findings #56 - Seeing The Trees For The Forest: Mapping Vegetation Biodiversity In Coastal Oregon Forests. Sept 2003. http://www.fs.fed.us/pnw/sciencef/scifi56.pdf. "[T]here's a looming shortage of diverse young forests - where seedlings intermingle with fallen logs, standing dead snags, and shrubs - that provide specialized habitat for certain animals and plants. [hellip] there's a looming gap in diverse, young, early-successional conifer forest, the type of forest that once came in naturally after forest fires. These young forests, up to 10 years old, have a diversity of forest structures - fallen logs and dead snags - and a diversity of plant life. They are important habitat for the western bluebird and other birds that prefer open areas, as well as some shrub species. Today, because of intense timber management on private lands, young forests don't get the chance to develop much diversity." OSU. 2001. Press Release: Researchers Assess Forest Sustainability.
http://web.archive.org/web/20060914032259/http://oregonstate.edu/dept/ncs/newsarch/2001/Oct01/assess.htm

According to the CLAMS project: "Diverse young forests: also rare but receiving less attention. Legacy tree habitat: uncertain future.." Ohmann, Spies, Gregory, Johnson. 2002. Vegetation Biodiversity in the Oregon Coast Range. http://www.fsl.orst.edu/clams/download/presentations/j02s_ohmann_10june02.pdf (slide 24).

h. Hutto, R.L., 2006. Toward Meaningful Snag-Management Guidelines for Postfire Salvage Logging in North American Conifer Forests. Conservation Biology Volume 20, No. 4, 984-993. http://web.archive.org/web/20090310114517/http://avianscience.dbs.umt.edu/documents/hutto_conbio_2006.pdf ("Species such as the Black-backed Woodpecker (Picoides arcticus) are nearly restricted in their habitat distribution to severely burned forests. Moreover, existing postfire salvage-logging studies reveal that most postfire specialist species are completely absent from burned forests that have been (even partially) salvage logged. I call for the long-overdue development and use of more meaningful snag-retention guidelines for postfire specialists, and I note that the biology of the most fire-dependent bird species suggests that even a cursory attempt to meet their snag needs would preclude postfire salvage logging in those severely burned conifer forests wherein the maintenance of biological diversity is deemed important.")

i. A recent study of birds that use post-fire mosaics highlighted the importance of resprouting shrubs and forbs on the re-establishment of nesting birds following wildfire. "Of the 39 species for which nests were found, 14 (37%) used cavities and 25 (63%) built open-cup nests.... Species that built cup nests used snags, residual live trees, resprouting hardwoods, and other ground vegetation and downed wood. The associations between the presence of breeding species and forb and shrub cover indicate that these are important components of the early establishment of bird populations following stand-replacing fires. These data suggest that post-fire management of resprouting hardwoods and herbaceous vegetation should consider potential impacts to bird species that nest and forage in burned forests." CFER 2007. Response of Birds to Fire Mosaics. CFER News. Winter 2007. http://www.fsl.orst.edu/cfer/pdfs/Vol7_1.pdf.

j. BLM admits that structurally complex young forests develop old forest characteristics twice as fast as structurally deprived initial conditions. BLM 2008. Western Oregon Plan Revision (WOPR) DEIS (pp. LI-LII) https://web.archive.org/web/20110524132346/http://www.blm.gov/or/plans/wopr/plan-doc-overview.php, https://web.archive.org/web/20110524184457/http://www.blm.gov/or/plans/wopr/deis/files/vol1/WOPR_DEIS_summary.pdf ("The retention of structural legacies in regeneration harvested areas, [hellip] would result in structurally complex forests that develop almost twice as fast after harvesting as in Alternatives 1 and 2. [with no green tree retention]"); ("This finding is consistent with other studies that concluded that green tree retention would speed the redevelopment of the structurally complex forests (Spies 2006, 94; Zenner 2005; Zenner 2000)." BLM 2008. WOPR DEIS p 489, https://web.archive.org/web/20090121055341/http://www.blm.gov/or/plans/wopr/deis/files/vol%202/chapter%204/WOPR_DEIS_Chapter_4a.pdf citing Spies, T.A. 2006. Maintaining old-growth forests. Chapter 6 in R.W. Haynes, B.T. Bormann, D.C. Lee, J.R. Martin, tech. eds. Northwest Forest Plan - The First 10 Years (1994-2003): Synthesis of Monitoring and Research Results. General Technical Report PNW-GTR-651. Pacific Northwest Research Station, U.S. Department of Agriculture, U.S. Forest Service. Portland, OR. https://www.fs.usda.gov/pnw/pubs/pnw_gtr651.pdf ("The ecological influences of old growth do not end with the death of the tree layer in a high-severity fire, however. Biological legacies of old growth, including dead trees, surviving live trees, and other organisms and organic matter carry over into the young forests and can persist for many decades as the new younger forest develops (Harmon and others 1986). For example, significant amounts of dead wood from the previous stand can be found 100 years later in postfire stands, and trace amounts can be detected in some 200-year-old stands (Spies and others 1988). [hellip] The "connected oldgrowth network" is more than a spatial concept[mdash]it is also a temporal one, in which developmental stages are connected to each other through surviving and slow-decaying structural and compositional components of previous stages. [hellip] [R]emoving any large dead trees would diminish amounts of late-successional habitat elements in young forests. Second, these early-successional stages, with many large dead trees, contribute to an important but not often stated goal2 of the Plan, which is to maintain biological diversity. [hellip] [T]he ecological value of large dead trees in early-successional forests has been reaffirmed in several synthesis papers on the subject (Beschta and others 2004, Lindenmayer and others 2004, McIver and Starr 2000). In addition, no empirical evidence has emerged that salvage logging can improve the desired ecological diversity of young forest or the development of late-successional forests later in succession"); Zenner, E. 2000. Do residual trees increase structural complexity in Pacific Northwest coniferous forests? Ecological Applications 10(3): 800-810, https://ecoshare.info/wp-content/uploads/2019/12/Zenner_2000_Do-residual-trees-increase-structural-complexity-in-PNW-coniferous-forests.pdf; Zenner, E.K. 2005. Development of tree size distributions in Douglas-fir forests under differing disturbance regimes. Ecological Applications 15(2): 701-714.

k. Mark E Swanson, Jerry F Franklin, Robert L Beschta, Charles M Crisafulli, Dominick A DellaSala, Richard L Hutto, David B Lindenmayer, and Frederick J Swanson 2010. The forgotten stage of forest succession: early-successional ecosystems on forest sites. Front Ecol Environ 2010; doi:10.1890/090157, https://www.fs.fed.us/pnw/pubs/journals/pnw_2010_swanson001.pdf;

l. Bats find favorable habitat in burned areas with abundant and diverse snags and abundant and diverse flying insects. Salvage logging will remove potential roost sites, and food sources. Carol Chambers and Erin Saunders. BATS IN THE BURNS - Studying the impact of wildfires and climate change. BATS. Bat Conservation International. Winter 2013, Volume 3, No. 4.
http://web.archive.org/web/20140209081630/http://www.batcon.org/index.php/media-and-info/bats-archives.html?task=viewArticle&magArticleID=1154;

m. "Leaving a damaged forest intact means the original conditions recover more readily," says David Foster, [hellip] director of the NSF Harvard Forest LTER site. "Forests have been recovering from natural processes like windstorms, fire and ice for millions of years. What appears to us as devastation is actually, to a forest, a natural and important state of affairs." 10-16-2012 Press Release 12-198, In Blown-Down Forests, a Story of Survival To preserve forest health, the best management decision may be to do nothing.
http://www.nsf.gov/news/news_summ.jsp?cntn_id=125744; Audrey Barker Plotkin, David Foster, Joel Carlson, and Alison Magill 2013. Survivors, not invaders, control forest development following simulated hurricane. Ecology, 94(2), 2013, pp. 414-423.
http://harvardforest.fas.harvard.edu/sites/harvardforest.fas.harvard.edu/files/publications/pdfs/BarkerPlotkin_Ecology_2013.pdf

n. "Unmanaged early-seral stages of forest development are now considered to be among the most threatened habitat types in coniferous regions of the western United States (Noss et al. 2006, Thomas et al. 2006). Not surprisingly, concern has arisen over viability of populations that use broadleaf vegetation in early-seral forest, particularly as this habitat type contributes disproportionately to forest biodiversity (Halpern and Spies 1997). In the northwestern United States, a number of bird species thought to be strongly associated with early-seral broadleaf habitat have declined and are considered conservation priorities (Altman 1999, U.S. Fish and Wildlife Service 2002). Because the PNW represents a substantial portion of the ranges of these species, loss of quality early-seral habitat could increase risk of extinction." M. G. BETTS, J. C. HAGAR, J. W. RIVERS, J. D. ALEXANDER, K. MCGARIGAL, AND B. C. MCCOMB. 2010. Thresholds in forest bird occurrence as a function of the amount of early-seral broadleaf forest at landscape scales. Ecological Applications, 20(8), 2010, pp. 2116-2130. http://www.fsl.orst.edu/flel/pdfs/Betts%20et%20al%202010%20Ecol%20Apps.pdf

o. Salvage logging after disturbance is detrimental to old-growth indicator species, has a homogenizing influence on the forest, and hinders future development of structurally complex forests. Orczewska, A., et al 2019. The impact of salvage logging on herb layer species composition and plant community recovery in Bialowieza Forest. Biodiversity and Conservation (2019) 28:3407-3428 https://doi.org/10.1007/s10531-019-01795-8
https://link.springer.com/content/pdf/10.1007%2Fs10531-019-01795-8.pdf. ("We conclude that continuous deterioration of the forest habitats via clearcutting of stands afected [sic] by insect outbreak, followed by tree planting, substantially reduces the chances of successful, natural regeneration towards deciduous, structurally complex and diverse forests. ... [S]alvage logging breaks the natural ecological processes of forest dynamics and

facilitates colonization of forest ecosystems by light-demanding, competitive species, associated with disturbed forest sites but hinders the number and cover of late-successional, shade-tolerant forest species.").

p. Many bird species benefit from fire that leaves a rich mix of plants and complex structure of snags and dead wood, but salvage logging removes the complex structure and truncates the early seral vegetation by planting conifers. The quality of habitat that results after fire often depends on the successional stage of the forest pre-disturbance, because much of this structure is carried over after the fire into the future forest. Salvage logging removes most of the trees and with it the structural legacies that bind the past and future forests. Dick Hutto said:

In a new paper, we show that fire effects cannot be accurately assessed through a simple comparison of recently burned and unburned forest plots. This is because the same species that show negative responses through simplistic comparisons of burned and unburned forests reveal strong POSITIVE responses to more restricted combinations of successional stage and fire severity. With 10 years of post-fire data, we show that the majority of bird species (60%) benefit from fire (as evidenced by greater abundances in burned forest patches belonging to a particular successional stage/fire severity combination than in forest patches that have been long unburned). With data from even longer times-since-fire (say, 15, 20, or 30 years after fire), the percentage of species that clearly benefit from fire is probably closer to 80%!

Describing Richard L. Hutto, and David A. Patterson 2016. Positive effects of fire on birds may appear only under narrow combinations of fire severity and time-since-fire. International Journal of Wildland Fire. http://dx.doi.org/10.1071/WF15228

Reforestation - Be More Tolerant of Vegetation Diversity. Plant at low density to extend the early seral community and avoid future stand management costs.

The Silvicultural Manual should not be so focused on trees. Our forests are enriched by a wide variety of plant types that provide a wide range of food and other benefits to wildlife. Objectives such as "Improve the quality and yield of new timber stands" do not belong in an ecologically-based system of forest management. Improving the yield of wood is but one objective in our forests, one that has significant adverse trade-offs on water, wildlife, carbon, and other values. The objectives for silviculture should include a wide variety of goals, and should not emphasize timber yield.

The Manual says about site preparation - "Schedule reforestation treatment after harvest to take full advantage of the favorable conditions of exposed mineral soil and reduced vegetation competition resulting from appropriate slash disposal." This is not a good idea, because it prioritizes trees over other vegetation that also provide valuable ecosystem services. Ideally, tree planting should not be accelerated, but rather delayed to allow diverse vegetation to flourish after disturbances. Prompt conifer reforestation is contrary to natural processes that typically occur after natural disturbances.

Unsalvaged, naturally regenerated, young stands are one of the rarest forest types in the Pacific northwest, and their biodiversity rivals that of old-growth forests.

"Indeed, naturally developed early-successional forest habitats, with their rich array of snags and logs and nonarborescent vegetation, are probably the scarcest habitat in the current regional [Pacific Northwest] landscape."

Lindenmayer, David B. and Jerry F. Franklin. 2002. Conserving Forest Biodiversity: A Comprehensive Multiscale Approach. Island Press. Washington, DC: 69. See also, DellaSala, D.A., J.E. Williams, C. Deacon-Williams, and J.F. Franklin. Beyond smoke and mirrors: a synthesis of fire policy and science. In review - Conservation Biology.

Replanting requirements for sites "suitable" for timber cultivation can drive reforestation versus potentially more climate-adaptive, landscape-scale approaches such as leaving and enhancing non-forest for heterogeneity.

[hellip]

Post-fire replanting can be an opportune time to introduce spatial heterogeneity in forest structure and species composition. Updating or developing management tools and other resources to include information on variable replanting spatial patterns would support land managers to experiment with these practices but further scoping work is needed to understand if this should be prioritized.

Northwest Fire Science Consortium 2024. Workshop Summary: Leveraging the Work of Wildfire Before, During, and After Fires. https://www.nwfirescience.org/sites/default/files/2024-08/WOW_Summary_Final.pdf.

"There has been a loss of diverse young forests on all ownerships. [hellip] Conservation of diverse young forests has received little attention in forest policy."

Janet Ohmann; Science Findings, Issue 56; Seeing the trees for the forest: mapping vegetation biodiversity in coastal Oregon forests; (September 2003). http://www.fs.fed.us/pnw/sciencef/scifi56.pdf.

Currently, early-successional forests (naturally disturbed areas with a full array of legacies, ie not subject to post-fire logging) and forests experiencing natural regeneration (ie not seeded or planted), are among the most scarce habitat conditions in many regions.

Noss et al. 2006. Managing fire-prone forests in the western United States. Front Ecol Environ 2006; 4(9): 481-487. https://ir.library.oregonstate.edu/downloads/cr56n5219?locale=en

Forest managers should avoid dense replanting that creates dense homogeneous plantations. Such areas inhibit biodiversity and also represent dangerous fuel conditions. FS scientists have found that "dense plantings of seedlings after harvesting may increase reburn severity and decrease forest resilience in the early stages of postfire ecological change. [hellip] [V]ariable-density reforestation can increase forest heterogeneity and reduce reburn severity." Kirkland, John; Johnson, Morris. 2022. Passive or active management? Understanding consequences and changes after large stand-replacing wildfires. Science Findings 247. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 6p. https://www.fs.usda.gov/pnw/sciencef/scifi247.pdf.

It is preferable to replant in patches and/or at a fairly low density to reduce fuel hazard, and avoid the need for future thinning and other stand management costs. Let's be patient and allow these stands recover slowly as diverse early seral communities. Diverse early seral plant communities are becoming less common and we should encourage slow and easy regeneration of forest communities. This is consistent with the research being done by Nathan Poage which indicates that many stands developed over much longer time periods than we typically allow under the agricultural model of forest management. David Hibbs' research is also showing that natural regeneration is sufficient to reforest most sites after disturbance. OSU Media Release, Slow but Reasonably Sure: Burned Forest Lands Regenerate Naturally, 4-03-07. http://web.archive.org/web/20071101041901/http://oregonstate.edu/dept/ncs/newsarch/2007/Apr07/forestrecovery.html ("Some studies have argued that, in the absence of aggressive management, burned areas might turn into unproductive shrub fields that could persist for decades or centuries. 'In contrast to expectations, we found natural conifer regeneration to be generally abundant across a variety of settings,' the scientists wrote in the new study. 'Management plans can benefit greatly from utilizing natural conifer regeneration, but managers must face the challenge of long regeneration periods, and be able to accommodate high levels of variation across the landscape of a fire.'").

Jerry Franklin points out that the more diverse forests that develop from natural regeneration are more resilient to climate change. In the 2007 Early Seral Forest Workshop, Jerry Franklin pointed out an important reason to rely on natural regeneration, saying [mdash]

Naturally-regenerated ESFCs are likely to be more resilient under climate change due to

- greater species diversity

- tree genotypes selected by nature (i.e., environmental stresses)

[hellip]

Reforestation will usually:

o [EC3] Reduce the duration of ESFCs

o Reduce heterogeneity of the process by which closed forest canopy is reestablished

o Alter genotype of planted species (less selection by environment)

o Homogenize composition of forest

http://www.reo.gov/ecoshare/ccamp/good_forest_opening/powerpoints/FranklinEarlySuccession.ppt

Brown and Kertis studied the seedlings that came up naturally after the Warner Creek fire, and found that "seedling density can vary a lot within a plot. You might have a general density of 50 thousand per hectare, but locally those numbers could be anywhere from 0 to 300 per hectare. These seedlings are numerous, but not laid out in a grid!" http://web.archive.org/web/20050428020846/http://www.brownandbrown.tv/warner-presentation-2002-05-14b.pdf.

Genetic Resource Management - Planting "Improved" Trees Undermines Genetic Diversity, Tree Fitness and Natural Selection

The Silvicultural Manual should emphasize genetic diversity, not designer plants with compromised genetic diversity.

De la Mata et al (2017) studied the variable survival of Ponderosa pine during a mountain pine beetle (MPB) outbreak and found that slow growing trees had an advantage. This means that replanting trees from tree breeding programs that have focused on tree growth rates may be creating forests that are less resilient to stress from insects and climate change.

Growth rates have fitness consequences and selection is expected (23). Indeed, we found significant genetic responses to selection on growth rates, but importantly, these responses changed in direction and strength over time (Fig. 2A). Fast growth was positively selected before the outbreak, but negatively selected during the outbreak, clearly showing that intense herbivory shifted selection patterns. Fast growth in trees under competitive environments is critical for light acquisition and resource capture, and slow growth is selected against and underrepresented at mature stages (27). Consistently, selection for fast growth was strongest during early seedling establishment when density-dependent mortality in trees typically occurs (38) and when the proportion of seeds that attain maturity is usually very small (6). The MPB outbreak, however, caused significant selection differentials in the opposite direction (positive selection for slow-growing phenotypes), which triggered a negative genetic response after the outbreak (Fig. 2A). Our results are consistent with studies showing that fast early growth within tree species correlates with decreased longevity (29) and increased herbivory at maturity (30), and provide strong empirical evidence of the conflicting effects of growth rates on fitness during ontogeny.

[hellip]

Our results also have important management implications. Tree improvement programs supply seed resources for managed tree plantations, and for restoration purposes after natural and human-caused disturbances (e.g., fire, severe drought, and reclamation). These programs have traditionally focused on selection on growth-related traits (52), although efforts to breed for tree resistance against insects and pathogens are currently in place (53). Our results indicate that the traditional focus on fast-growth by tree breeding programs may reduce survival under intense, unpredictable stress (54).

Raul de la Mata, Sharon Hood, and Anna Sala 2017. Insect outbreak shifts the direction of selection from fast to slow growth rates in the long-lived conifer Pinus ponderosa. PNAS. www.pnas.org/cgi/doi/10.1073/pnas.1700032114.

The amended FSM says "Produce increased biomass per unit area of higher quality forest products and greater quantities of sequestered carbon." This reference to dense biomass per unit area and wood products represents a very narrow set of goals that focuses on maximizing growth of crop trees, to the detriment of other important goals such as clean water, stable water flow, fish & wildlife habitat, etc.

We support assisted migration of native species, but we urge that it be done cautiously. Start with small geographic steps. Allow establishment of small pioneer populations then allow them to disperse naturally. It is critical to emphasize genetic diversity in this effort.

Retain and Restore Genetic Diversity of Trees

Genetics must be carefully considered not only in replanting but also in decisions about which trees to harvest and which trees to retain.

There are significant unacknowledged risks involved when humans decide which trees live and which trees die. Natural mortality from drought, insects, and fire have shaped the genetic makeup of the forest for millennia, favoring more fit individuals and increasing the resilience of forest stands. Logging is a novel cause of mortality that does not favor the fittest individuals. The agency must carefully consider the consequences of logging that decouples mortality from fitness, survival and resilience. This is especially important in light of climate change. Conserving genetic and phenotypic diversity is important for climate adaptation. Halofsky, J.E.; Peterson, D.L., eds. 2016. Climate change vulnerability and adaptation in the Blue Mountains. Gen. Tech. Rep. PNW-GTR-xxx. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. (Table 6.8e) http://adaptationpartners.org/bmap/docs/BMAP_final.pdf. Also, Matthew Reilly, 2018. Chapter 2: Climate, Disturbance, and Vulnerability to Vegetation Change in the Northwest Forest Plan Area. Northwest Forest Plan Science Synthesis - Science Forum | Tuesday, June 26, 2018 | Portland, Oregon. https://docs.wixstatic.com/ugd/8f8000_08456f0927cb4aa88b18f341b3c7c435.pdf. A strategy to conserve genetic diversity would do two things: First, protect all old trees that have survived previous climate extremes. These legacy trees have already shown their fitness for survival. Protecting such trees might involve careful actions to reduce competition and ladder fuels in the immediate vicinity of those legacy trees. Second, let natural processes determine which of the younger trees are most fit to survive. Genetic fitness is not obvious even to the trained forester. Logging might inadvertently let the least fit survive and kill the trees with the most fit genes.

Old trees that are alive today are survivors. In the least 50 years, they have survived one of the wettest 20 year periods in more than 1,000 years, and one of the driest periods, now referred to as a megadrought. These survivors may be hard to replace and they deserve to be retained. "The 2000-2018 drought was preceded by the wettest 19-year period (1980-1998) in at least 1200 years. [hellip] [T]he 2000-2018 drought was on a megadrought-like trajectory throughout its development [hellip]" A. Park Williams, et al. 2020. Large contribution from anthropogenic warming to an emerging North American megadrought. Science 368, 314-318 (2020). https://science.sciencemag.org/content/368/6488/314.

A careful study of trees' growth response to high temperatures tested two competing hypotheses, that trees exposed to high temperatures when young, were more adapted to high temperatues when older, versus, high temperatures experienced by trees when young resulted in cumulative damage when exposed to high temperatures when older.

There is some adaptation among Douglas Firs to temperatures above 26[deg]C (Figures S17-S19), among Ponderosa Pines to temperatures above 14[deg]C (Figures S20 and S21), and weaker adaptation in Cfa to temperatures above 26[deg]C (Figures S15 and S16), and among White Oaks to temperatures above 14[deg]C (Figures S22 and S23). On average, a one standard deviation increase in the average incidence of high temperatures, corresponds to lower damage from those temperatures by 803% (45% after excluding outliers), 106%, 11% and 14% in each of those respective samples.

[hellip]

I find that many ecoregions are characterized by a non-linear response to temperature, where increases in temperature are neutral or slightly beneficial to growth up to a point, beyond which increases in temperature are harmful to growth.

Jos[eacute]phine Gantois 2022. New tree-level temperature response curves document sensitivity of tree growth to high temperatures across a US-wide climatic gradient. Global Change Biology, Vol 28, Issue 20. https://doi.org/10.1111/gcb.16313.

The agency must recognize that natural mortality provides an important ecological function - that is, it promotes evolutionary adaptation which is critical right now in the face of climate change.

[R]esearchers were surprised to find that the mortality of established trees considerably promotes the adaptation of forests to the changing environment. [hellip] Evolution is promoted by the mortality of established trees. The researchers assumed that demographic characteristics of the trees would have a notable impact on their adaptability. Tree species differ for example so that birch matures at a considerably younger age than pine, and birch seeds spread more effectively than pine seeds. However, the results showed that these differences had only minor impacts. Instead, the mortality of established trees played a large role in the evolutionary adaptation.

Northern forests do not benefit from lengthening growing season. UNIVERSITY OF HELSINKI. PUBLIC RELEASE: 12-JAN-2010. http://www.eurekalert.org/pub_releases/2010-01/uohnfd011210.php.

Importantly, for natural selection to occur, mortality must be caused by natural events like drought, insects, and fire, rather than through human choices about which trees will live and which will die. There is already evidence that this is happening. Trugman et al (2020) found "evidence for coordinated shifts toward communities with more drought-tolerant traits driven by tree mortality[hellip]" Anna T. Trugman, Leander D. L. Anderegg, John D. Shaw, William R. L. Anderegg 2020. Trait velocities reveal that mortality has driven widespread coordinated shifts in forest hydraulic trait composition. Proceedings of the National Academy of Sciences. Mar 2020, 201917521; DOI: 10.1073/pnas.1917521117. https://www.pnas.org/content/early/2020/03/24/1917521117.

Biologist Derek Lee points out that

[hellip] logging schemes are the latest in a series of Forest Service attempts to chainsaw their way out of a perceived problem. However, forests in the western United States have evolved to naturally self-thin

uncompetitive trees through forest fires, insects, or disease. Forest fires and other disturbances are natural elements of healthy, dynamic forest ecosystems, and have been for millennia. These processes cull the weak and make room for the continued growth and reproduction of stronger, climate-adapted trees. Remaining live trees are genetically adapted to survive the new climate conditions and their offspring are also more climate-adapted, resistant, and resilient than the trees that perished. Without genetic testing of every tree in the forest, indiscriminate thinning will remove many of the trees that are intrinsically the best-adapted to naturally survive drought, fire, and insects.

Derek Lee. January 14, 2017. Blog post: Proposed Forest Thinning Will Sabotage Natural Forest Climate Adaptation and Resistance to Drought, Fire, and Insect Outbreaks. http://dereklee.scienceblog.com/34/proposed-forest-thinning-will-sabotage-natural-forest-climate-adaptation-and-resistance-to-drought-fire-and-insect-outbreaks/

Another study shows that slower growing Ponderosa pine trees may be better adapted to survive drought. This might mean that logging prescriptions that favor removal of smaller trees might be making Ponderosa pine forests less resilient. University of Montana. June 18, 2019. Cell structure linked to longevity of slow-growing Ponderosa Pines. https://www.sciencedaily.com/releases/2019/06/190618174358.htm ("Slow-growing ponderosa pines may have a better chance of surviving longer than fast-growing ones, especially as climate change increases the frequency and intensity of drought, according to new research from the University of Montana. ... [A] key difference between fast and slow growers resides in a microscopic valve-like structure between the cells that transport water in the wood, called the pit membrane. The unique shape of this valve in slow-growing trees provides greater safety against drought, but it slows down water transport, limiting growth rate."). citing Beth Roskilly, Eric Keeling, Sharon Hood, Arnaud Giuggiola, Anna Sala. Conflicting functional effects of xylem pit structure relate to the growth-longevity trade-off in a conifer species. Proceedings of the National Academy of Sciences, 2019; 201900734 DOI: 10.1073/pnas.1900734116.

The bottom line is that nature does a good job of picking trees that are fit for survival in a stressful world. Foresters cannot predict which trees will survive drought and insects, so they will kill some trees that are relatively more fit and retain trees that are relatively less fit. This indicates that natural mortality will lead to greater forest resilience, while logging will lead to reduced forest resilience.

e360: So by trying to fix the problem, we sometimes only make it worse.

Six: As humans, we have this feeling that if something goes awry, we need to fix it, and that somehow we can. I don't think that we necessarily always know what needs to be done, or that when we do apply management that we are always actually doing the right thing. Sometimes we just need to realize that nature can sort itself out perhaps better than we can.

[hellip]

[M]odels assume that the forest is genetically homogenous, that everything is the same. And they are not. I suspect that there is a lot more genetic variability out there that will allow for more adaptation and greater persistence than we currently anticipate.

e360: You are suggesting that evolution will kick in and help to a degree?

Six: If we let it. If we don't go out and replant with stock that may not be genetically correct, if we don't thin or cut down trees that may have been selected by beetles or drought to survive. We have to get smart about how we are treating our forest if we're going to help nature's process of adaptation to proceed.

Richard Shiffman interview with Diana Six. 04 JAN 2016: INTERVIEW- How Science Can Help to Halt The

Western Bark Beetle Plague http://e360.yale.edu/content/feature.msp?id=2944

A press release from the University of Montana says:

A University of Montana researcher has discovered that mountain pine beetles may avoid certain trees within a population they normally would kill due to genetics in the trees.

UM Professor Diana Six made the discovery after studying mature whitebark and lodgepole trees that were the age and size that mountain pine beetle prefer, but had somehow escaped attack during the recent outbreak.

After DNA screening, survivor trees all contained a similar genetic makeup that was distinctly different from the general population that were mostly susceptible to the beetle.

"Our findings suggest that survivorship is genetically based and, thus, heritable," Six said, "which is what gives us hope."

...

"Our results suggest that surviving trees possess a wealth of information that can be used to inform our understanding of the genetic and phenotypic bases for resistance and to develop management approaches that support forest adaptation," Six said.

PUBLIC RELEASE: 16-AUG-2018. UM Researcher discovers genetic differences in trees untouched by mountain pine beetles. THE UNIVERSITY OF MONTANA https://www.eurekalert.org/pub_releases/2018-08/tuom-urd081618.php citing Six, Diana L.; Vergobbi, Clare; Cutter Mitchell. 2018. Are Survivors Different? Genetic-Based Selection of Trees by Mountain Pine Beetle During a Climate Change-Driven Outbreak in a High-Elevation Pine Forest. Frontiers in Plant Science 9(993). https://doi.org/10.3389/fpls.2018.00993; https://www.frontiersin.org/articles/10.3389/fpls.2018.00993/full. ("We found that surviving mature trees in a high elevation forest of whitebark and lodgepole pine were genetically distinct from "general population" trees that were assumed to represent the genetic structure of the population pre-outbreak and without selection by the beetle. In line with our hypothesis, a low percentage (<10%) of "survivor" genotypes were identified within the general population. ... We found surprisingly high levels of differentiation between survivor and general population trees in both species of pine. ... With climate change supporting the invasion of aggressive bark beetles into na[iuml]ve forests, and predictions of more frequent and severe outbreaks, it is increasingly important to understand the capacity of trees to adapt and persist (Millar et al., 2007; Ramsfield et al., 2016). ... While the massive mortality of pines in western North America in recent years is cause for concern, we should also look at these hard-hit forests as opportunities to learn. In almost all cases, affected forests are not completely dead-they retain many living large diameter trees. If these trees are genetically different than those selected and killed by the beetles as our study suggests, these trees may aid in in situ adaptation and persistence. They may also be key to developing management and trajectories that allow for forest adaptation. For example, retaining surviving trees as a primary seed source, rather than removing them during salvage operations could support in situ adaptation. In contrast, the effects of natural selection in these stands could be instantly negated by clearcutting or replanting with general seed stock. Supporting forest adaptation is critical in this time of rapid change (Millar et al., 2007). Given the great expanses of forest that are being affected by climate change and the fact that most will need to adapt in situ, it is imperative we begin to move past structural approaches to consider the genetic capacity of forest trees to adapt. The high degree of standing genetic variation found in most forest trees indicates many will have considerable ability to adapt. We need to be cognizant of adaptation that is occurring so that our management approaches act to support rather than hinder natural selection for traits needed under future conditions.")

George Wuerthner often reminds public land managers that [hellip] there is significant genetic variation in individual trees, and thinning the forest can reduce the genetic diversity of the remaining stand, in effect, reducing its "resilience" and the ability of the forest ecosystem to adapt to changing conditions. [Studies] show that ponderosa pine seedlings have tremendous variation in their adaptation to drought and mature trees ability to fend off bark beetles. Under natural conditions, the beetles and drought would [selectively] eliminate the trees without these adaptations. But the average forester with his or her paint gun marking trees has no idea of the genetic makeup of the trees they are logging. Yet I do not even hear any sense of caution from the collaborative about this matter. They are of the belief that logging creates resilience. In fact, it impoverishes the forest ecosystem.

Wuerthner, George. 3-28-2017 Email to Deschutes Collaborative via Vernita Ediger, citing Kolb, T.E., Grady, K.C., McEttrick, M.P., and A. Herrero 2017. Local-Scale Drought Adaptation of Ponderosa Pine Seedlings at Habitat Ecotones. For. Sci. 62(6), pp.641-651. http://dx.doi.org/10.5849/forsci.16-049 ("The large amount of phenotypic variation within populations suggests the potential for future evolution of stress tolerance[hellip]") and Pinnell, Sean, 2016. MS Thesis: "Resin Duct Defenses In Ponderosa Pine During A Mountain Pine Beetle Outbreak: Genetic Effects, Mortality, And Relationships With Growth" (2016). Paper 10709. http://scholarworks.umt.edu/cgi/viewcontent.cgi?article=11753&context=etd. ("Analyses at both the phenotypic and genetic levels indicated that drought significantly predisposed some trees and families to mortality [hellip]"). In a Sept 2023 guest column in the Bend Bulletin, George Wuerthner said:

We are told that chain saw medicine treatments aim to reduce large, high-severity wildfires and enable trees to survive insects, drought and disease. The problem is that the above are the evolutionary factors that have maintained "healthy" forest communities for millennia. In a sense, these evolutionary agents select which trees are best adapted to current conditions (not some past historical situation that no longer exists).

To quote the poet, Roberson Jeffers, "What but the wolf's tooth whittled so fine. The fleet limbs of the antelope?" It is the same for our forests [mdash] wildfire, drought, insects and disease are whittling the woodlands to withstand present and future challenges just as wolves select the least fit elk or deer for their prey, improving the species' overall genetic health.

https://www.bendbulletin.com/opinion/guest-column-chainsaws-are-not-medicine-for-our-forests/article_645dafa2-50c9-11ee-beaa-1bc53c575f52.html

Studies show that forests have a natural ability to weed out trees that are less likely to survive and retain trees that are more likely to survive, so that forests become progressively more resilient to stress over time. Logging can interfere with this process by choosing the wrong trees for removal and retention. Katherine Kornei 2023. Surviving a drought may help forests weather future dry spells - After a drought, California's forests withstood a second one surprisingly well. ScienceNews. JUNE 9, 2023 https://www.sciencenews.org/article/drought-forests-trees-weather-future ("Some forests take one-two punches surprisingly well. Researchers have shown that certain California forests exposed to two successive droughts weathered the second one much better than forests only hit by the later dry period. Given that the frequency and severity of droughts is increasing with climate change, the findings suggest that forested regions might fare better than predicted in the future[hellip] Norlen and Goulden speculate that the first drought eliminated trees weakened by pests like bark beetles, or perhaps that the dry conditions prompted trees to protect themselves by growing deeper roots. Those changes would have helped protect the remaining trees from future droughts, Goulden says. 'You effectively have a stronger population.'") citing C.A. Norlen and M.L. Goulden. Recent Tree Mortality Dampens Semi-Arid Forest Die-Off During Subsequent Drought. AGU Advances. Published online May 17, 2023. doi: 10.1029/2022AV000810, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2022AV000810; and X. Jiang et al. Projected Future Changes in Vegetation in Western North America in the Twenty-First Century. Journal of Climate. 2013. doi: 10.1175/JCLI-D-12-00430.1, https://journals.ametsoc.org/view/journals/clim/26/11/jcli-d-12-00430.1.xml.

Note also, Pinnell (2016) found that fast growing trees are not necessarily more fit to survive drought and insects. ("I found no evidence of a resin duct defense-growth tradeoff. [hellip] [F]aster growing families did not suffer lower mortality.") Foresters often identify stands for thinning based on their growth rate as measured by annual growth rings/inch, and they identify trees for retention based on observed vigor and form. This study indicates that these factors may not be associated with resistance to mortality. Again, foresters think they are improving forest resilience, but they may be removing trees that are more fit, and retaining trees that are less fit, leaving more ill-fitting genes in the stand to reproduce and leaving the stand less resilient over the long term.

Generally speaking, outbreaks of beetles can facilitate the development of a forest that is structurally, genetically and compositionally more diverse (Axelson et al., 2009) and therefore perhaps less prone to subsequent beetle attack (Amman, 1977). Thus, despite causing mortality of many individual trees, outbreaks can also play a critical role in ecosystem processes (Berryman, 1982).

Black, S. H., D. Kulakowski, B.R. Noon, and D. DellaSala. 2010. Insects and Roadless Forests: A Scientific Review of Causes, Consequences and Management Alternatives. National Center for Conservation Science & Policy, Ashland OR.
http://www.geosinstitute.org/images/stories/pdfs/Publications/RoadlessAreas/FireandBugReport.pdf.
http://www.xerces.org/wp-content/uploads/2010/03/insects-and-roadless-forests1.pdf

Epidemics of forest insects and pathogens have always occurred, and the selective killing of susceptible trees tends to increase overall stand fitness (Haack and Byler 1993). Spruce budworm, for example, may help maintain ecosystem health by selectively killing weaker, genetically inferior trees and thus increasing resistance to future outbreaks (Alfaro et al. 1982).

...

Mountain pine beetle epidemics are part of a natural boom-and-bust cycle (Amman 1977). Large populations of beetles selectively kill large numbers of the most susceptible trees. Killing these trees facilitates the development of a forest that is structurally, genetically, and compositionally more diverse and therefore less prone to beetle attack in the long run (Amman 1977).

Black, S.H. 2005. Logging to Control Insects: The Science and Myths Behind Managing Forest Insect "Pests." A Synthesis of Independently Reviewed Research. The Xerces Society for Invertebrate Conservation, Portland, OR. http://www.xerces.org/wp-content/uploads/2008/10/logging_to_control_insects1.pdf citing Amman, G.D. 1977. The role of the mountain pine beetle in lodge pole pine ecosystems: Impact of succession. In The Role of Arthropods in Forest Ecosystems: Proceedings in the Life Sciences, W.J. Mattson, ed. Pp. 3-18. New York: Springer-Verlag. https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1110&context=barkbeetles

Climate change is driving natural selection, but we will interfere in that process by choosing the winners and losers instead of letting natural mortality do it.

From 2012 to 2016, drought and bark beetles killed more than 129 million trees in California, most of them conifers in the Sierra Nevada. On the drier, south-facing slopes on this basin's north side, sugar pines were hit especially hard as mountain pine beetles attacked the water-starved trees, tunneling through their bark until many of them died.

"You had literally side-by-side sugar pines, one alive, one dead," said UC Davis forest biologist Patricia Maloney.

But it's not the dead trees that interested Maloney. It's the survivors.

She wanted to know how they managed to stay healthy and green despite experiencing the same parched conditions that killed their neighbors. She thinks it has to do with innate characteristics that gave them a selective advantage over their peers.

Maloney is now leading an effort to plant thousands of seedlings descended from drought-surviving sugar pines from around Lake Tahoe, hoping they carry genes that make them more resilient to drought, waning snowpack and other effects of global warming.

... [S]he sees hope in the genetic variation in local populations that allows some trees to survive while others succumb to drought and other environmental threats.

"I think what we're witnessing is contemporary natural selection. Species have been evolving for millions of years, we've just hastened the pace with climatic change and drought," Maloney explained. "Let nature and evolution in some way run its course, but we can assist in its regeneration. There is promise in these survivors. So let's work with what we have."

... Sally Aitken, a professor of forest genetics at the University of British Columbia [said] "The raw material of natural selection is genetic diversity. Increase diversity and you increase the chances of survival. It's a way of hedging your bets."

...

After the drought ended, in 2017, [Maloney] and her team selected 100 of these surviving sugar pines to be mothers to a new generation. They studied, cored and examined the rings of a portion of those trees and learned they all had at least one thing in common: They used water more efficiently than their deceased neighbors.

That ability can be passed along to the next generation, Maloney said. But they probably have other advantageous traits that she wants to study, such as when they time their spring growth, how massive their roots are and what chemicals they send out from their resin that might attract or repel beetles.

...

The 1859 discovery of the Comstock Lode in Virginia City, Nev., sparked a silver rush and a logging boom, with trees felled and ferried by raft, water flume and rail to supply lumber to the mines. Loggers cut down so many sugar pines, Maloney's research has found, that in some locations their genetic diversity suffers to this day.

TONY BARBOZA 2019. In the Sierra, scientists bet on 'survivor' trees to withstand drought and climate change. LA Times 11-18-2019. https://www.latimes.com/california/story/2019-11-18/sierra-trees-climate-change-adaptation-lake-tahoe.

Foresters are more likely to choose retention trees based on size than on cryptic features such as the size of resin ducts, but Zhao & Erbilgin (2019) showed that lodgepole pine fitness to survive mountain pine beetle attack is more closely associated with large resin ducts rather than radial growth rates.

In this study, we compared the resin duct-based anatomical defenses and radial growth between beetle-killed and live residual lodgepole pine trees... We found that tree radial growth was not associated with tree survival. The best two predictors of tree survival were resin duct size and production (number per year). Trees having larger but fewer resin ducts showed higher survival probability compared to those with smaller but more abundant resin ducts annually. ... Healthy trees had consistently larger resin ducts than declining trees in the past 20 years in post-outbreak stands. Survival trees ranked between healthy and declining trees. Overall, these results demonstrate that resin duct size of lodgepole pine trees can be an important component of tree defenses against mountain pine beetle attacks and suggest that lodgepole pine trees with large resin ducts are likely to show resistance to future bark beetle attacks. ... By increasing the volume of resin flow, larger resin ducts likely substantially reduced the probability of successful beetle colonization on residual trees by providing sticky physical barriers, sealing beetle entry wounds, and releasing toxic compounds (Franceschi et al., 2005; Erbilgin et al., 2017; Erbilgin, 2019; Mason et al., 2019). Thus, these results are in agreement with earlier studies emphasizing the importance of anatomic defenses in the survival of conifers against tree-killing bark beetle species in North America (Kane and Kolb, 2010; Ferrenberg et al., 2014; Gaylord et al., 2015; Hood and Sala, 2015; Mason et al., 2019). .... Among the anatomical characteristics measured, the number of resin ducts did not seem to be as important as their size; lodgepole pine trees with relatively smaller but more resin ducts were killed during MPB outbreak, and trees with larger but fewer resin ducts had a higher probability of survival during outbreak, suggesting a possible tradeoff between size and number of resin ducts in pine trees (Herms and Mattson, 1992). ... We provided four possible explanations to support our results.

First, larger resin ducts likely result in the storage and biosynthesis of a higher volume of resin, thereby increasing resin accumulation within the tree (Hood and Sala, 2015). Consequently, such trees could form a stronger constitutive defense line against bark beetles. Second, larger resin ducts could rapidly deploy a much higher amount of resin flow to the beetle attack points, which would increase the likelihood of the entrapment of beetles at the host entrance during initial host colonization (Schopmeyer et al., 1954; Hood and Sala, 2015; Cale et al., 2017; Erbilgin et al., 2017). Using the Poiseuille's Law, one unit increasing in the radius of resin ducts can result in resin flow increasing by a fourth power. Third, larger resin ducts can transport higher viscosity resin within trees (Tyree and Zimmermann, 2002). With higher viscosity, resin can carry higher amounts of terpenes and be more effective during beetle attack (Franceschi et al., 2005). Finally, the resin duct size of residual trees in the healthy and survived categories either remained the same or increased after MPB outbreak, suggesting possible effects of tree genetics and genetics-environment interaction on resin duct size. While some resin duct characteristics (density and production) are influenced by tree genetics in some pine species (Moreira et al., 2015; Westbrook et al., 2015), the heritability of resin duct size remains unclear in lodgepole pine and requires further investigations. Nevertheless, the survival of pine trees with larger resin ducts suggests that bark beetle outbreaks likely drive selection for better-defended lodgepole pine phenotypes. ... We consistently found enhanced anatomical defense structures in residual pine trees during post-outbreak as compared to pre-outbreak periods. This is the first report of enhanced anatomical defenses in pines after bark beetle outbreaks. Two possible post-outbreak stand conditions may explain these results. First, these stands may not provide optimal conditions for tree growth following MPB outbreaks (Cigan et al., 2015; Karst et al., 2015; Pec et al., 2017). In fact, the reduced growth in residual trees right after an outbreak in the current study may reflect less optimal growing conditions in these stands and a possible trade-off between anatomical defense and tree growth. This is expected as the growth-differentiation balance hypothesis predicts that plants favor defense over growth when resources are limited (Herms and Mattson, 1992). Second, it has been widely documented that plants, including lodgepole pine, under attack from herbivory insects can release volatile organic compounds that can alarm neighboring trees (Baldwin and Schultz, 1983; Engelberth et al., 2004; Hussain et al., 2019), which might have led to the production of additional resin ducts in the healthy trees. This explanation warrants further studies in the field.

Shiyang Zhao and Nadir Erbilgin. 2019. Larger Resin Ducts Are Linked to the Survival of Lodgepole Pine Trees During Mountain Pine Beetle Outbreak. Front. Plant Sci., 26 November 2019 | https://doi.org/10.3389/fpls.2019.01459. https://www.frontiersin.org/articles/10.3389/fpls.2019.01459/full.

Silvicultural Prescriptions Must Accurately Reflect Fuel Management Effectiveness

An implicit assumption of many logging proponents is that less fuels means less fire. This is not supported by the evidence. Less fuel does NOT mean less fire. Some fuel can actually help reduce fire, such as deciduous hardwoods that act as heat sinks (under some conditions), and dense canopy fuels that keep the forest cool and moist and help suppress the growth of surface and ladder fuels, and those canopy fuels are connected to large tree boles with thick bark that do not readily burn.

Even retaining ladder fuels can help moderate fires by blocking wind, so removing ladder fuels could increase winds and increase fire spread. Atchley Adam L., Linn Rodman, Jonko Alex, Hoffman Chad, Hyman Jeffrey D., Pimont Francois, Sieg Carolyn, Middleton Richard S. (2021) Effects of fuel spatial distribution on wildland fire behaviour. International Journal of Wildland Fire, https://doi.org/10.1071/WF20096. ("...with increased fuel density fidelity and heterogeneity, fire spread and area burned decreased owing to a combination of fuel discontinuities and increased fine-scale turbulent wind structures that blocked forward fire spread.").

We support efforts to limit the initiation and spread of crown fires (in appropriate forest types) through the reduction of fine surface fuels and (partial) treatment of ladder fuels to increase the crown base height, but we oppose efforts to heavily thin the overstory canopy in an effort control crown-to-crown fire spread. The most significant effect of this type of heavy thinning is to increase the warming and drying of surface fuels and to increase the growth of ladder fuels, both of which significantly detract of the risk reduction objectives and are expensive to treat. The NEPA analysis must address the complex effects of thinning including low likelihood that fuel treatments will interact with fire and the tendencies for fuel treatments to both reduce and increase fire hazard. The description of the "no action" alternative must recognize that "High overstory density can be resilient" when ladder fuel are absent and there is a gap between surface and canopy fuels. Terrie Jain (2009) Logic Paths for Approaching Restoration: A Scientist's Perspective, from Workshop: Restoring Westside Dry Forests - Planning and Analysis for Restoring Westside Cascade Dry Forest Ecosystems: A focus on Systems Dominated by Douglas-fir, Ponderosa Pine, Incense Cedar, and so on. May 28, 2009. http://ecoshare.info/projects/central-cascade-adaptive-management-partnership/workshops/restoring-westside-dry-forests/

Dominick DellaSala explained why thinning for fuel reduction is not always a good idea:

Can [thinning] work on fires - maybe

It depends on many factors all coming together at once. You have to

1 - leave all fire resistant large trees alone

2 - you have to maintain the overstory canopy

3 - you have to remove the slash

4 - you have to keep an understory - seldom is a reference condition used

5 - you have to pray that the thinned site encounters a fire - good luck with that!

6 - you have to keep coming back

7 - it only "works" in low-moderate fire weather

If all of those factors are present - rarely - then you can reduce fire line intensity - if that's the objective. But guess what? In a changing climate, those conditions are the "black swan" - a rare event that is unpredictable and unusual.

[hellip]

[hellip] trust is earned esp when it comes to the agencies. Can they be trusted? Maybe but definitely not always!

[hellip]

My preference is to girdle trees, tip them into streams, create snags when there are "too many firs" in the "drip line of a pine" or there are drought concerns. Will that happen? Of course not, but that's what my science brain free of any influence from federal funding thinning doublespeak tells me is the right thing to do.

Dominick DellaSala. 30 Dec 2022. Why I am thinning agnostic. Citing DellaSala, Ingalsbee, Hanson 2018. EVERYTHING YOU WANTED TO KNOW ABOUT WILDLAND FIRES IN FORESTS BUT WERE AFRAID TO ASK: LESSONS LEARNED, WAYS FORWARD. https://wild-heritage.org/wp-content/uploads/2020/10/wildfire-report-2018.pdf

A review of fuel management efforts reveals that funding priorities emphasize less effective activities such as fire suppression and fuel reduction, while neglecting the most effectiveness fire mitigation strategies, e.g., focusing on the built environment and prescribed fire). Dale & Barrett 2023. Missing the Mark: Effectiveness and Funding in Community Wildfire Risk Reduction. https://headwaterseconomics.org/wp-content/uploads/HE_2023_Missing-the-Mark-Wildfire.pdf. ("This analysis concludes that the most effective policies for reducing community wildfire risk tend to be those that manage the built environment, including mandated building codes and home hardening. Those policies are also among the least funded or supported. Managing fuels, especially on private lands near homes, was also found to be effective, as it can reduce risks to communities, but is similarly underfunded. Meanwhile, policies such as broad wildfire suppression are regularly funded but do little to reduce risk to communities and actually contribute to increasing risk over time. [hellip] This analysis demonstrates that we have multiple opportunities to reduce wildfire risk to communities if we strategically target funding to the most efficacious policies and programs.").

Reinhardt et al (2008) summarized several important consideration, cautions, and trade-offs when using thinning to reduce fuels. Elizabeth D. Reinhardt, Robert E. Keane, David E. Calkin, Jack D. Cohen 2008. Objectives and considerations for wildland fuel treatment in forested ecosystems of the interior western United States. Forest Ecology and Management 256 (2008) 1997-2006. https://web.archive.org/web/20210829155347/http://www.fs.fed.us/rm/pubs_other/rmrs_2008_reinhardt_e001.pdf .

Contents

[hellip]

Wildlands cannot be fire-proofed.

Fuel treatments in wildlands should focus on creating conditions in which fire can occur without devastating consequences, rather than on creating conditions conducive to fire suppression.

Even extensive fuel treatments may not reduce the amount of area burned over the long-term and furthermore, reduction of area burned may actually be an undesirable outcome.

Fuel treatments should not be driven by a primary objective of reducing fire's rate-of-spread.

Treating fuels may not reduce suppression expenditures.

Treating fuels may not improve ecosystem health.

Treating fuels will not restore pre-European settlement conditions.

[hellip]

The need for site specific analysis.

Treating fuels by thinning stands to prevent crown fires.

Spatially designing fuel treatments to protect untreated areas.

Need for repeated fuel treatments.

BLM reviewed the effects of forest management at the landscape scale in SW Oregon and found that -

The BLM-administered lands constitute only a small portion of the entire interior/south dry forest landscape. Consequently, the modest shifts under any alternative would not result in any substantial change in the overall landscape fire resilience.

BLM RMP Revisions for Western Oregon DEIS, Vol I, p 173.
http://www.blm.gov/or/plans/rmpswesternoregon/files/draft/RMP_EIS_Volume1_pg_173-235.pdf

A recent review of the effectiveness of fuel reduction practices on federal lands in the Continental United Sates found - "Overall, 6.8% of [fuel] treatment units evaluated were encountered by a subsequent fire during the [15 year] study period.

SEE LETTER SUBMISSION: Encounter rate (%)

"[T]his study[hellip] used standardized spatial datasets of fire and fuel treatments to systematically quantify the frequency, extent, and geographic variation of fire and fuel treatment interactions on federal lands across the CONUS. [hellip] [including] a sample of 3908 unique fire events that occurred between 2000 and 2013 on federal lands in the CONUS [that] burned a total of 18,851,801 ha." This study brings into question the effectiveness of fuel treatment investments.

One principal critique of fuel treatments is that their benefits are rarely realized because of the low likelihood that an unplanned fire will encounter a previously treated area during its effective lifespan. [hellip] Characterizing interactions among fuel treatments and wildland fires at broad spatial and temporal scales is an important step to track investments made in fuels reduction programs. [hellip] Treated area was relatively high across the western CONUS but did not correlate to encounter rates (Spearman's r = 0.12); several western ecoregions had high treated area but a low encounter rate (e.g., Northwestern Rocky Mountains, Cascade Mountain Range, and Blue Mountain Region of the Columbia Plateau). This finding has implications for fuels treatment planning in the western US because simply treating more area may not help to achieve long-term fire and land management goals if wildland fire cannot be safely managed.

Kevin Barnett, Sean A. Parks, Carol Miller, and Helen T. Naughton. 2016. Beyond Fuel Treatment Effectiveness: Characterizing Interactions between Fire and Treatments in the US. Forests [open access] 2016, 7, 237; doi:10.3390/f7100237. http://www.mdpi.com/1999-4907/7/10/237

A review of fuel treatment effectiveness after the Rim fire said:

[Restored forest] Plots that burned on days with strong plume activity experienced moderate- to high-severity fire effects regardless of forest conditions, fire history or topography. Fire severity was also highly negatively associated with elevation, with lower severity observed in plots over [hellip] Our results suggest that wildfire burning under extreme weather conditions, as is often the case with fires that escape initial attack, can produce large areas of high-severity fire even in fuels-reduced forests with restored fire regime.

Lydersena, J.M., North, M.P., and B.M. Collins 2014. Severity of an uncharacteristically large wildfire, the Rim Fire, in forests with relatively restored frequent fire regimes. Forest Ecology and Management 328 (2014) 326-334.

A review of studies of fuel treatment effectiveness brings into question the effectiveness of fuel reduction, especially when it is accomplished with commercial timber sales. The NEPA analysis needs to clearly disclose the extent to which commercial log extraction undermines fuel hazard reduction objectives.

Ex et al. (2019) addressed a question that is applicable to many montane landscapes in western North America that contain a patchwork of cover types associated with different topographic settings. They asked whether it would be more effective to treat more mesic north-facing slopes dominated by Douglas fir versus more xeric south-facing slopes dominated by ponderosa pine, given a one-time treatment opportunity at the start of a 50-year simulation. The south-facing slope strategy was initially more effective, but after the first decade, effects of the two strategies became more similar, and both strategies were ultimately less effective than the untreated control at reducing the ratio of crown fire to surface fire (Ex et al. 2019).

[hellip]

Studies that compared fuel treatment scenarios with scenarios where the main objective was commercial timber harvest (or a combination of harvest and fuel reduction) showed that harvest-oriented scenarios tended to be less effective at reducing fire impacts (Fig. 11; Merzenich et al. 2003; Ganz et al. 2007; Kim et al. 2009; Cassell 2018; Krofcheck et al. 2019b) and sometimes even resulted in increased fire impacts compared to untreated scenarios (Merzenich et al. 2003) [hellip] Prescriptions aimed at restoring historical forest structure also tended to be less effective [hellip]

[hellip]

Sturtevant et al. (2009) found that eliminating ignitions caused by debris burning had a greater effect than fuel treatments on reducing area burned by wildfire on a forested landscape in northern Wisconsin.

[hellip]

Tradeoffs between wildfire protection and other management objectives such as commercial harvest, forest restoration, habitat protection, and carbon sequestration may need to be addressed on many managed landscapes (Stockmann et al. 2010; Ager et al. 2016, 2019; Stevens et al. 2016; James et al. 2018). Potential strategies for dealing with these tradeoffs include adjustments to harvesting procedures or restoration prescriptions to make them better aligned with fuel reduction goals (Acuna et al. 2010; Stephens et al. 2021) or the use of optimization algorithms to identify management solutions that could maximize a set of competing benefits (Hummel and Calkin 2005; Bagdon et al. 2016; Kreitler et al. 2020).

[hellip] [S]ingle-year studies did not capture feedbacks between fuel treatments, wildfire, and vegetation succession, such as the possibility that short-term reductions in wildfire due to treatments allow greater fuel buildup leading to more damaging subsequent wildfires (Calkin et al. 2015; Parks et al. 2016; McKenzie and Littell 2017).

Ott, J.E., Kilkenny, F.F. & Jain, T.B. Fuel treatment effectiveness at the landscape scale: a systematic review of simulation studies comparing treatment scenarios in North America. Fire ecol 19, 10 (2023). https://doi.org/10.1186/s42408-022-00163-2. https://fireecology.springeropen.com/counter/pdf/10.1186/s42408-022-00163-2.pdf citing Ex, S.A., J.P. Ziegler, W.T. Tinkham, and C.M. Hoffman. 2019. Long-term impacts of fuel treatment placement with respect to forest cover type on potential fire behavior across a mountainous landscape. Forests 10 (5): 438. https://doi.org/10.3390/f10050438.

Crown fire does not necessarily threaten destruction of homes, and managing for surface fire does not necessarily protect homes.

The Hayman Fire, in Colorado in June 2002, burned 132 houses[mdash]70 houses (53%) were surrounded by crown fire, while 62 houses (47%) were surrounded by surface fire.16 In addition, 662 homes (83% of all homes within the fire perimeter) survived the fire, even though 35% of the area was severely burned and 16% was moderately burned.17 This suggests that at least some of the structures survived despite a crown fire around them.

Kelsi Bracmort, Congressional Research Service. Wildfire Protection in the Wildland-Urban Interface. 7-5700. RS21880. January 2014. http://fas.org/sgp/crs/misc/RS21880.pdf footnotes citing 16 Jack Cohen and Rick Stratton, "Home Destruction Within the Hayman Fire Perimeter," Hayman Fire Case Study, Gen. Tech. Rept. RMRS-GTR-114 (Ft. Collins, CO: USDA Forest Service, September 2003), p. 264. 17 Peter Robichaud, Lee MacDonald, Jeff Freeouf, Dan Neary, Deborah Martin, and Louise Ashman, "Postfire Rehabilitation of the Hayman Fire," Hayman Fire Case Study, Gen. Tech. Rept. RMRS-GTR-114 (Ft. Collins, CO: USDA Forest Service, September 2003), p. 294.

Another study looked at tree survival after fire in a mixed conifer forest in Idaho. "Tree survival 8-13 years after fire depended on complex interactions between species, size, and initial burn severity. [hellip] Greater relative abundance of fire-tolerant larch was associated with reduced levels of mortality at community scales. Interestingly, higher tree densities were either uncorrelated with community-level mortality or associated with lower community-level mortality." R. Travis Belote, Andrew J. Larson, Matthew S. Dietz. 2015. In press. Tree survival scales to community-level effects following mixed-severity fire in a mixed-conifer forest. Forest Ecology and Management xxx (2015) xxx-xxx.

The actual effects of fuel reduction on wildfires is highly variable and fairly modest.

Analysis of simulation results from the 14 wildfires indicates that fuels treatments reduced the average size of any given wildfire by an estimated 7.2%, with amount of change correlated with the proportion of the landscape treated (Spearman's correlation p=0.692, n=14; P=0.008). The size effects were highly variable among fires, ranging from -63.6 to 46.1%. Eleven of the fourteen individual wildfires had net size reductions (average -13.2%) in burned area owing to the combined effects of all landscape fuels treatments, whereas three had average increases in area burned (average 24.1%)

[hellip]

[T]he Kelsay and Boulder fires are from similar mixed-conifer forests in Oregon, with combinations of Douglas fir, ponderosa pine, lodgepole pine (Pinus contorta) and western hemlock (Tsuga heterophylla). Both were characterised by patchwork clearcuts, averaging ~5 ha in size, that had experienced mastication or prescribed burning and replanting, with most (90%) occurring 5-30 years before the fire [hellip] [T]he simulated exacerbation of overall fire spread rates is still realistic owing to increased crown fire prevalence caused by the continuous, even-aged fuel complexes of the treated areas.

[hellip]

[N]o simple relationships exist between changes in fire size and the treated percentage of the landscape.

[hellip]

These forest management activities represent a trade-off between formation of large areas with low probabilities of increased burning and increased certainty of substantially reduced fire risks in known portions of landscapes, combined with modestly reduced fire extents. This patterning holds promise for using fuels treatments to reduce fire risk in wildland-urban interfaces and other regions of perceived value, reinforcing calls for greater concentration of future fuels treatments in these inhabited areas (Schoennagel et al. 2009)

M. A. Cochrane, C. J. Moran, M. C. Wimberly, A. D. Baer, M. A. Finney, K. L. Beckendorf, J. Eidenshink, and Z. Zhu. 2012. Estimation of wildfire size and risk changes due to fuels treatments. International Journal of Wildland Fire. http://dx.doi.org/10.1071/WF11079. http://www.publish.csiro.au/?act=view_file&file_id=WF11079.pdf. This raises a serious question whether the adverse habitat effects of landscape fuel treatments are off-set by modified fire effects.

Geoffrey J. Cary, Ian D. Davies, Ross A. Bradstock . Robert E. Keane, Mike D. Flannigan. 2016. Importance of fuel treatment for limiting moderate-to-high intensity fire: findings from comparative fire modelling. Landscape Ecol. Aug 2016. DOI 10.1007/s10980-016-0420-8. ("Our key objective was to determine the importance of fuel treatment effort, relative to the other factors, when considering area burned by moderate-to-high intensity unplanned fire, compared to an identical analysis involving total unplanned area burned. [hellip] In each model, IME [ignition management effort] and WY [weather year] were markedly more important than FTE [fuel treatment effort] in explaining area burned by moderate-to-high intensity unplanned fire, consistent with the result for total area burned. [hellip] in all cases the magnitude of the effect of FTE in reducing area burned in total, or area burned with moderate-to-high fire intensity, was less than that resulting from IME and WY variations. [hellip] FTE was ranked the least important influence by a considerable margin for each model [hellip] Therefore, it is reasonable to conclude that, at the landscape level, increasing fuel management effort did not further reduce, compared with the reduction in total area burned, the area of moderate-to-high intensity fire that (i) is beyond control by remote fire crews. [hellip]")

The Report to the President that forms the foundation for the National Fire Plan recommends that we "Invest in Projects to Reduce Fire Risk. Addressing the brush, small trees, and downed material that have accumulated in many forests because of past management activities, especially a century of suppressing wildland fires, will require significant investments to treat landscapes through thinning and prescribed fire." Whitehouse. Managing the Impact of Wildfires on Communities and the Environment. A Report to the President In Response to the Wildfires of 2000. September 8, 2000. http://www.forestsandrangelands.gov/resources/reports/documents/2001/8-20-en.pdf The main point here is that the fuels that need to be removed are small fuels, including brush and down wood that will require "investments" as opposed to commercial sized material. Similarly, [E]ven when considered under the most favorable of assumptions, most densely stocked stands would not be treatable without significant investments. Rainville, Robert; White, Rachel; Barbour, Jamie, tech. eds. 2008. Assessment of timber availability from forest restoration within the Blue Mountains of Oregon. Gen. Tech. Rep. PNW-GTR-752. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 65 p. http://www.fs.fed.us/pnw/pubs/pnw_gtr752.pdf. And "Restoration of an old-forest network carries with it long-term management costs with little commodity production." Everett, R., P. Hessburg, J. Lehmkuhl, M. Jensen, and P. Bourgeron. 1994. Old Forests in Dynamic Landscapes: Dry-Site Forests of Eastern Oregon and Washington. Journal of Forestry 92: 22-25.

Collins et al. (2011) found that diameter limits of 30.5 cm (12 in.) was just about as effective at reducing high-intensity fire as larger diameter limits of 50.8 cm (20 in.) and 76.2 cm (30 in.). Collins, B.M., S.L. Stephens, G.B. Roller, and J.J. Battles. 2011. Simulating fire and forest dynamics for a landscape fuel treatment project in the Sierra Nevada. Forest Science 57 (2): 77-88.

The NEPA document must address the fact that there is very little scientific support for aggressive thinning to reduce fire hazard. In fact, there is mounting scientific evidence that thinning can make the fuel hazard worse instead of better. Thinning makes forests "Hotter, Drier and Winder." Science still has a long way to go to be able to confidently predict the consequences of various combinations of thinning and other treatments. "Detailed site-specific data on anything beyond basic forest structure and fuel properties are rare, limiting our analytical capability to prescribe management actions to achieve desired conditions for altering fuels and fire hazard." Graham, Russell T.; McCaffrey, Sarah; Jain, Theresa B.(tech. eds.) 2004. Science basis for changing forest structure to modify wildfire behavior and severity. Gen. Tech. Rep. RMRS-GTR-120. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 43 p. https://www.fs.usda.gov/rm/pubs/rmrs_gtr120.pdf.

The agency must recognize that canopy thinning has complex effects of fuel and fire hazard. Canopy thinning makes the stand hotter, drier, windier, produces lots of slash, and stimulates the growth of ladder fuels.

In many forests, latent ladder fuels exist in the form of advance regeneration[mdash]seedlings and saplings occurring in the understory that are capable of accelerated growth upon disturbance to (or cutting of) the overstory. [hellip] [D]ry mixed conifer forests often include species with high or moderate shade tolerance, and advance regeneration of those species beneath a ponderosa pine dominated canopy is common. The rate of accelerated growth upon treatment is proportional to site quality and thinning intensity.

Ladder fuel growth is governed by the number and sizes of overstory trees. [Overstory trees] can help fuel managers identify cutting levels that meet fuels management goals yet suppress seedling (ladder fuel) growth.

[hellip] [R]etaining more and larger trees serves to suppress ladder fuel development.

[hellip]

Fuel treatments directly affect the recruitment of ladder fuels by the extent to which bare mineral soil is exposed. Treatments that burn or scarify the forest floor will generally result in the accelerated recruitment of new ladder fuels. Commercial thinning, for example, scarifies the forest floor and provides a mineral soil seedbed that enhances ponderosa pine seedling germination and survival (Oliver and Ryker 1990), increases light to the forest floor that facilitates litter decomposition, and enhances the growth and fecundity of residual trees that can result in greater seed production. [hellip] [M]echanical and prescribed fire treatments that result in greater ground disturbance will typically result in less longevity than treatments that minimize forest floor scarification.

SEE LETTER SUBMISSION: Figure 12.2

Jain, Theresa B.; Battaglia, Mike A.; Han, Han-Sup; Graham, Russell T.; Keyes, Christopher R.; Fried, Jeremy S.; Sandquist, Jonathan E. 2012. A comprehensive guide to fuel management practices for dry mixed conifer forests in the northwestern United States. USDA Forest Service Gen. Tech. Rep. RMRS-GTR-292. 2012 https://www.fs.usda.gov/rm/pubs/rmrs_gtr292.pdf. A meta-analysis of the effects of partial cutting showed that understory growth was stimulated in all cases. D. Zhou, S. Q. Zhao, S. Liu, and J. Oeding. 2013. A meta-analysis on the impacts of partial cutting on forest structure and carbon storage. Biogeosciences, 10, 3691-3703, 2013. https://www.biogeosciences.net/10/3691/2013/bg-10-3691-2013.pdf. ("Understory C was stimulated significantly by partial cutting in all of the studies. This stimulation can be mostly attributed to an increase in the availability of light, water, and nutrients to the understory because of tree removal (Aussenac, 2000; Kleintjes et al., 2004; Deal, 2007)")

Because the fire environment components are interrelated, changes in one component can set off a chain of reactions that will cause changes in others. For example, cutting a timber stand will change the radiation receiving surfaces so that it will be heated more strongly, raising the air temperature in a cleared area. Because relative humidity varies with temperature, the relative humidity will be lowered. The moisture content of the dead fuel is dependent on both temperature and humidity; hence, the moisture content will also be lowered.

Removal of the trees that restrict the airflow, and the more active convection resulting from the higher temperature, can alter the airflow pattern. Thus, the fire environment - and the fire behavior - in the cutover area will probably be much altered, not only because the fuel characteristics are changed, but because the weather characteristics are also changed.

Clive M. Countryman.1972. THE FIRE ENVIRONMENT CONCEPT. PACIFIC SOUTHWEST. Forest and Ranger Experiment Station. Revised for inclusion in Intermediate Wildland Fire Behavior, S-290. May 1992.

Page 771 of BLM's 2007 WOPR DEIS admits that "The greater than canopy retained, the less influence wind has on surface fire. This in turn reduces flame length which can lead to reduced mortality. (Fire Behavior Field Reference Guide: NFES 2224)."

UQ Professor and Wildlife Conservation Society Director James Watson said logging regimes have made many forests more fire prone for a host of reasons. "Logging causes a rise in fuel loads, increases potential drying of wet forests and causes a decrease in forest height," Professor Watson said.

University of Queensland News Release. 2020. Recent Australian wildfires made worse by logging. 6 May 2020. https://www.uq.edu.au/news/article/2020/05/recent-australian-wildfires-made-worse-logging citing Lindenmayer, D.B., Kooyman, R.M., Taylor, C. et al. Recent Australian wildfires made worse by logging and associated forest management. Nat Ecol Evol (2020). https://doi.org/10.1038/s41559-020-1195-5 .

Proposals for increased logging on public lands in Australia in the aftermath of the 2020 wildfires, lead to relevant scientific criticism:

Scientists warn a timber industry proposal to allow some logging in national parks and on other public land to reduce bushfire risk is an "incredibly misleading" idea that could actually make forests more flammable.

...

Australian National University landscape ecology expert Professor David Lindenmayer said multiple academic and forest industry studies showed forest thinning in Australia "makes forests more fire prone".

"It [thinning and mechanical fuel reduction] is a misleading argument that is simply wrong," Prof Lindenmayer said.

Forest and fire expert Professor Philip Zylstra from Curtin University said while thinning trees might sound like a simple way to reduce fuel loads and with it fire risk, it would actually make the forest more flammable.

"Before thinning is used as a hazard reduction tool, there should be evidence to underpin it," he said. "The mechanisms that drive fire lead us to expect thinning will make fires worse.

"Thinning trees would allow stronger winds access to fires burning beneath the trees. Also the more open a tree canopy is, the more able fire is to spread because the leaf litter will be drier from more light coming through and there will be a more dense shrub layer due to increased light for plants - that will make fires far more intense."

...

Prof Zylstra said thinning and fuel reduction wouldn't be feasible across broad areas but could be used close to homes, although cleared zones would be more effective.

"You couldn't do that on a landscape scale. It would have to be focused on asset- protection zones where you can get vehicles in to fight fires," he said.

Professor Lindenmayer also said doing mechanical fuel reduction on a scale required to be effective would be too expensive and damage the environment.

"You would need a huge road network to cart the wood-chipped undergrowth and we know roads are one of the major ignition sources for bushfires, and building that many roads would cost a fortune," he said. "More intervention in forests will also have a big negative impact on biodiversity.

"I know why the industry is talking about this, they have run out of timber [hellip] this is crass opportunism to take advantage of a catastrophe."

Foley, M. 2020. Scientists warn forest industry plan could increase fire risk. The Sydney Morning Herald. Jan 9, 2020. https://www.smh.com.au/politics/federal/scientists-warn-forest-industry-plan-could-increase-fire-risk-20200109-p53q4u.html.

In my experience, logging a forest to stop the spread of fire is rarely justified. Trees left standing after logging often suffer mechanical damage to their root systems and bark from falling and skidding operations, leaving them prone to disease and drought stress long into the future. Heavily thinned stands will contain less potential fuel as standing green timber, but will have heavier ground fuel loads in the form of logging slash and the flashy light fuels and brush which grow in the absence of forest canopy shade. In open areas that have been logged, fuels tend to be much drier, and fires are more likely to be wind-driven, with a higher Rate of Spread and a greater Energy Release Component than would occur in shaded areas with wind breaks.

Declaration of retired Forest Service employee Richard J. Haydon in FSEEE v. USFS, Case 2:16-cv-00293 http://fseee.org/attachments/1004659_usfs%20complaint.pdf.

In a study that sought to identify the controlling variables related to fire severity for the Rim Fire in the Sierras, "Forest management variables showed low overall variable importance regardless of the management action for both reburned and fire-excluded areas. [hellip] Results confirm that low- and moderate-severity fire can mitigate subsequent wildfire severity, even under extreme fire weather, regardless of past management history. In these environments, prescribed burning alone, or as a surface treatment following mechanical operations, has high utility in restoring historical fire regime properties and concomitant ecological processes, as well as allowing forests to adapt to future predicted increases in temperature and drought (Williams et al. 2015)." Nicholas A. Povak, Van R. Kane, Brandon M. Collins, Jamie M. Lydersen, Jonathan T. Kane. 2020. Multi-scaled drivers of severity patterns vary across land ownerships for the 2013 Rim Fire, California. Landscape Ecol (2020) 35:293-318. https://doi.org/10.1007/s10980-019-00947-z;
https://www.fs.usda.gov/pnw/pubs/journals/pnw_2020_povak001.pdf.

In a study of fuel treatment effectiveness on the Klamath National Forest, Vaillant et al. (2014) found that both mechanical fuel treatments and prescribed fire -

"resulted in increased live understory vegetation by 8 yr post-treatment relative to pretreatment [hellip] [and] Surface fire flame lengths were initially reduced as a result of prescribed fire, but by 10 yr post-treatment they exceeded the pre-treatment lengths. [hellip] Mechanical treatments showed variable and minimal effects on surface fire flame length over time [hellip] Overall, modeled fire behavior in mechanical treatments showed that goals of reduced fire behavior were initially reached, and then began diminishing around 5 to 8 yr post-treatment, with some positive changes still apparent through 8 yr posttreatment."

Vaillant et al. 2014. Effectiveness and longevity of fuel treatments in coniferous forests across California - Managers' Report: Klamath National Forest. JFSP Grant 09-1-01-1. https://web.archive.org/web/20161129000245/http://www.firescience.gov/projects/09-1-01-1/project/09-1-01-1_ManagersReport_KNF.pdf. Similar results were reported on the Six Rivers NF. https://web.archive.org/web/20160707035548/http://www.firescience.gov/projects/09-1-01-1/project/09-1-01-1_ManagersReport_SRF.pdf. This indicates that fuel treatment effects are modest and short-lived. The habitat effects however can be long-term, especially with respect to deadwood habitat recruitment when canopy fuels are targeted. The NEPA analysis needs to weigh the short-term benefits and the long-term costs of fuel reduction.

***FIRE WEATHER, a joint U. S. Department of Commerce and U. S. Department of Agriculture document, is a 229 page detailed, scientific explanation, which explains *closed canopy forest* as one which *provides a variety of benefits that decrease the risk of forest fires *and states that* all features of the environment that affect heating and cooling are _significant_. *

The forest canopy of dense timber stands *shades the ground and the forest fuels from elevated temperatures from solar radiation*. The forest canopy *radiates out the heat* accumulated from solar radiation. The forest canopy *provides moisture by transpiration through the leaves* to the air and forest fuels, which decreases the possibility of forest fires. *Transpiration from an area of dense vegetation can contribute up to eight times as much moisture to the atmosphere as can an equal area of bare ground*. The forest canopy *slows down wind* movement and fire progress, due to its large friction area. A forest with a dense understory* is an effective barrier to downslope winds*.

The two most important weather, or weather-related, elements affecting wildland fire behavior are wind and fuel moisture. Wind affects wildfire in many ways. It carries away moisture-laden air and hastens the drying of forest fuels. *Logs under a forest canopy remain more moist (approximately 25% more moist) through the season than those exposed to the sun and wind.* The flow beneath a dense canopy is affected only slightly by thermal turbulence, except where holes let the sun strike bare ground or litter on the forest floor, causing local heating. Convective winds have their origin in local temperature differences. The nature and strength of convective winds vary with many other factors. Since they are temperature-dependent*, all features of the environment that affect heating and cooling are significant. *Even small openings in a moderate to dense timber stand may become warm air pockets during the day. These openings often act as natural chimneys and may accelerate the rate of burning of surface fires. Temperature of forest fuels, and of the air around and above them, is one of the key factors in determining how wildland fires start and spread.

Logging and logging roads open the forest canopy and increase the temperature of the air, the ground and the forest fuels, which accelerate the rate of burning of surface fires. Logging and logging roads open the forest canopy and lower humidity of forest fuels, which increases the flammability of forest fuels and critically influences the behavior of wildland fires. Logging and logging roads open the forest canopy and may cause rapid and intense fire spread.

Mark J. Schroeder & Charles C. Buck. 1977. FIRE WEATHER... A Guide For Application Of Meteorological Information To Forest Fire Control Operations. U.S. Government Printing Office: 0-244 :923, first printed in May 1970. AGRICULTURE HANDBOOK 360. Reviewed and approved for reprinting August 1977. Stock No. 001-000-0193-0 / Catalog No. A 1.76:360. https://www.frames.gov/documents/behaveplus/publications/Schroeder_and_Buck_1970_PMS-425-1_NFES-1174_Fire_Wx_all.pdf.

In a mixed-conifer, mixed-severity fire regime study area in SW Oregon, Crystal Raymond found that "Fire severity was greater in thinned treatments than untreated. [hellip] The additional fine wood left from the thinning operation (despite whole-tree yarding) most likely caused higher fire intensity and severity in the thinned treatments."

[hellip] [T]he presence of activity fuels increased potential surface fire intensity, so increases in canopy base height did not decrease the potential for crown fire initiation. [hellip] [C]rown fire is not a prerequisite for high fire severity; damage and mortality of overstory trees in the wildfire was extensive despite the absence of crown fire, and the low predicted crown fire potential before and after the fuel treatment. Damage to and mortality of overstory trees were most severe in thinned treatments (80 - 100% mortality), least severe in the thinned and under-burned treatment (5% mortality), and moderate in untreated stands (53-54% mortality) following a wildfire in 2002. Fine fuel loading was the only fuel structure variable significantly correlated with crown scorch of overstory trees. Percentage crown scorch was the best predictor of mortality 2 years post-fire. Efforts to reduce canopy fuels through thinning treatments may be rendered ineffective if not accompanied by adequate reduction in surface fuels.

Crystal L. Raymond. 2004. The Effects of Fuel Treatments on Fire Severity in a Mixed-Evergreen Forest of Southwestern Oregon. MS Thesis. http://depts.washington.edu/nwfire/publication/Raymond_2004.pdf. Raymond also found that "A greater percentage of pre-fire fine wood was consumed in the thinned plots than in the unthinned plots during the Biscuit fire suggesting that fine fuel moisture may have been lower in the thinned plots." And "the Biscuit Fire was observed to have more moderate fire behavior in stands with a sub-canopy tree layer compared to more open stands, suggesting that the subcanopy trees did not function as ladder fuels. [hellip] Higher foliar moisture of broad-leaved species could have dampened fire behavior, inhibiting rather than aiding crown fire initiation."

Similarly, Hanson and Odion (2006) compared wildfire behavior in seven previously thinned mixed-conifer forests vs. adjacent unthinned forest in the Sierra Nevada and found [mdash]

Contrary to our hypothesis, the mechanically thinned areas had significantly higher fire-induced mortality (p =.016, df = 6) and combined mortality (p =.008, df = 6) than the adjacent unthinned areas. Thinned areas predominantly burned at high severity, while unthinned areas burned predominantly at low and moderate severity [hellip] Possible explanations for the increased severity in thinned areas include persistence of activity fuels, enhanced growth of combustible brush post-logging, desiccation and heating of surface fuels from increased insolation, and increased mid-flame windspeeds. Given that sampling transects in thinned versus unthinned areas were only 100 m apart in each experimental unit, fire weather should have been the same for the thinned and unthinned areas sampled in each site. Thus, mechanical thinning on these sites appears to have effectively lowered the fire weather threshold necessary for high severity fire occurrence.

Hanson and Odion. 2006. Fire Severity In Mechanically Thinned Versus Unthinned Forests of the Sierra Nevada, California 2006 Fire Congress Proceedings.
ftp://ftp2.fs.fed.us/incoming/r5/VMS/reference_library/Fire%20and%20Fuels%20References/Hanson%20and%20Odion%20%202006%20Fire%20severity%20in%20thinned%20vs%20unthinned%20forests%20.pdf

Similar results were demonstrated in a review of the fuel treatments that preceded the American River Complex of fires. Hugh Safford, USDA Forest Service, Pacific Southwest Regional Ecologist. Fire Severity in Fuel Treatments - American River Complex fire, Tahoe National Forest, California, June 21 - August 1, 2008. http://www.sierraforestlegacy.org/Resources/Conservation/FireForestEcology/FireScienceResearch/FuelsManagement/FM-AmRivComplex8-2008.pdf ("masticated units appears to have abetted rather than resisted fire.... only one treatment succeeded in both forcing fire to the surface and preserving most of the stand. The successful treatment was the only one which appeared to have had explicit reduction and removal of ladder and surface fuels. Crown thinning removes combustible biomass from the target stand, but is unlikely to represent sufficient treatment to guarantee desired fuel treatment performance under typical wildfire conditions. [hellip] Mastication does not remove fuels from the site, but redistributes them (Figure 19). By design, mastication reduces the ladder fuel effect but increases surface fuels. Until the masticated fuels decompose, they are also much drier and more easily ignited than live fuels. [hellip] All but one of the [thinning] fuel treatments we visited in mature forest experienced moderate to severe fire effects. It is probably no coincidence that the exception (Texas Hill Spring) was the only treatment where both reduction and removal of surface and ladder fuels had been (apparently) accomplished[hellip]. The cost of cutting small trees and removing natural surface fuels is prohibitive and this situation - where commercial thinning has been accomplished but it has been followed by little or no explicit treatment of ladder fuels or natural surface fuels - is common on National Forest land across California. [hellip] Agee and Skinner [2005, For. Ecol & Mgt., vol. 211:83-96]) note that crown thinning alone is not likely to meaningfully change potential fire behavior or effects. Events on the American River Complex fire support these general findings.")

A study in mixed-conifer forests in California showed that forest reserves were more effective than logging in terms of reducing fire hazard.

[T]he efficacy of seven traditional silvicultural systems and two types of reserves used in the Sierra Nevada mixed conifer forests is evaluated in terms of vegetation structure, fuel bed characteristics, modeled fire behavior, and potential wildfire related mortality. The systems include old-growth reserve, young-growth reserve, thinning from below, individual tree selection, overstory removal, and four types of plantations. These are the most commonly used silvicultural systems and reserves on federal, state, and private lands in the western United States. Each silvicultural system or reserve had three replicates and varied in size from 15 to 25 ha; a systematic design of plots was used to collect tree and fuel information. The majority of the traditional silvicultural systems examined in this work (all plantation treatments, overstory removal, individual tree selection) did not effectively reduce potential fire behavior and effects, especially wildfire induced tree mortality at high and extreme fire weather conditions. Overall, thinning from below, and old-growth and young-growth reserves were more effective at reducing predicted tree mortality.

Scott L. Stephens and Jason J. Moghaddas. 2005. Silvicultural and reserve impacts on potential fire behavior and forest conservation: Twenty-five years of experience from Sierra Nevada mixed conifer forests. Biological Conservation 125 (2005) 369-379.

Thinning opens stands to greater solar radiation and wind movement, resulting in warmer temperatures and drier fuels throughout the fire season. [T]his openness can encourage a surface fire to spread, [hellip]

USDA Forest Service; Influence of Forest Structure on Wildfire Behavior and the Severity of Its Effects, November 2003. http://www.fs.fed.us/projects/hfi/2003/november/documents/forest-structure-wildfire.pdf.

Opening up closed forests through selective logging can accelerate the spread of fire through them because a physical principle of combustion is that reducing the bulk density of potential fuel increases the velocity of the combustion reaction. Wind can flow more rapidly through the flaming zone. Thinned stands have more sun exposure in the understory, and a warmer microclimate, which facilitates fire (Countryman 1955).

[hellip]

[F]uel reduction activities - particularly mechanized treatments - inevitably function to disturb soils and promote the invasion and establishment of nonnative species. Pile burned areas associated with the treatments are also prone to invasion (Korb et al. 2004). Annual grasses can invade treated areas if light levels are high enough, leading to increased likelihood of ignition, and more rapid spread of fire, which can further favor annual grasses (Mack and D'Antonio 1998). This type of feedback loop following the establishment of nonnative plants may result in an altered fire regime for an impacted region, requiring extensive (and expensive) remedial action by land managers (Brooks et al. 2004).

Odion, Dennis. 2004. Declaration in NWEA v. Forest Service. citing Countryman, C. M. 1956. Old-growth conversion also converts fire climate. U.S. Forest Service Fire Control Notes 17: 15-19. https://www.fs.fed.us/sites/default/files/legacy_files/fire-management-today/017_04.pdf

Theoretically, fuel treatments have the potential to exacerbate fire behavior. Crown fuel reduction exposes surface fuels to increased solar radiation, which would be expected to lower fuel moisture content and promote production of fine herbaceous fuels. Surface fuels may also be exposed to intensified wind fields, accelerating both desiccation and heat transfer. Treatments that include prescribed burning will increase nutrient availability and further stimulate production of fuels with high surface-area-to-volume ratios. All these factors facilitate the combustion process, increase rates of heat release, and intensify surface fire behavior.

[hellip]

Thus, treatments that reduce canopy fuels increase and decrease fire hazard simultaneously. [hellip]. Still unanswered are questions regarding necessary treatment intensities [hellip] more information is clearly needed.

Omi, P.N., and Martinson, E. J. 2002. Effect of fuels treatment on wildfire severity. Final report. Western Forest Fire Research Center. Submitted to the Joint Fire Science Program Governing Board http://web.archive.org/web/20060303071717/http://www.warnercnr.colostate.edu/frws/research/westfire/FinalReport.pdf

Thinning in the thin + burn treatment increased the mass of these large woody fuels, and the higher fuel mass led to higher fire intensity and ultimately greater pine mortality.

ANDREW YOUNGBLOOD, JAMES B. GRACE, JAMES D. McIver 2009. Delayed conifer mortality after fuel reduction treatments: interactive effects of fuel, fire intensity, and bark beetles. Ecological Applications, 19(2),2009, pp. 321-337. http://www.fs.fed.us/pnw/pubs/journals/pnw_2009_youngblood001.pdf.

Fuel reduction using commercial logging methods is not necessary or desired in riparian reserves, because large wood serves important biophysical functions in riparian reserves.

[W]e suggest that managers proceed with caution in altering fuel loads near streams, particularly in watersheds that have been logged.... There is little ecological justification for the direct removal of large wood from riparian areas or riparian trees or snags that would create it.

Elliot, William J.; Miller, Ina Sue; Audin, Lisa. Eds. 2010. Cumulative watershed effects of fuel management in the western United States. Gen. Tech. Rep. RMRS-GTR-231. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 299 p. https://web.archive.org/web/20220120071251/http://www.fs.fed.us/rm/pubs/rmrs_gtr231.pdf.

EPA also recognizes that unmaintained fuel management zones can "increase the risk of fire as slopes are opened up to sunlight and undergrowth is stimulated." See EPA 2-18-04 comments on the Biscuit Fire Salvage Project.

"[S]lash generated from thinning treatments may increase potential area burned." Johnson, Morris C. 2008. Analyzing fuel treatments and fire in the Pacific Northwest. Seattle, WA: University of Washington. Ph.D. dissertation. http://www.fs.fed.us/pnw/fera/publications/abstracts/johnson2008.shtml.

"Accelerating the development of multi-storied stands may increase the risk of wildfire." Andrews, Perkins, Thrailkill, Poage, Tappeneiner. 2005. Silvicultural Approaches to Develop Northern Spotted Owl Nesting Sites, Central Coast Ranges, Oregon. West. J. Appl. For. 20(1):13-27.

The Forest Trust conducted a thorough literature review and found that:

* Although the assertion is frequently made that simply reducing tree density can reduce wildfire hazard, the scientific literature provides tenuous support for this hypothesis.
* The literature leaves little doubt, however, that fuel treatments can modify fire behavior. Thus, factors other than tree density, such as the distance from the ground to the base of the tree crown, surface vegetation and dead materials play a key role. Research has not yet fully developed the relationship among these factors in changing fire behavior.
* The specifics of how treatments are to be carried out and the relative effectiveness of alternative prescriptions in changing wildfire behavior are not supported by a significant consensus of scientific research at this point in time.
* Substantial evidence supports the effectiveness of prescribed fire, a treatment that addresses all of the factors mentioned above. Significantly, several empirical studies demonstrated the effectiveness of prescribed fire in altering wildfire behavior.
* By contrast, we found a limited number of papers on the effects of mechanical thinning alone on wildfire behavior. The most extensive research involved mathematical simulation of the impact of mechanical thinning on wildfire behavior. However, the results of this research are highly variable.
* A more limited number of studies addressed the effectiveness of a combination of thinning and burning in moderating wildfire behavior. The impacts varied, depending on the treatment of thinning slash prior to burning. Again, crown base height appeared as important a factor as tree density. The research community is still building a scientific basis for this combination of treatments.
* The proposal that commercial logging can reduce the incidence of canopy fire was untested in the scientific literature. Commercial logging focuses on large diameter trees and does not address crown base height - the branches, seedlings and saplings which contribute so significantly to the "ladder effect" in wildfire behavior.
* Much of the research on the effectiveness of fuel treatments uses dramatically different methodology, making a comparison of results difficult. To provide a basis for analysis, we structured our review of the literature into four general groupings: observations, case studies, simulation models and empirical studies. Empirical studies provide the strongest basis for evaluating treatments whereas personal observations are the least reliable.
* We found the fewest studies in the most reliable class - empirical research. We found the greatest number of studies in the least reliable class of research - reports of personal observation. Several other reviews of the literature confirm this finding, stating that the evidence of the efficacy of fuel treatment for reducing wildfire damage is largely anecdotal.
* The results of simulation studies are highly variable, in terms of such factors as fire spread, intensity and the occurrence of spotting and crowning.
* Scientists recognize that large scale prescribed burning and mechanical thinning are still experimental and may yet reveal unanticipated effects on biodiversity, wildlife populations and ecosystem function.

Henry Carey and Martha Schumann. Modifying WildFire Behavior - The Effectiveness of Fuel Treatments [mdash] The Status of Our Knowledge. April 2003; http://web.archive.org/web/20070702114635/http://theforesttrust.org/images/swcenter/pdf/WorkingPaper2.pdf. This report also said:

Stephens [1998. "Evaluation of the effects of silvicultural and fuels treatments on potential fire behaviour in Sierra Nevada mixed-conifer forests." Forest Ecology and Management 105(1):21-35.] used FARSITE to investigate the interaction between slash from logging and fire behavior. When silvicultural treatments were conducted without reducing slash, the simulated fire behavior appeared more extreme than in the area that had not been harvested at all.

[hellip]

We did not find any empirical studies that evaluated commercial harvesting as a means of altering fire behavior.

[hellip] studies suggest that slash resulting from logging is a key factor in predicting subsequent fire risk and that removal of large diameter trees alone may contribute to increased fire severity.

[hellip]

A report prepared for Congress stated: "We do not presume that there is a broad scientific consensus surrounding appropriate methods or techniques for dealing with fuel build-up or agreement on the size of areas where, and the time frames when, such methods or techniques should be applied" (US GAO RCED-99-65. 1999:56). A research report by Omi and Martinson (2002:1) stated: "Evidence of fuel treatment efficacy for reducing wildfire damages is largely restricted to anecdotal observations and simulations."

Duke University issued an "expert advisory" May 24, 2004 with Professor Norm Christensen saying:

"[hellip]the practice of suppressing wildfires has allowed debris to accumulate to dangerous levels on the forest floor."

Indiscriminate logging aggravates the problem by thinning a fire-prone forest's canopy and littering its floor with sawdust and other combustible debris.

"Loss of canopy increases wind speed and air temperatures and decreases humidity in the forest," Christensen notes. "As a result, ground fuel fires that break out can spread faster and farther than they would normally."

http://today.duke.edu/2004/05/fires_0504.html

Studies have shown that thinned stands are warmer and windier than unthinned stands. Trevor D. Hindmarch and Mary L. Reid. Effects of Commercial Thinning on Bark Beetle Diversity and Abundance. PROJECT REPORT 1999-13. May 1999. http://web.archive.org/web/20050502055041/http://sfm-1.biology.ualberta.ca/english/pubs/PDF/PR_1999-13.pdf

(see figures 2&3, pp 14-15). " [hellip] [I]n more open canopies where significant surface heating can occur, vertical convection contributes to turbulence, which interacts with air movement above the canopy to produce complex effects on mass and energy exchanges with the atmosphere. Interestingly, some recent research by Zhu, et al. (2003) has revealed a strong correlation between canopy light interception measured using hemispherical photography and windspeed within the canopy relative to that measured above." Applications of Meteorology to Forestry and Non-forest Trees. Chapter 8, p 11. Compiled by J. Paulo De Melo-Abreu. http://www.agrometeorology.org/files-folder/repository/gamp_chapt8.pdf citing Zhu, J., Gonda, Y., Matsuzaki, T. & Yamamoto, M. 2003. Modeling relative wind speed by optical stratification porosity within the canopy of a coastal protective forest at different stem densities. Silva Fennica 37(2): 189-204. http://www.metla.fi/silvafennica/full/sf37/sf372189.pdf.

George Wuerthner recently compiled information about the effect of logging on subcanopy wind speeds and reported [hellip]

Thinning forests [hellip] can often exacerbate fire spread by opening up a forest to wind penetration. Since wind is often the biggest factor that creates large blazes, thinning by reducing the "drag" created by dense timber, can actually enhance fire spread. Here are some details that might be useful for understanding this.

Recent findings about flawed wildland fire models, as reported by atmospheric physicist Dr. Joseph Warne. See Dr. Warne's declaration from Unite the Parks v. U.S. Forest Service, E.D. Cal (2021) [hellip].

[middot] When ladder fuels are removed (by thinning), ground-level windspeed and turbulent mixing both

increase, leading to faster fire spread and greater oxygen-transport efficiency; this, in turn, results in increased fire intensity.

[middot] In many cases this aerodynamic effect is more important than the fire-dampening effects of the fuels reduction being evaluated.

[middot] Two recent studies demonstrate just how consequential neglecting canopy wind-drag effects can be, leading to potentially disastrous results if aggressive ladder-fuel removal is applied. See Atchley et al. 2021, and Banerjee et al. 2020 (attached to [Warne] declaration).

[middot] Both papers demonstrate that the removal of ladder fuels reduces the sub-canopy wind drag, ultimately leading to increased fire spread.

[middot] In other words, they both show how fuels-reduction treatments can increase fire spread, which is the opposite of what currently-used operational model studies predict.

[middot] Furthermore, the Banerjee et al. 2020 paper goes further and also shows that aggressive ladder fuel removal increases the likelihood of overstory crown fires compared to more modest ladder fuel reductions, which is again opposite to operational model-run predictions.

[middot] Other recent studies also confirm these findings. Coen et al. 2018 (attached to [Warne] declaration) demonstrate that drought and fuel load were secondary effects compared to fire-induced atmospheric motions, which operational fire-behavior models neglect.

[middot] Bradley et al. (2016) (attached to declaration) analyzed satellite data for 1500 fires from 1984 to 2014, affecting 23.5 million acres of forestland. Their results show that the more heavily forestland is managed, the more severely it burns, and the least-managed land (i.e., our National Parks and Wilderness Areas) are the most firesafe.

Summary and Conclusion:

[middot] By omitting atmospheric dynamics and wind-drag effects associated with vegetation treatments, fuels reductions designed to reduce fire intensity and fire spread are undoubtedly producing the opposite effect.

[middot] Given recent trends in California of ever-increasing fire size and severity, the desire to take decisive action to make things better is understandable. However, if our actions are ill-informed by flawed application of operational fire-behavior models, they are guiding us to make an already dire situation worse.

Wuerthner, George. How thinning can promote fire spread FYI. April 20, 2021 email.

The 9th Circuit recently admonished the Forest Service to ensure the effectiveness of treatments before embarking on potentially irreversible treatment programs.

Just as it would be arbitrary and capricious for a pharmaceutical company to market a drug to the general population without first conducting a clinical trial to verify that the drug is safe and effective, it is arbitrary and capricious for the Forest Service to irreversibly "treat" more and more old-growth forest without first determining that such treatment is safe and effective for dependent species.

...

The EIS discusses in detail only the Service's own reasons for proposing treatment, and it treats the prediction that treatment will benefit old-growth dependent species as a fact instead of an untested and debated hypothesis."

Ecology Center v. Austin, 9th Circuit. Dec 8, 2005. http://bulk.resource.org/courts.gov/c/F3/430/430.F3d.1057.03-35995.html.

The NEPA document must acknowledge the paucity of scientific support for commercial logging to reduce fuels and reduce fire effects and fails to recognize that logging often increases fine fuel loads while removing the large logs that are relatively less prone to burn. Thinning also increases wind and light penetration of the canopy and causes fuels to dry out which make them more prone to burn and increases the time it takes woody material to decompose. Removing medium and large trees also removes shade and resource competition that helps suppress the growth of small trees and brush known as "ladder fuels."

In a challenge to a timber sale in the Sierra Nevada Mountains, U.S. District Judge Morrison C. England Jr. found on July 1, 2003 that John Muir Project and Earth Island Institute had made a strong case that logging slash could fuel future fires and that logging would harm wildlife habitat by increasing the risk of fire. A stay to halt the fuels reduction project was granted. Judge England issued a temporary restraining order (TRO) in Earth Island Institute v. USDA Civ. No. S-03-1242 MCE DAD (Eastern District of California 2003) because logging would create "extreme levels of flammable slash."

Consider these words from Mike Dombeck, former Chief of the Forest Service:

"Some argue that more commercial timber harvest is needed to remove small-diameter trees and brush that are fueling our worst wildlands fires in the interior West. However, small-diameter trees and brush typically have little or no commercial value. To offset losses from their removal, a commercial operator would have to remove large, merchantable trees in the overstory. Overstory removal lets more light reach the forest floor, promoting vigorous forest regeneration. Where the overstory has been entirely removed, regeneration produces thickets of 2,000 to 10,000 small trees per acre, precisely the small diameter materials that are causing our worst fire problems. In fact, many large fires in 2000 burned in previously logged areas laced with roads. It seems unlikely that commercial timber harvest can solve our forest health problems."

Dombeck on Fires in 2001 - How Can We Reduce the Fire Danger in the Interior West (Fire Management Today, Winter 2001, page 11).

As eloquently stated by Neil Lawrence:

We're a long way from a model that accounts for the drying effect of insolation and increased wind penetration, the loss of water from run-off on machine compacted soil, the increased availability of residual fine fuels post-thinning, the morbidity and mortality associated with diseases and pests imported by logging equipment, and all the other real world phenomena that cut against the ivory tower view that large fuel structure and crown bulk density are the sole significant drivers of fire occurrence, intensity, and spread.

Logging very likely will have little effect on the severity or controllability of large intense canopy fires that are of most concern both environmentally and economically. If proposed logging has any effect it will likely lead to increased controllability of low intensity surface fires, but these lower intensity fires are precisely the fires that are beneficial ecologically and should probably not be controlled. So logging will help control fires which should remain wild and free, while logging will fail to control that which is most destructive.

The agencies tend to rely far too much on commercial logging as a tool for restoration. This may be part of a deep problem related to over-estimating our ability to control nature:

In landscape solutionism, this pathology manifests in three interlocking ways. First, solutionists ignore the many aspects of landscapes that are ecologically or socially important but are not problems. Second, when they find something that looks like a problem, they reach for known solutions, which may not fit the context. (When all you have is a hammer, everything looks like a nail.) And third, they avoid engaging with unsolvable problems, or, worse, mis-categorize them as solvable, producing cascades of unintended consequences.

[hellip]

In the past half century, there has been a paradigm shift in the field of ecology. Where ecologists once saw the world as a collection of self-regulating systems oriented toward "equilibrium and stability," they now see "nonequilibrium, heterogeneity, stochasticity, and hierarch[y]." 26 [EC4] This indeterminacy extends across scales, from local ecosystems to broader processes like global biogeochemical cycles, erosion and sediment transport, and weather and climate. 27 Influenced by this new ecological thinking, many designers have retooled their practices to acknowledge the dynamism of landscapes. 28

[hellip]

Indeed, the problems identified by solutionist thinkers are often just normal landscape processes. Erosion imperils beachfront property, but the movement of sand has always been part of the behavior of beaches and barrier islands. Flooding threatens farms and cities, but it is also a vital link between rivers, floodplains, and deltas, and the species that inhabit them. The idea of fixing a landscape by making it permanently stable may be wholly incompatible with a healthy planet. 30

[hellip]

The formulation of a wicked problem is inherently political, because of its pluralistic social context; and since there is no one formulation, there is no one solution. Wicked problems are never solved, according to Rittel and Webber: "at best they are only resolved [mdash] over and over again." 35

[hellip]

Solutionism doesn't know what to do with landscapes like this, and it leaves us in the unsatisfactory bind of either reducing landscape complexities to solvable problems, or avoiding altogether the problems that are now most pressing.

[hellip]

To be clear, I am not arguing against solutions, but solutionism, the recurring temptation to see landscape design through the prism of known solutions.

[hellip]

Before landscape problems can be analyzed and solved, they must be framed. Solutionism short-circuits this crucial step in the design process.

[hellip]

Solutionism takes a response that may be innovative and valuable in one context and applies it everywhere, without regard for cultural, political, socioeconomic, and geographic circumstances. 45

[hellip]

This is the first principle of non-solutionist design: the framing of a problem must be a conscious activity that precedes solving.

[hellip]

[hellip] form and process are merged into a single phenomenon, a consequential trajectory that both shapes and is shaped by environmental forces over time. 50 This is what landscape architecture must be today, at a much greater scale. We need designs that not only make space for the landscape to change, but that also actively and intelligently participate in shaping that change.

[hellip]

[hellip] we must also develop and work within a posture of epistemic humility. 90 To frame a landscape situation well, we have to see beyond our instincts and assumptions and think outside our training. Designing with change means that our framings must change, too, as landscapes shift and confound our expectations. It is neither necessary nor possible to definitively frame a dynamic situation. When we pretend that we can, we are continually frustrated and thwarted.

ROB HOLMES 2020. The Problem with Solutions- We need to engage troubled landscapes without presuming to fix them. Notes toward a history of non-solutionist design. Places Journal. July 2020. https://placesjournal.org/article/the-problem-with-solutions/

A recent article in the Vancouver Sun quoted numerous scientists sho cast doubt on the efficacy of using traditional logging to addres forest fuels.

Experts interviewed for this story agreed the best solution to a growing wildfire crisis is to reduce the amount of forest fuels that have built up for more than a century [mdash] the result of unbridled wildfire suppression and logging practices that have left forests primed to burn. But just who should decide how to do that has divided many in industry, government and science.

[hellip]

The disagreement hinges on what appears to be a simple question: does logging more reduce wildfires? Glacier Media asked seven experts in wildfires and forest ecology to help answer that question.

Karen Price, an old-growth ecologist who served as a technical advisor on B.C.'s Old Growth Strategic Review, said she now frequently hears the argument for logging to solve wildfires from people inside the Ministry of Forests.

She described the argument put forward at the COFI conference as "mendacious and dangerous" and that she has "seen no evidence to support logging to reduce wildfire risk in most of B.C.'s ecosystems."

Price said thinning [mdash] removing small trees, leaving big ones and then burning understories [mdash] can reduce fire risk in some fire-dominated ecosystems. But in the thin-barked ecosystems that make up most of B.C., those practices would burn big trees. "And even worse, where people have thinned in the name of 'fuel reduction,' they've taken the big trees and left small ones, removing old-growth values with no decrease in wildfire risk[hellip]" said Price.'Forest management' far more nuanced than 'logging' Price pointed to evidence from B.C., collected in May 2023, when B.C. Forest Service ecologist Paula Bartemucci carried out a field visit in a forest at Deception Lake outside the town of Smithers. The forest had earlier been deemed to have a "sufficiently high fuel hazard to warrant treatment." A contractor was brought in to thin the forest and remove 15 tons of surface fuels per hectare, according to her report.

The forest there has spruce up to 200 years old and is classified as "big-treed old forests." But after it was thinned, the forest "no longer had large, standing dead trees, large downed wood, large live trees, or abundant regeneration of various sizes," wrote Bartemucci.

"The treated forest has lost old forest structure and function."

Bartemucci later added that "the thinning treatment will likely make the site vulnerable to fire" [mdash] a result of increased drying, stronger winds, and lower relative humidity than before.

Price said that report is part of a body of evidence suggesting only fire-dominated forests of interior B.C. should be thinned and burned with low-intensity fires.

Fireweed grows among forest fire tree snags in B.C.'s Kootenay National Park. James Gabbert / iStock / Getty Images Plus

Most of the forest ecologists interviewed for this story agreed that limiting wildfires would require a combination of leaving moist forests unharvested, leaving burned forests unsalvaged, and encouraging the re-growth of more fire-resistant deciduous trees.

Lori Daniels, a professor in the University of British Columbia's Faculty of Forestry, said the forestry industry would need to go through a transformative change if it wants to be part of the solution to wildfires.

"While it is true that fuels need to be reduced and reconfigured across many landscapes of interior B.C., forestry as it is currently practiced in B.C. contributes to the wildfire problem. So more of the same is deeply problematic," said Daniels in an email. Mathieu Bourbonnais, an assistant professor at UBC Okanagan's Department of Earth, Environmental and Geographic Sciences, said that if logging to reduce wildfires means more cutblocks and more conifer tree plantations of a single species "then it won't help at all."

Bourbonnais said mechanical thinning may use some of the same equipment as logging but generally involves removing fibre that is not profitable, such as small trees and saplings.

"They aren't wrong in that we need to figure out ways to remove large amounts of hazardous fibre from many of our forests, but how to do that is far more nuanced than 'logging.' I hear this a lot but conflating logging with fuel treatments is a problem," said Bourbonnais.

Evidence from U.S. show limits of 'forest management'

Forest ecologist Rachel Holt, who also served on B.C.'s Old Growth Technical Advisory Panel, said that for forest management to actually reduce wildfires, it needs to focus on feeding value-added mills with small bits of wood [mdash] not chipping logs to feed the pellet industry and not exporting barely processed timber.

When Holt hears the words "forest management" she says it's never clear what vision is actually being talked about. Rarely, she said, is there a recognition that to be successful, forest management will require cutting fewer trees.

"I hear the same words, but they don't mean the same thing," she said. "They are talking about sanitizing the forest of its biodiversity values [mdash] i.e. its old trees, its dead trees. They are talking about creating an agricultural forest."

One 2022 study looking at thinning practices across the American West found "active management" led to widespread logging of fire-resistant live trees and snags. Degradation of wildlife habitat was "functionally equivalent to clear-cutting the forest understorey" in many cases leading to "weed-infested woodlands or savannahs that look nothing like the original forest."

High-severity wildfire, found the study, is "substantially underestimated in thinned areas."

Stefan Labb[eacute]. 2024. Canada's logging industry is seeking a wildfire 'hero' narrative. Apr 23, 2024. https://www.vancouverisawesome.com/highlights/canadas-logging-industry-is-seeking-a-wildfire-hero-narrative-8610429.

Efforts toward ember reduction are unsupported by the evidence. Embers can travel very far and it does not take much vegetation to generate embers, so any attempt to address this problem will likely have a big footprint and a small effect.

Logging also has many effects that fires do not have. Soil compaction, roads, weeds, etc.

It would be better to just do a controlled prescribed burn at the right time of year without logging. The NEPA analysis should consider such an alternative.

Considerations for Harvest (Especially Even-Aged Stand Management) Should Include Carbon Storage

Logging transfers carbon from the forest to the atmosphere and causes net emissions of greenhouse gases to the atmosphere. The effects of these emissions are long-lasting. It takes 100 years or more to recapture the carbon emitted by logging, and even that does not mitigate the artificial warming caused by the extra GHG in the atmosphere during the long recapture period.

While we strive to address the climate crisis, the Forest Service must make carbon storage a primary consideration in silvicultural decisions about whether and when to harvest trees on our National Forests, especially mature and old-growth trees are store a lot of carbon, continue to capture more carbon every year, emit a lot of carbon when logged, and are very hard to replace.

The Forest Service analyses of carbon storage and global climate change are typically deeply flawed and fail to take a hard look at the relevant effects.

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

The Forest Service cannot meet its legal obligations unless it works to reduce climate change. Those legal obligation emanate from the Forest Service Organic Act, the National Forest Management Act, the Endangered Species Act, Multiple-Use Sustained-Yield Act, and the applicable Land and Resources Management Plan.

"Public forest reservations are established to protect and improve the forests for the purpose of securing a permanent supply of timber for the people and insuring conditions favorable to continuous water flow." 1897 FS Organic Act. https://winapps.umt.edu/winapps/media2/wilderness/NWPS/documents/publiclaws/ORGANIC-ACT-OF-1897.pdf. Climate change is expected to disrupt forest ecosystems and hydrologic systems to an extent that threatens to violate the very foundations of the agency's Organic Act. The FS should make every effort to reduce GHG emissions that exacerbate global climate change.

The agency is required by law to faithfully implement its Resource Management Plan. Meeting resource management objectives set forth in the RMP requires properly functioning ecosystems with biophysical conditions and disturbance regimes within the historic range of variability. Global climate change is a clear and present threat to forest ecosystems and watersheds and is preventing the agency from meeting the goals and standards & guidelines described in the applicable Resource Management Plan, and other core legal requirements for management of federal lands. The agency cannot meet the RMP without bringing climate change under control, which requires reducing emissions, including emissions from logging. The agency cannot say that carbon storage is outside the scope of this project or not part of the purpose and need. The agency must include carbon storage as part of the purpose and need for this project.

The agency typically says one of the purposes of this project is to 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 Silvicultural Prescription (and 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 underpriced and over-supplied due to "externalities" (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 receive artificially inflated profits 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.

Maintaining and increasing carbon storage in ecosystems on public lands is also required to meet LRMP desired future conditions and standards & guidelines. Carbon emissions from logging and other land management activities exacerbate global climate change and drive ecosystem changes that diverge from desired future conditions, such as uncharacteristic drought, fire, insect outbreaks, vegetation and wildlife mortality, species range shifts, low summer stream flows, unfavorable stream temperatures, extreme precipitation and peak flows and erosion, uncertainty related to vegetation recovery post-disturbance, uncertainty about the ability to provide a predictable, sustainable supply of forest products, etc. The agency should identify a purpose and need that recognizes the necessity of avoiding carbon emissions from logging and optimizing carbon storage to fulfill the promises in the LRMP.

Do not rely on the flawed boilerplate climate analyses

NEPA analyses are supposed to reflect the actual considerations that go into federal decision-making. Therefore, considerations relevant to silvicultural decisions should be reflected in NEPA analyses, and vice versa.

Silvicultural decisions are not separate from NEPA, then are central to the analyses.

As explained below, the Forest Service's standardized NEPA language handed down from the PNW regional office regarding carbon and climate change fails to take a hard look that NEPA requires. The analysis makes several highly misleading statements about managing forests for carbon storage, climate resilience, and the effects on 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 "deforestation." 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 Silvicultural Prescription (and the NEPA analysis) should consider the adverse climate consequences of GHG emissions caused directly and indirectly by logging. The Silvicultural Prescription (and the NEPA analysis) should estimate the quantity of GHG emitted by logging and associated activities throughout the wood products supply chain, and describe the contribution of this project to cumulative impacts of excess GHG in the atmosphere. The Silvicultural Prescription (and the NEPA analysis) should use a proxy such as the social cost of carbon dioxide emissions to describe effects.

The Forest Service should not rely on the boilerplate 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 (and effects) of climate change are 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. Storing carbon in wood products is not preferable to storing carbon in forests. Evidence shows that forests are a more secure way of storing carbon. If this forest is not logged, or if more green tree are retained in situ, the agency cannot conclude that natural mortality will be greater than logging mortality. In fact, it is quite easy to predict that logging causes significantly more mortality than natural processes.
* Must not compare carbon before and after logging. That is an improper framework for NEPA analysis. The proper analytic 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.

Logging Does Not Increase Forest Productivity or Capacity for Growing Trees

The Silvicultural Prescription (and the NEPA analysis) must reflect the fact that logging is adverse to carbon storage goals. The Forest Service often suggests that logging will increase forest productivity, but there is no evidence that this is true. The agency often says "Projects like the proposed action that create forests or improve forest conditions and capacity to grow trees are positive factors in carbon sequestration."

"I am unaware of a single study, or plausible mechanism, by which tree removal increases stand-level productivity (and by extension carbon stocks). For instance, the CFCP fairly cites Battles et al. (2015) as empirical evidence that thinned forests can "within a decade or two" regain the carbon lost due to the removal of smaller trees, but fails to acknowledge that the un-thinned control forests in this same study continued to grow over this period and, at all times, contained more carbon that the thinned ones. Even when one considers the protection thinning affords forests from carbon losses in high-severity fire, thinned forests contain less carbon over space and time than do fire suppressed ones (provided conditions afford timely post-fire regeneration). Such is well-established in several reviews of the subject, all of which are notable missing from the CFCP citations (Campbell et al., 2012; Restaino and Peterson 2013; Young, 2015; Kalies and Kent 2016)."

Campbell, J.L. 2017, Comments on the Jan 2017 draft California Forest Carbon Plan. http://www.fire.ca.gov/fcat/downloads/FCAT_PublicComment/Campbell_CFCP_Review_Final-2nd.pdf. The "capacity to grow trees" (i.e., net ecosystem productivity) on this landscape will actually be adversely affected by the proposed action to the extent the agency builds roads, compacts soil, removes biomass, etc.

Wang et al. (2024) found that the presence of tall trees are the best indicator of stability of forest productivity. Cutting down tall trees would therefore undermine efforts to maintain forest productivity. Wang, T., Dong, L., & Liu, Z. (2024). Stand structure is more important for forest productivity stability than tree, understory plant and soil biota species diversity. Frontiers in Forests and Global Change, 7, 1354508. https://doi.org/10.3389/ffgc.2024.1354508; https://www.frontiersin.org/articles/10.3389/ffgc.2024.1354508/full ("Stand structure is more important than tree and soil fauna species diversity for forest productivity stability. Specifically, increasing crown height (CH) from its minimum to maximum value leads to a substantial gain of 20.394 in forest productivity stability.").

In deciding the NEPA case against the Kootenai NF's Black Ram Project (which includes 3900 acres of commercial logging), the court said:

[hellip] the USFS is required to determine "the extent to which this particular project's [carbon emissions] will add to the severe impacts of climate change." Id.

In light of the above, the USPS's consideration of the Project's climate impacts fails NEPA in two ways. First, by relying almost entirely on the cookiecutter and boilerplate Project Climate Report to analyze the carbon impact of the project, the USFS did not utilize high quality and accurate information which NEPA requires. See 40 C.F .R [sect] 1500.1. Second, even though the USFS posited that the short-term loss of carbon from logging would be outweighed by the net increase in carbon sequestration resulting from a healthier forest, this assertion is not backed up by a scientific explanation. [hellip]

[hellip]

the EA discusses how the USFS plans to ameliorate root disease from a selection of trees in the Project area, which will lead to growth of trees that can store more carbon than diseased trees. See FS-002243 (noting that a purpose and need of the Project is to "[p]romote" root disease-resistant tree species like "western larch, ponderosa pine, and western white pine"). However, like its analysis of the net carbon loss resulting from logging, the EA does not sufficiently provide scientific evidence indicating why this benefit would offset the carbon loss leading to an overall "minor" impact on the environment.

Ultimately, "[greenhouse gas] reduction must happen quickly" and removing carbon from forests in the form of logging, even if the trees are going to grow back, will take decades to centuries to re-sequester. FS-038329. Put more simply, logging causes immediate carbon losses, while re-sequestration happens slowly over time, time that the planet may not have. FS-020739[hellip]

CBD v. USFS, Case 9:22-cv-00114-DWM Filed 08/17/23 (D. Mont.) https://www.biologicaldiversity.org/programs/public_lands/forests/pdfs/Black-Ram-093-ORDER-Granting-MSJ-2023-08-17.pdf.

Law et al (2013) showed that logging to address climate change does not increase forest productivity. Beverly E. Law, Tara W. Hudiburg & Sebastiaan Luyssaert (2013): Thinning effects on forest productivity: consequences of preserving old forests and mitigating impacts of fire and drought, Plant Ecology & Diversity, 6:1, 73-85 http://dx.doi.org/10.1080/17550874.2012.679013; https://terraweb.forestry.oregonstate.edu/sites/terraweb/files/Law_PED13.pdf ("The regional analysis indicates that proposed climate change mitigation actions to reduce impacts in Pacific Northwest US forests that included a treatment of sparing mesic mature forests, clear-cutting mesic young forests (<50 years, reducing harvest cycle from 80 to 50 years, which is already being planned) and thinning all age classes of dry forests to minimise drought and fire impacts on carbon (<650 mm precipitation per year) resulted in a 29% decrease in NPP over the 20-year treatment period compared with NPP resulting from current practices. [hellip] The zero-order estimate of fire-induced loss in NPP (11%) was less than that of large-scale prevention of forest fires (12.5%) over the 20-year treatment period (Sparing/Sharing treatment for dry forest only) [hellip] This and other studies suggest that the net effect of thinning the drier forests would be reduced NPP compared with NPP after fires").

In the context of carbon and climate change, the agency cannot define "improve forest conditions" in way that justifies logging when doing so will increase GHG emissions at the expense of maintaining forest carbon storage.

Also, this project will cause far more tree mortality by logging than would be avoided via natural mortality. See discussion in DeCicco J.M. 2013. Biofuel's carbon balance: doubts, certainties and implications. Climatic Change (2013) 121:801-814. DOI 10.1007/s10584-013-0927-9 http://download.springer.com/static/pdf/522/art%253A10.1007%252Fs10584-013-0927-9.pdf?auth66=1398528430_ad123a71083ade45750f8bec9a091a43&ext=.pdf ("A first-order model shows that biofuels are beneficial only to the extent that their production effectively enhances net ecosystem production.").

A study by Forest Service scientists compared a wide variety of logging methods and showed that the unmanaged (UM) control stands stored the most carbon overall, in spite of some natural mortality in the unmanaged stand.

SEE LETTER SUBMISSION: Figure 3

Joshua J. Puhlick, Aaron R. Weiskittela, Laura S. Kenefic, Christopher W. Woodall, and Ivan J. Fernandez. 2020. Strategies for enhancing long-term carbon sequestration in mixed-species, naturally regenerated Northern temperate forests. CARBON MANAGEMENT. 2020, VOL. 11, NO. 4, 381-397 https://doi.org/10.1080/17583004.2020.1795599, https://www.fs.fed.us/nrs/pubs/jrnl/2020/nrs_2020_puhlick_001.pdf. ("For one of the unmanaged stands (stand 32 A), tree mortality at the beginning of the 100-year period led to an initial loss of C in live trees, but with a corresponding increase in dead wood C accumulation. Despite this initial decrease, C accumulated in combined pools consistently increased over time in both unmanaged stands.").

Where clear-cutting of long-established virgin forest is followed by the establishment of commercial plantation forests or agroforestry systems, it is doubtful that the C released to the atmosphere will ever be fully recovered within the ecosystem.

Matthews R.W. et al. (1996) WG3 Summary: Evaluating the role of forest management and forest products in the carbon cycle. In: Apps M.J., Price D.T. (eds) Forest Ecosystems, Forest Management and the Global Carbon Cycle. NATO ASI Series (Series I: Global Environmental Change), vol 40. Springer, Berlin, Heidelberg. http://www.sysecol2.ethz.ch/pdfs/Ma121-lq.pdf

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 ("ABSTRACT: Climate change and loss of biodiversity are widely recognized as the foremost environmental challenges of our time. Forests annually sequester large quantities of atmospheric carbon dioxide (CO2), and store carbon above and below ground for long periods of time. Intact forests[mdash]largely free from human intervention except primarily for trails and hazard removals[mdash]are the most carbon-dense and biodiverse terrestrial ecosystems, with additional benefits to society and the economy. Internationally, focus has been on preventing loss of tropical forests, yet U.S. temperate and boreal forests remove sufficient atmospheric CO2 to reduce national annual net emissions by 11%. U.S. forests have the potential for much more rapid atmospheric CO2 removal rates and biological carbon sequestration by intact and/or older forests. The recent 1.5 Degree Warming Report by the Intergovernmental Panel on Climate Change identifies reforestation and afforestation as important strategies to increase negative emissions, but they face significant challenges: afforestation requires an enormous amount of additional land, and neither strategy can remove sufficient carbon by growing young trees during the critical next decade(s). In contrast, growing existing forests intact to their ecological potential[mdash]termed proforestation[mdash]is a more effective, immediate, and low-cost approach that could be mobilized across suitable forests of all types. Proforestation serves the greatest public good by maximizing co-benefits such as nature-based biological carbon sequestration and unparalleled ecosystem services such as biodiversity enhancement, water and air quality, flood and erosion control, public health benefits, low impact recreation, and scenic beauty. ... Proforestation produces natural forests as maximal carbon sinks of diverse species (while supporting and accruing additional benefits of intact forests) and can reduce significantly and immediately the amount of forest carbon lost to nonessential management. Because existing trees are already growing, storing carbon, and sequestering more carbon more rapidly than newly planted and young trees (Harmon et al., 1990; Stephenson et al., 2014; Law et al., 2018; Leverett and Moomaw, in preparation), proforestation is a near-term approach to sequestering additional atmospheric carbon: a significant increase in "negative emissions" is urgently needed to meet temperature limitation goals. The carbon significance of proforestation is demonstrated in multiple ways in larger trees and older forests. For example, a study of 48 undisturbed primary or mature secondary forest plots worldwide found, on average, that the largest 1% of trees [considering all stems [ge]1 cm in diameter at breast height (DBH)] accounted for half of above ground living biomass (The largest 1% accounted for [sim]30% of the biomass in U.S. forests due to larger average size and fewer stems compared to the tropics) (Lutz et al., 2018). Each year a single tree that is 100 cm in diameter adds the equivalent biomass of an entire 10-20 cm diameter tree, further underscoring the role of large trees (Stephenson et al., 2014). Intact forests also may sequester half or more of their carbon as organic soil carbon or in standing and fallen trees that eventually decay and add to soil carbon (Keith et al., 2009). Some older forests continue to sequester additional soil organic carbon (Zhou et al., 2006) and older forests bind soil organic matter more tightly than younger ones (Lacroix et al., 2016).") See also, How to fight climate change? Save existing forests. Guest column by William R. Moomaw, Bob Leverett, Robert A. Jonas and Monica Jakuc Leverett. 7-24-2019. https://www.gazettenet.com/Guest-column-by-William-R-Moomaw-Bob-Leverett-Robert-A-Jonas-and-Monica-Jakuc-Leverett-27110056.

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 ("... [P]reserving existing mature forests will have an even more profound effect on slowing global warming in the coming decades, since immature trees sequester far less CO2 than older ones. ... 'The most effective thing that we can do is to allow trees that are already planted, that are already growing, to continue growing to reach their

full ecological potential, to store carbon, and develop a forest that has its full complement of environmental services,' said Moomaw. ... [I]n order to meet our climate goals, we have to have greater sequestration by natural systems now. So that entails protecting the carbon stocks that we already have in forests. ... We've seen a lot of interest lately in planting more trees. And planting trees is great and it makes us all feel good and it's a wonderful thing to do ... but they will not make much of a difference in the next two or three decades because little trees just don't store much carbon. Letting existing natural forests grow is essential to any climate goal we have.")

As climate stress increases, maintaining forest productivity will require conserving fungal diversity, which in turn requires conserving the trees and dead wood that support fungal diversity. As explained by Peter et al (2013) -

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 (Bu[eacute]e 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 Bu[eacute]e 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.

A literature review by Tomao et al (2020) 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 symbionts, (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.

Highlights -

[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 "old-growth forests". 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).

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.

Stenzel et al (2021) showed that thinning Ponderosa pine increased net primary productivity on a tree basis, but reduced carbon storage on a stand basis, even after accounting for carbon stored in wood products. The carbon deficit caused by thinning is expected to last for at least several decades. Stenzel, J. E., Berardi, D. B., Walsh, E. S., & Hudiburg, T. W. (2021). Restoration thinning in a drought-prone Idaho forest creates a persistent carbon deficit. Journal of Geophysical Research: Biogeosciences, 126, e2020JG005815. https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2020JG005815. ("[hellip] [R]esults suggested that thinned stand NEP would exceed control NEP in subsequent years following several years of canopy recovery due to increases in available mineral nitrogen and increased allocation of carbon to wood (and a resulting decrease in biomass turnover). However, a carbon deficit relative to control remained due to the removal of [sim]40% of live ecosystem carbon as well as the subsequent release of [sim]60% of removed biomass by 2050. Despite the continued storage of a portion of removed biomass in long-lived wood products, large immediate and short-term emissions were associated with slash combustion, on-site decomposition, and short-term product chain emissions (i.e., waste and paper), and do not represent avoided emissions through 2050."). The climate does not benefit if a few trees increase productivity, it only benefits if more carbon remains stored and less greenhouse gas is emitted to the atmosphere. Logging does NOT accomplish this goal.

Stabilizing Forest Carbon is not a Climate Solution.

"Stabilizing" forest carbon is becoming a buzzword and a new goal for forest management, but it is NOT a climate solution. In order to address the global climate crisis, we need to reduce atmospheric carbon at the global scale, not stabilize forest carbon at the local scale. This is because Earth's atmosphere is well-mixed. It does not matter if forest carbon booms and busts at the scale of stands or even landscapes. What matters is the total amount of carbon in the atmosphere, which is the net result of both carbon emissions in some locations, and carbon uptake in the rest of the living landscape that is still growing. From a climate perspective, it might make more sense to let forests grow and accumulate carbon in vegetation and soils (let forest carbon boom), even if it is not considered "sustainable" over the long term because it will eventually burn (the carbon might go bust), because every day/week/month/year that carbon stays in forests and soils is a day/week/month/year with less solar forcing.

The goal of stabilizing carbon is especially suspect when the proposed activities required to stabilize carbon themselves emit carbon. The first problem is that emissions come first and alleged carbon benefits from avoided disturbance are delayed. This time lag conflicts with the urgent need to avoid emissions and store carbon in the near term.

The second problem is that the carbon emissions from efforts to stabilize carbon very likely exceed the carbon "savings" from those stabilizing actions. This is because it is impossible to predict where or when natural destabilizing events such as wildfire might occur. Only a small fraction of deliberate actions taken to stabilize forest carbon will actually interact with natural disturbance events and provide carbon benefits. Most individual efforts to stabilize carbon will cause carbon emissions without any offsetting carbon benefits, so collectively, efforts to stabilize carbon will emit more carbon than just letting forest carbon accumulate, and eventually boom and bust.

Some forests may be storing more carbon than the carbon carrying capacity projected under climate change. Such forests are providing a great climate service to humanity (as well as great benefits to threatened & endangered species that rely on such forests), especially in the short-term, while the global need to reduce GHG emissions is most urgent. There are significant tradeoffs related to any proposal to artificially remove medium and large trees from carbon-rich forests in order to help them match their projected carbon carrying capacity. We must carefully consider the cumulative effects of doing so across large areas, because it would cause tremendous additional and unneeded GHG emissions.

Wood Products Are a Source of GHG Emissions, not a Sink. The Carbon Value of Wood Products is Over-estimated.

Forest Service analyses often states "Utilizing trees to create long-lived wood products sequesters carbon (IPCC 2007) (FAO 2007) (Stavins 2005) (Upton 2007). Some have shown that using wood to build houses has a more favorable carbon balance when compared to other building materials such as steel, concrete or plastic (Wilson 2006)." This is inaccurate and misleading.

From a climate perspective, wood products represent net carbon emissions, NOT net carbon sequestration, because only a small fraction of the carbon in a logged forest ends up in wood products. Logging to create wood products causes the majority of forest carbon to be transferred to the atmosphere, not to wood products. Science clearly shows that carbon is more safely stored in forests, not in wood products.

More than 200 scientists recently wrote to Congress saying -

We find no scientific evidence to support increased logging to store more carbon in wood products, such as dimensional lumber or cross-laminated timber (CLT) for tall buildings, as a natural climate solution. The growing consensus of scientific findings is that, to effectively mitigate the worst impacts of climate change, we must not only move beyond fossil fuel consumption but must also substantially increase protection of our native forests in order to absorb more CO2 from the atmosphere and store more, not less, carbon in our forests (Depro et al. 2008, Harris et al. 2016, Woodwell 2016, Erb et al. 2018, IPCC 2018, Law et al. 2018, Harmon 2019, Moomaw et al. 2019). Moomaw et al 2020. Scientists Letter to Congress Urging Protection of Forests to Mitigate the Climate Crisis. May 13, 2020. https://96a.96e.myftpupload.com/wp-content/uploads/2020/05/200TopClimateScientistCongressProtectForestsForClimateChange13May20.pdf.

Carbon emissions form the forest sector are often reported as net emissions which account for forest growth. This is not a proper way to account for emissions. The emissions from logging and the wood products supply chain must be reported sperately, because carbon uptake via forest growth occurs whether forests are logged or not. Bysouth, D., Boan, J. J., Malcolm, J. R., & Taylor, A. R. (2024). High emissions or carbon neutral? Inclusion of "anthropogenic" forest sinks leads to underreporting of forestry emissions. Frontiers in Forests and Global Change, 6, 1297301. https://doi.org/10.3389/ffgc.2023.1297301; Polanyi, Skeene, and Simard 2024.

LOGGING EMISSIONS UPDATE - Reported greenhouse gas (GHG) emissions from logging in Canada double after revision to government data. https://naturecanada.ca/wp-content/uploads/2024/09/2024-Logging-Emissions-

Update-Report.pdf. The Silvicultural Prescription (and the NEPA analysis) must accurately disclose to the public and the decisionmaker the benefits of forest growth and continued carbon sequestration if the forest is conserved, versus all the GHG emissions from logging and associated activities.

World Resources Institute conducted a thorough analysis and concluded that increased use of wood does not provide climate benefits and has significant trade-offs, such as adverse effects on biodiversity.

1) Most wood (and its stored carbon) is lost during production.

2) Harvesting wood is not carbon-neutral.

3) Using wood in construction will most likely increase climate warming for decades.

4) Relying only on plantation forests in warm climates for mass timber might yield climate benefits from a specific hectare, but not when factoring in the growing needs for wood.

5) Mass timber would have large adverse effects on the world's forests.

Tim Searchinger, Liqing Peng, Richard Waite and Jessica Zionts. July 20, 2023. Wood Is Not the Climate-friendly Building Material Some Claim it to Be. https://www.wri.org/insights/mass-timber-wood-construction-climate-change, citing Timothy Searchinger, Liqing Peng, Jessica Zionts, And Richard Waite 2023 The Global Land Squeeze: Managing The Growing Competition For Land. World Resources Institute. https://doi.org/10.46830/wrirpt.20.00042; https://files.wri.org/d8/s3fs-public/2023-07/the-global-land-squeeze-report.pdf ("? Initiatives to increase demands for bioenergy and mass timber for construction would vastly increase land-use competition.

? Wood use is not "carbon neutral," even if forests are managed "sustainably," once one accounts for the loss in forest carbon from harvests. In most scenarios, harvesting additional wood, even for construction, will likely increase atmospheric carbon for decades.

? Solutions require strategies that produce, protect, reduce, and restore: produce more food and wood on already managed land, protect native habitats, reduce demand for land-intensive products, and, if successful, restore forests and other habitats.

? In general, policies should not increase demand for land-based products until the world shows that it can meet rising food and wood demands without additional land conversion.

Our analysis also shows that "sustainable forest management," as conventionally understood, does not mean that wood use is carbon neutral or that using wood in construction in place of concrete and steel necessarily provides a net climate benefit. Harvesting wood comes with a time-discounted cost in lost carbon in the forest. The climate benefits of harvesting wood include the storage of some of that forest carbon elsewhere and avoided emissions from other carbon-intensive products such as concrete and steel. But the climate costs are reduced storage of carbon in the forest.

According to our analysis, large net climate benefits from wood harvesting probably require that a high percentage of this wood is used to replace concrete and steel in construction[mdash]perhaps at levels not realistic[mdash]and that the wood come from or be associated with the establishment of fast-growing forest plantations. If these plantations come at the expense of natural forests, they would have high biodiversity costs.").

Applying discounting to the carbon costs of forest management improves accuracy. Peng, L., Searchinger, T.D., Zionts, J. et al. The carbon costs of global wood harvests. Nature (2023). https://doi.org/10.1038/s41586-023-06187-1. https://www.nature.com/articles/s41586-023-06187-1.pdf ("[H]arvests of wood have major, although often ignored, carbon costs that should be attributed to human activity. ... [W]e present results of a new model that uses [4%] time discounting to estimate the present and future carbon costs of global wood harvests under diferent scenarios. We fnd that forest harvests between 2010 and 2050 will probably have annualized carbon costs of 3.5-4.2 Gt CO2e yr[minus]1. [hellip] These findings are, in a sense, good news because they imply that if people could reduce forest harvests, forest growth could do more to reduce atmospheric carbon, a potential mitigation 'wedge' that is rarely identified in climate strategies.").

Various forest management mitigation strategies based on modifying conventional management of forests for commodity production in ways that reduce logging emissions and take account of the carbon stored in wood products have been proposed as constituting the most effective mitigation (Fusset al 2020, Verkerk et al 2020). However, other empirical case studies have challenged these proposals (Keith et al 2015) and shown that alternative forest management practices such as reduced impact logging do little to reduce atmospheric CO2 compared to forest protection and regrowth (i.e. allowing growth to continue) whereas tree harvesting immediately releases large amounts of CO2 (Law et al 2018).

Brendan Mackey et al 2022. Net carbon accounting and reporting are a barrier to understanding the mitigation value of forest protection in developed countries. Environ. Res. Lett. 17 054028. DOI 10.1088/1748-9326/ac661b. https://iopscience.iop.org/article/10.1088/1748-9326/ac661b/pdf.

Some argue that wood products are a good place to store carbon. This is a counter-productive climate strategy, because -

Only a small fraction of carbon from logged forests ends up in long-term storage in wood products, most is transferred to the atmosphere. Of all the carbon that is killed and/or exposed to accelerated decay in a logging operation only a small fraction ends up as durable goods and buildings -- most ends up as slash, sawdust, waste/trim, hog fuel, and non-durable goods like paper. Some say that converting forest to wood products "delays" emissions, but in fact logging accelerates emissions because they are the result of a process that kills trees that would continue to actively sequester carbon if not logged, and logging involves tremendous waste in the logging process, milling process, construction/manufacturing process.

OFRI says "in 2013. Of the [log] volume delivered to sawmills, 49.4% became finished lumber or other sawn products and 48% became mill residues[hellip]" Kuusela, Rossi et al 2019. Forest Resources And Markets: Trends And Economic Impacts. The 2019 Forest Report. OFRI. https://theforestreport.org/wp-content/uploads/2019/07/OFRI-2019-Forest-Sector-Economic-Report-Web.pdf. There are additional losses throughout the wood products supply chain, resulting in logging waste, milling waste, plus GHG emissions from processing and transportation.

SEE LETTER SUBMISSION: Fate of Carbon From Harvested Wood

Carbon remains stored much longer in forests than in wood products. Much of the wood products which can reasonably be considered "durable" are in fact less durable than leaving the carbon stored safely inside a mature tree that might live to be hundreds of years old. Most of our wood products are disposable. It turns out that well-conserved forests on average store carbon more securely than our "throw-away" culture and economy does. Law, B. & M.E. Harmon 2011. Forest sector carbon management, measurement and verification, and discussion of policy related to mitigation and adaptation of forests to climate change. Carbon Management 2011 2(1). https://archives.corvallisoregon.gov/public/ElectronicFile.aspx?dbid=0&docid=4256162 ("To the extent that management can direct carbon into longer lived pools, it can increase the stores of carbon in the forest sector. Harvest of carbon is one proposed strategy to increase carbon stores. However, harvesting carbon will increase the losses from the forest itself and to increase the overall forest sector carbon store, the lifespan of wood products carbon (including manufacturing losses) would have to exceed that of the forest. Under current practices this is unlikely to be the case. A substantial fraction (25-65%) of harvested carbon is lost to the atmosphere during manufacturing and construction depending on the product type and manufacturing method. The average lifespan of wood buildings is 80 years in the USA, which is determined as the time at which half the wood is no longer in use and either decomposes, burns or, to a lesser extent, is recycled. However, many forest trees have the potential to live hundreds of years (e.g. 800 years in the Pacific northwest USA). Mortality rates of trees are generally low, averaging less than 2% of live mass per year in mature and old forests; for example, in Oregon, mortality rates average 0.35-1.25% in forests that are older than 200 years in the Coast Range and Blue Mountains, respectively [8]. Moreover, the average longevity of dead wood and soil carbon is comparable to that of live trees. When the loss of carbon associated with wood products manufacturing is factored in, it is highly unlikely that harvesting carbon and placing it into wood products will increase carbon stores in the overall forest sector. This explains why in all analyses conducted to date, wood products stores never form the majority of total forest sector stores.")

"Of the cumulative wood harvested in the past 115 years, 65% is in the atmosphere, 16% is in landfills, and 19% is in long-lived products (Hudiburg et al. 2019)." Law, B. 2021. Response to Questions for the Record, attached to STATEMENT OF DR. BEVERLY LAW, PROFESSOR EMERITUS, OREGON STATE UNIVERSITY, BEFORE THE UNITED STATES HOUSE OF REPRESENTATIVES, SUBCOMMITTEE ON NATIONAL PARKS, FORESTS AND PUBLIC LANDS, APRIL 29, 2021, CONCERNING "WILDFIRE IN A WARMING WORLD: OPPORTUNITIES TO IMPROVE COMMUNITY COLLABORATION, CLIMATE RESILIENCE, AND WORKFORCE CAPACITY" https://naturalresources.house.gov/imo/media/doc/Law,%20Beverly%20-%20Testimony%20-%20NPFPL%20Ov%20Hrg%2004.29.21.pdf (link to Statement, without Response to Questions) citing Hudiburg, T.W, B.E. Law, W.R. Moomaw, M.E. Harmon, J.E. Stenzel. 2019. Meeting GHG reduction targets requires accounting for all forest sector emissions. Env. Res. Lett. 14: 095005. https://iopscience.iop.org/article/10.1088/1748-9326/ab28bb/pdf.

Reliance on wood products prevents forests from reaching their full potential for carbon storage. Shanks (2008) said "There are also losses of carbon that occur during the creation of forest products. These losses to decay and wood products make carbon sequestration slower when harvesting is allowed. The young timberlands that replace older harvested lands grow quickly, but hold less in total carbon stores than their older counterparts; the net sequestration from forest products adds to total carbon stores, but does not come close to the vast amounts of carbon stored in non-harvested older timberlands. This finding differs from other papers that have shown that the highest carbon mitigation can be reached when high productivity lands are used exclusively for wood products creation (Marland and Marland, 1992). The wood products considered in these studies were either long lasting or used for fuel purposes. Allowing harvested timber to be allocated to all types of wood products increases carbon emissions and results in no harvest regimes sequestering more carbon." Alyssa V. Shanks. 2008. Carbon Flux Patterns on U.S. Public Timberlands Under Alternative Timber Harvest Policies. MS Thesis. March 2008.
http://ir.library.oregonstate.edu/dspace/bitstream/1957/8326/1/A_Shanks_Thesis_04%2002%2008_final.pdf.

Careful scientific study and analysis has demonstrated that timber harvest is not increasing removal of carbon from the atmosphere by terrestrial systems nor is it reducing emissions. In Oregon, for example, private industrial timberland is storing less than half the total carbon potential of the sites. This is because, in many cases, the trees are harvested on a 35-40 year rotation, and very little downed or dead wood is left on site. The soil profile and the amount of carbon it stores is also impacted by intensive, short rotation forestry.

[hellip]

[W]estern states are net sinks because there is a positive net balance of forest carbon uptake exceeding losses due to harvest, wood product use and combustion by wildfire. However, wood product use is reducing the potential annual sink by ~21%, suggesting forest carbon storage can become more effective in climate mitigation through reduced harvest, longer rotations and more efficient wood product use, [hellip]

Law, B. 2021. Response to Questions for the Record, attached to STATEMENT OF DR. BEVERLY LAW, PROFESSOR EMERITUS, OREGON STATE UNIVERSITY, BEFORE THE UNITED STATES HOUSE OF REPRESENTATIVES, SUBCOMMITTEE ON NATIONAL PARKS, FORESTS AND PUBLIC LANDS, APRIL 29, 2021, CONCERNING "WILDFIRE IN A WARMING WORLD: OPPORTUNITIES TO IMPROVE COMMUNITY COLLABORATION, CLIMATE RESILIENCE, AND WORKFORCE CAPACITY" https://naturalresources.house.gov/imo/media/doc/Law,%20Beverly%20-%20Testimony%20-%20NPFPL%20Ov%20Hrg%2004.29.21.pdf (link to Statement, without Response to Questions).

"[W]ood product usage is reducing the potential annual sink by an average of 21%, suggesting forest carbon storage can become more effective in climate mitigation through reduction in harvest, longer rotations, or more efficient wood product usage. ... Allowing forests to reach their biological potential for growth and sequestration, maintaining large trees (Lutz et al 2018), ... will remove additional CO2 from the atmosphere. Global vegetation stores of carbon are 50% of their potential including western forests because of harvest activities (Erb et al 2017). Clearly, western forests could do more to address climate change through carbon sequestration if allowed to grow longer." Tara W Hudiburg, Beverly E Law, William R Moomaw, Mark E Harmon and Jeffrey E Stenzel 2019. Meeting GHG reduction targets requires accounting for all forest sector emissions. 23 August 2019. Environmental Research Letters, Volume 14, Number 9. https://iopscience.iop.org/article/10.1088/1748-9326/ab28bb/pdf.

Diaz et al (2018) showed that Washington's forest practice rules are better for the climate than Oregon's forest practice rules, in part because Washington requires greater riparian retention. This study accounted for the total carbon stored both in the forest and in wood products. Riparian retention does nothing more than allow trees to grow and accumulate more carbon. If some retention is good for the climate, more retention is better, and 100% retention is best. Diaz, D.D.; Loreno, S.; Ettl, G.J.; Davies, B. 2018. Tradeoffs in Timber, Carbon, and Cash Flow under Alternative Management Systems for Douglas-Fir in the Pacific Northwest. Forests 2018 9, 447. https://www.mdpi.com/1999-4907/9/8/447, https://www.sierraclub.org/sites/www.sierraclub.org/files/program/documents/Ecotrust%20FSC%20v%20BAU%20forestry%20study.pdf. ("In general, policies encouraging or incentivizing increased riparian protections, green tree retention, or the extension of rotation ages are likely to translate into greater carbon storage. [hellip] Both green tree retention and greater RMZ protections are likely to correspond to other additional values including water quality and habitat for fish and wildlife that are not quantified here. [hellip] Our work clearly demonstrates that the adoption of certain forest practices including expanded riparian protections, increased green tree retention, and the extension of rotation ages can translate into substantially higher carbon storage than contemporary common practice for Douglas-fir management in the Pacific Northwest.").

See also, Anderson, Kate 2022. YES, LONG ROTATIONS CAN YIELD REAL CLIMATE GAINS FOR CASCADIA - Harvesting trees at 80 years, instead of 40, stores more carbon and yields more timber. https://www.sightline.org/2022/03/17/yes-long-rotations-can-yield-real-climate-gains-for-cascadia/ ("As far as ecosystem modelers are concerned, extended rotations as a top climate priority for Cascadia is settled science. In California, Oregon, and Washington, extending forest harvest rotations on industrial forestlands offers the highest potential carbon gains of any natural carbon solution. [hellip] The key to the biological growth maximum is not wasting the sunshine. After a clear-cut, the sun pours down its photons, but they fall on stumps and seedlings. There are hardly any tree leaves or needles to photosynthesize sunlight and carbon into wood and oxygen. As a result, the photons are wasted, and the land's capacity to grow timber and store carbon is squandered. In round numbers, it takes at least ten years for a replanted clear-cut to green up and begin to look like a forest again. A 40-year rotation, driven more by a financial rotation age, means that 25 percent of the rotation is spent in the factory rebuilding stage, with timber production and carbon storage on hold." citing Beverly E. Law, Tara W. Hudiburg, Logan T. Berner, Jeffrey J. Kent, Polly C. Buotte, Mark E. Harmon. 2018. Land use strategies to mitigate climate change in carbon dense temperate forests. Proceedings of the National Academy of

Sciences Mar 2018, 201720064; DOI: 10.1073/pnas.1720064115 https://web.archive.org/web/20180727130028/http://www.pnas.org/content/pnas/115/14/3663.full.pdf.)

The amount of carbon missing from our forests vastly greater than the amount of carbon that can be accounted for in wood products storage. BLM's Western Oregon Plan Revision FEIS shows that decades of converting old growth forests to plantations has reduced current forest carbon stores on BLM lands in western Oregon by 149 million tons, while some of that wood was converted into wood products, only 11 million tons of that carbon remains stored in wood products today, so logging our public forests to make wood products results in approximately 13 times more carbon emissions than carbon storage. This is pieced together from BLM's Western Oregon Plan Revision FEIS Figures 3-17 (p 3-221) and Figure 3-18 (p 3-224). Further logging of mature forests will exacerbate this outcome. See also, Tara W Hudiburg, Beverly E Law, William R Moomaw, Mark E Harmon and Jeffrey E Stenzel 2019. Meeting GHG reduction targets requires accounting for all forest sector emissions. Environmental Research Letters, Volume 14, Number 9. https://iopscience.iop.org/article/10.1088/1748-9326/ab28bb/pdf ("[hellip] over 100 years of wood product usage is reducing the potential annual sink by an average of 21%, suggesting forest carbon storage can become more effective in climate mitigation through reduction in harvest, longer rotations, or more efficient wood product usage. Of the [sim]10,700 million metric tonnes of carbon dioxide equivalents removed from west coast forests since 1900, 81% of it has been returned to the atmosphere or deposited in landfills.")

The Forest Service estimates that carbon storage in wood products is only 5.25% of total carbon associated with National Forests in the Pacific Northwest. "[hellip] [W]e estimate that the Pacific Northwest Region HWP [harvested wood products] carbon stocks represent roughly 5.25% of total forest carbon storage associated with national forests in the Pacific Northwest Region in 2012." USDA Forest Service. 2015. Baseline Estimates of Carbon Stocks in Forests and Harvested Wood Products for National Forest System Units; Pacific Northwest Region. 48 pp. Whitepaper. https://www.fs.usda.gov/sites/default/files/pacific-northwest-region-carbon-assessment.pdf. Meanwhile, Depro et al (2008) estimate that a no harvest scenario applied to public forests in the US could add as much as 43% to the current carbon stocks. Depro, B., Murray, B., Alig, R., Shanks, A. 2008. Public land, timber harvests, and climate mitigation: quantifying carbon sequestration potential on U.S. public timberlands. Forest Ecology and Management. 255(3-4): 1122-1134. https://pubag.nal.usda.gov/download/21039/PDF.

A lot of wood products are "stored" in landfills where they emit methane which has a global warming effect much greater than CO_2. Ingerson, A. 2009 Wood Products and Carbon Storage: Can Increased Production Help Solve the Climate Crisis? Washington, D.C.: The Wilderness Society. http://web.archive.org/web/20100601080813/http://wilderness.org/files/Wood-Products-and-Carbon-Storage.pdf. ("Key Points - 1. When wood is removed from the forest, most of it is lost during processing. The amount lost varies tremendously by region, tree species and size, and local infrastructure. 2. The majority of long-term off-site wood carbon storage occurs in landfills, where decomposing wood gives off significant amounts of methane, a gas with high global warming potential. 3. In addition to wood processing losses, fossil fuels are required to turn raw logs into finished products and ship them from forest to mill to construction site to landfill. 4. Once wood losses and fossil emissions are accounted for, the process of harvesting wood and turning it into products may release more greenhouse gases than the emissions saved by storing carbon in products and landfills. [hellip] 9. Properly managed, wood can be a renewable source of building materials and fuels, but solving the climate crisis will require reducing the use of all materials and energy.")

Living trees store and accumulate carbon better than dead wood products. Even a suppressed tree stores carbon better than a dead tree after it is logged, limbed, bucked, debarked, milled, planed, processed, trimmed, manufactured, used, and then discarded. Recent evidence shows that slower-growing older trees tend to channel their energy into structural support and defense compounds to "maximize durability while minimizing [hellip] damage". Colbert & Pederson. 2008. Relationship between radial growth rates and lifespan within North American tree species. Ecoscience 15(3), 349-357 (2008).

http://fate.nmfs.noaa.gov/documents/Publications/Black_et_al_2008_Ecoscience.pdf. See also, University of Montana. June 18, 2019. Cell structure linked to longevity of slow-growing Ponderosa Pines. https://www.sciencedaily.com/releases/2019/06/190618174358.htm ("Slow-growing ponderosa pines may have a better chance of surviving longer than fast-growing ones, especially as climate change increases the frequency and intensity of drought, according to new research from the University of Montana. ... [A] key difference between fast and slow growers resides in a microscopic valve-like structure between the cells that transport water in the wood, called the pit membrane. The unique shape of this valve in slow-growing trees provides greater safety against drought, but it slows down water transport, limiting growth rate.") citing Beth Roskilly, Eric Keeling, Sharon Hood, Arnaud Giuggiola, Anna Sala. Conflicting functional effects of xylem pit structure relate to the growth-longevity trade-off in a conifer species. Proceedings of the National Academy of Sciences, 2019; 201900734 DOI: 10.1073/pnas.1900734116.

The "substitution" value of wood products is vastly over-estimated. Some say that using wood as a building material is better for the climate than using steel and cement because steel and cement are so energy intensive. It is important to recognize that steel and cement may be energy intensive but energy is fungible and can be produced renewably, so these alternative building materials can theoretically be decarbonized, whereas wood is made of carbon and is an integral part of the global carbon cycle. It can never be decarbonized.

In May 2020, over 200 scientists wrote to Congress, saying:

The wood products industry claims that substituting wood for concrete and steel reduces the overall carbon footprint of buildings. However, this claim has been refuted by more recent analyses that reveal forest industries have been using unrealistic and erroneous assumptions in their models, overestimating the long-term mitigation benefits of substitution by 2 to 100-fold (Law et al. 2018, Harmon 2019). The climate impact of wood is even worse if the reduced forest carbon sequestration and storage caused by nutrient loss and soil compaction from logging is included [hellip]

Moomaw et al 2020. Scientists Letter to Congress Urging Protection of Forests to Mitigate the Climate Crisis, May 13, 2020. https://96a.96e.myftpupload.com/wp-content/uploads/2020/05/200TopClimateScientistCongressProtectForestsForClimateChange13May20.pdf.

The timber industry vastly over-states the alleged climate benefit of storing carbon in wood products or using wood as a substitute for alternative building materials. While wood may be preferable to other materials in some applications and there is a grain of truth in the substitution analysis, the timber industry's efforts to show a "substitution" benefit from short-rotation forestry is severely flawed. Most of the analyses that tout this effect are produced and advocated by the timber industry with unreasonable assumptions that don't stand up to scrutiny. Note that the mission of the CORRIM group is to promote the use of wood products, not to develop sound forest policy or climate policy. The substitution argument is an example of the timber industry carefully choosing assumptions to guarantee a certain result and then stopping the analysis short of a complete picture of the issue.

Substitution of wood for more fossil carbon intensive building materials has been projected to result in major climate mitigation benefits often exceeding those of the forests themselves. A reexamination of the fundamental assumptions underlying these projections indicates long-term mitigation benefits related to product substitution may have been overestimated 2- to 100-fold. This suggests that while product substitution has limited climate mitigation benefits, to be effective the value and duration of the fossil carbon displacement, the longevity of buildings, and the nature of the forest supplying building materials must be considered. ... Conversion of older, high carbon stores forests to short rotation plantations would over the long term likely lead to more carbon being added to the atmosphere despite some of the harvested carbon being stored and production substitution occurring.

Mark E Harmon 2019. Have product substitution carbon benefits been overestimated? A sensitivity analysis of key assumptions. Environ. Res. Lett. in press https://doi.org/10.1088/1748-9326/ab1e95.

The timber industry must not be allowed to continue business-as-usual and call it "climate friendly" because logging mature and old-growth forests on public lands and short-rotation clear-cutting on private lands are NOT climate friendly. Many in the timber industry like to promote logging as a solution to climate change because (they say) building with wood helps offset construction using alternative materials such as steel and cement that may release more CO_2 during their manufacture. (See e.g., CORRIM analysis, http://www.corrim.org/reports/2005/swst/140.pdf , http://www.masonbruce.com/wfe/2004Program/1B1_Bruce_Lippke.pdf) Others appropriately promote protection of mature and old-growth forests as more reliable ways to store carbon in forests and long-rotation forestry as the most appropriate way to obtain wood products. It's absurd to conclude that we can continue to destroy our forests to save the climate. Life on earth, especially forests, are the bilge pump that keeps our climate boat afloat.

The benefits of wood product substitution are vastly over-stated:

1) Wood, concrete and steel are not the only building materials. The analysis must consider a wider range of alternatives, including reducing demand for building materials. Or, what if we converted annual plants such as grasses into long-term storage in buildings? Here's an idea: Take a portion of the land devoted to growing subsidized livestock feed and instead grow annual or semi-annual fiber crops that are made into wood substitutes. Unlike wood from trees that could better protect the climate if allowed to grow and store carbon hundreds of years, these alternative fiber products will store carbon far longer than the annual lifecycle of the fiber crops. We can grant legitimate carbon credits to promote their use. Then we can let forests grow and help save the climate.

2) Buildings made of steel and concrete have longer useful lifespans than wood and might outperform wood, over the long term. A credible analysis of substitution must account for factors such as the time it takes to reabsorb the carbon after forests are logged, differences in the useful lifespan of different building materials (steel and cement typically last longer), the improving carbon efficiency of the energy input used to make alternative building materials, the possibility of demand-side policies such as recycling and "demand reduction."

3) Like trees, cement absorbs CO_2 during its life time. "[R]esearchers estimate that between 1930 and 2013, cement has soaked up 4.5 gigatons of carbon or more than 16 gigatons of CO_2, 43% of the total carbon emitted when limestone was converted to lime in cement kilns." Warren Cornwall 2016. Cement soaks up greenhouse gases. AAAS Science. Nov. 21, 2016. doi:10.1126/science.aal0408 https://www.sciencemag.org/news/2016/11/cement-soaks-greenhouse-gases citing Xi, F., Davis, S., Ciais, P. et al. Substantial global carbon uptake by cement carbonation. Nature Geosci 9, 880-883 (2016). https://doi.org/10.1038/ngeo2840, https://authors.library.caltech.edu/72406/2/ngeo2840-s1.pdf.

4) Making steel and cement requires energy, but that energy does not need to come from fossil fuels. They can be made with electricity which is becoming increasingly renewable. Ellis et al 2019. Toward electrochemical synthesis of cement[mdash]An electrolyzer-based process for decarbonating $CaCO_3$ while producing useful gas streams. PNAS September 16, 2019 https://doi.org/10.1073/pnas.1821673116. https://www.pnas.org/content/pnas/early/2019/09/10/1821673116.full.pdf. In effect, the carbon footprint of steel and concrete shrink as the energy sector becomes decarbonized via expansion of wind and solar. Mooney 2016. Wind power is going to get a lot cheaper as wind turbines get even more enormous. The Washington Post, Sept 12, 2016. https://www.washingtonpost.com/news/energy-environment/wp/2016/09/12/wind-power-is-going-to-get-a-lot-cheaper-as-wind-turbines-get-enormous/.

* Justin Gillis. NYT, October 16, 2019. The Steel Mill That Helped Build the American West Goes Green - Wind and solar power will replace coal at a Colorado furnace. https://www.nytimes.com/2019/10/16/opinion/solar-colorado-steel-mill.html?smtyp=cur&smid=tw-nytimesscience.

* Just Have a Think - Fossil Free Steel - Another giant step towards net carbon zero? https://youtu.be/ywHJt88H5YQ Dec 13, 2020,
* News of a new steel plant in Sweden that uses hydrogen from renewable electricity. Dan Gearino 2021. Inside Clean Energy: From Sweden, a Potential Breakthrough for Clean Steel - A Swedish partnership is cheering a milestone in its quest to make steel in a way that sharply reduces emissions. Inside Climate News. June 24, 2021 https://insideclimatenews.org/news/24062021/inside-clean-energy-clean-steel-sweden/;
* Lobet, Ingrid 2021. Steelmakers forge ahead on cleaning up their notoriously dirty industry - From miners to automakers, steel industry players are starting to come together to make "green steel" the new norm. 28 September 2021. https://www.canarymedia.com/articles/clean-industry/steelmakers-forge-ahead-on-cleaning-up-their-notoriously-dirty-industry ("In Europe, all major steelmakers have announced plans to scale up an alternative to coal-fired production: using hydrogen fuel made via electrolysis to create 'green steel.'");
* Matthew Hutson 2021. The Promise of Carbon-Neutral Steel A new manufacturing technique could drastically reduce the footprint of one of our dirtiest materials. September 18, 2021. https://www.newyorker.com/news/annals-of-a-warming-planet/the-promise-of-carbon-neutral-steel ("[hellip]we've since learned that there's more than one way to purify iron. Instead of using carbon to remove the oxygen from ore, creating CO_2, we can use hydrogen, creating H_2O[mdash]that is, water. Many companies are working on this approach; this summer, a Swedish venture used it to make steel at a pilot plant. If the technique were widely employed, it could cut the steel industry's emissions by ninety per cent, and our global emissions by nearly six per cent.");
* Paul Fennell, Justin Driver, Christopher Bataille & Steven J. Davis 2022. Cement and steel [mdash] nine steps to net zero It is possible [mdash] and crucial [mdash] to green the building blocks of the modern world. Nature 603, 574-577 (2022) doi: https://doi.org/10.1038/d41586-022-00758-4. https://www.nature.com/articles/d41586-022-00758-4;
* Palash Badjaty, Abdullah H. Akc, Daniela V. Fraga Alvarez, Baoqi Chang, Siwei Ma, Xueqi Pan, Emily Wang, Quinten van Hinsber, Daniel V. Esposito, and Shiho Kawashima. 2022. Carbon-negative cement manufacturing from seawater-derived magnesium feedstocks. PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, Vol. 119 | No. 34, August 23, 2022 https://www.pnas.org/doi/full/10.1073/pnas.2114680119 ("the present study demonstrates the key steps in an environmentally friendly process for the manufacture of carbon-negative cement derived from highly abundant magnesium (Mg^{2+}) ions in seawater. If the electricity used to power electrochemical reactors used to harvest Mg^{2+} is derived from carbon-free electricity sources and CO_2 consumed by the process is sourced from the atmosphere or ocean, this carbon-negative process has the potential to transform the world's most carbon-intensive industries into one of its biggest carbon sinks.");
* Dunant, C. F., Joseph, S., Prajapati, R., & Allwood, J. M. (2024). Electric recycling of Portland cement at scale. Nature, 1-7. https://doi.org/10.1038/s41586-024-07338-8, https://www.nature.com/articles/s41586-024-07338-8.pdf ("This study demonstrates that using existing industrial-scale equipment it is possible to recycle Portland cement into Portland cement in an all-electric process. The process can be operated as co-production with steel recycling or for the exclusive production of cement using an EAF with a small untapped pool of molten steel. The process is fundamentally a material substitution within existing processes, equipment and standards, and so it could scale rapidly.").

5) Substitution is speculative because the alleged benefits are in the distant future, and it takes more than a century to off-set the carbon emissions (carbon debt) caused by logging forests. Only a small fraction of the carbon in a logged forest ends up in long-term storage in wood products. Most of the carbon in a logged forest is subject to an accelerated transferred to the atmosphere where it causes warming and ocean acidification. For every ton of carbon stored in wood products, there are several times more carbon from the forest prematurely transferred to the atmosphere. Since the alleged carbon benefits from substitution are typically realized in the distant future and must be discounted. The CORRIM study appears to assume a 0% discount rate which is inconsistent with rational decision making because it effectively places no value on the carbon stored in forests in the short-term under a no-harvest scenario compared to a harvest scenario. Near-term carbon storage is critically important while the economy transitions to low carbon methods, yet it will take over a century for substitution to off-set the initial carbon deficit associated with logging mature forests.

Under well-established principles of discounting, it is clear that the net present value of current carbon storage in existing mature forests exceeds the net present value of distant future benefits of substitution. This graph shows why the near term matters (most of the warming happens within 20 years and then slowly continues to increase):

SEE LETTER SUBMISSION: % of equilibrium temperature change

Related: the IPCC made a policy decision to place more value on the near-term because the majority of warming happens within 10-20 years after emissions. If it is true that we need to be more concerned about the near-term, then we can also say that forests are more valuable as places to store carbon and wood products are less valuable. This is because every effort to transfer carbon from the forest into wood products results in a net near-term pulse of carbon to the atmosphere, and this carbon "debt" is not repaid until the distant future when the replacement forest grows (not to the point that it stores the same amount of carbon as before harvest) but rather to a point that recaptures all the carbon PLUS mitigates for the climate impacts caused during the "carbon debt" payback period. See Katsumasa Tanaka & Brian C. O'Neill. 2018. The Paris Agreement zero-emissions goal is not always consistent with the 1.5 [deg]C and 2 [deg]C temperature targets. Nature Climate Change (2018) doi:10.1038/s41558-018-0097-x. https://www.nature.com/articles/s41558-018-0097-x#Abs1, and see Brack, Duncan 2017. Woody Biomass for Power and Heat: Impacts on the Global Climate. Chatham House. https://www.chathamhouse.org/sites/files/chathamhouse/publications/research/2017-02-23-woody-biomass-global-climate-brack-embargoed.pdf.

6) "If wood buildings are replaced by wood buildings, substitution is not occurring, and because wood is preferred for construction of single-family housing in North America, some of our substitution values are overestimated (Sathre and O'Connor 2010). Wood products store carbon temporarily, and a larger wood product pool increases decomposition emissions over time (figure 3)." Tara W Hudiburg, Beverly E Law, William R Moomaw, Mark E Harmon and Jeffrey E Stenzel 2019. Meeting GHG reduction targets requires accounting for all forest sector emissions. Environmental Research Letters, Volume 14, Number 9. https://iopscience.iop.org/article/10.1088/1748-9326/ab28bb/pdf.

7) Many analyses of substitution fail to account for the carbon debt associated with logging. They do this by starting with "bare ground" instead of an existing forest, which biases the analysis by crediting wood products with growing the forest in the first place instead of debiting wood products for dramatically reducing the carbon stored in an existing forest.

SEE LETTER SUBMISSION: But if we start from a native forest instead of a clearcut

8) Substitution offers no guarantees that fossil fuels will stay in the ground. Fossil fuel use associated with the manufacture of steel and concrete will not be permanently avoided, but just delayed. The longest it could be delayed will be the earlier of:

* The point in time when the rising price of fossil fuels is undercut by the declining price of renewable energy.
* The point in time when we stop using fossil fuels for making steel and cement.
* The point in time when the fossil fuels that would have been used to make steel and cement are extracted and used for some alternative activity.

9) The CORRIM analysis fails to recognize that the production techniques used to make steel and concrete are continually improving leading to increased energy efficiency. For instance, steel recycling rates are always increasing, the addition of fly ash during the manufacture of concrete reduces its carbon footprint. Cement producers recently agreed to a voluntary 25% reduction in carbon emissions.
http://www.reuters.com/article/GCA-GreenBusiness/idUSTRE54J5L420090520;
http://www.wbcsdcement.org/pdf/agenda.pdf; There are several ways that emissions from cement and steel can

be reduced, e.g., Reduce use; Clinker substitution; Carbon capture & storage; Alternative 'novel' cement https://www.carbonbrief.org/qa-why-cement-emissions-matter-for-climate-change ("Progress so far has come in three main areas. First, more efficient cement kilns have made production less energy-intensive. This can improve further ... [R]educing the proportion of Portland clinker in cement has also cut emissions. "High-blend" cements can reduce emissions per kilogram by up to four times, ... Geopolymer-based cements, for example, have been a focus of research since the 1970s. These do not use calcium carbonate as a key ingredient, harden at room temperature and release only water. Zeobond and banahUK are among firms producing these, with both claiming around 80-90% reduction in emissions compared to Portland cement. There are also several firms developing "carbon-cured" cements, which absorb CO2, rather than water, as they harden. If this CO2 absorption can be made higher than CO2 released during their production, cements could potentially be used as a carbon sink. US firm Solidia, for example, claims its concrete emits up to 70% less CO2 than Portland cement, including this sequestering step. The firm is now in a partnership with major cement producer LafargeHolcim. ... Other firms are using completely different materials to make cement. North Carolina-based startup Biomason, for example, uses bacteria to grow cement bricks which it says are both similarly strong to traditional masonry and carbon-sequestering."). The energy grid that powers the steel mills and concrete plants are always becoming less carbon intensive. For instance, here in Oregon, only about 32% of electricity is from coal:

SEE LETTER SUBMISSION: Fuel

http://www.oregon.gov/energy/energy-oregon/Pages/Electricity-Mix-in-Oregon.aspx.

Law et al (2018) said:

Increased long-term storage in buildings and via product substitution has been suggested as a potential climate mitigation option. Pacific temperate forests can store carbon for many hundreds of years, which is much longer than is expected for buildings that are generally assumed to outlive their usefulness or be replaced within several decades (7). By 2035, about 75% of buildings in the United States will be replaced or renovated, based on new construction, demolition, and renovation trends (31, 32). Recent analysis suggests substitution benefits of using wood versus more fossil fuel-intensive materials have been overestimated by at least an order of magnitude (33). Our LCA accounts for losses in product substitution stores (PSSs) associated with building life span, and thus are considerably lower than when no losses are assumed (4, 34). While product substitution reduces the overall forest sector emissions, it cannot offset the losses incurred by frequent harvest and losses associated with product transportation, manufacturing, use, disposal, and decay. Methods for calculating substitution benefits should be improved in other regional assessments.

Beverly E. Law, Tara W. Hudiburg, Logan T. Berner, Jeffrey J. Kent, Polly C. Buotte, Mark E. Harmon. 2018. Land use strategies to mitigate climate change in carbon dense temperate forests. Proceedings of the National Academy of Sciences Mar 2018, 201720064; DOI: 10.1073/pnas.1720064115
https://web.archive.org/web/20180727130028/http://www.pnas.org/content/pnas/115/14/3663.full.pdf.

Shafer et al (2011) state:

An alternative to increasing carbon stores within the forest is to harvest wood and store some of this carbon within wood products (Perez-Garcia et al., 2005). Under current manufacturing, use, and disposal practices this alternative is unlikely to increase the overall carbon store of the forest sector, which includes the forest and wood products derived from the forest (Harmon et al., 2009). Manufacturing, use, and disposal of harvested wood all entail significant carbon losses that are either as large as or larger than those in the forest itself (Krankina and Harmon, 2007). Wood products carbon offsets associated with biofuels and substitution of wood for more energy intensive building materials, such as steel and concrete, can theoretically increase the carbon "stores" of wood products beyond that stored in the forest itself (Perez-Garcia et al., 2005; Lippke et al. 2010). However, several issues need to be recognized regarding these offsets. First, most analyses have presented theoretical maximum product substitution offsets and ignored the effects of additionality (i.e., degree to which practices differ from business as usual or statutory requirements), permanence and replacement of existing wood products, and end-user preferences for building materials. If these factors are included, then substitution effects are substantially lower than the theoretical maximum and unlikely to surpass carbon stores in forests for many centuries if at all. Second, depending on the starting condition of the forest, both product substitution and forest-related biofuels can create carbon debts that delay carbon benefits. For example, biofuels harvested from existing forests could offset fossil fuel releases of carbon, but recent studies have indicated that carbon debts associated with the energy used during biofuel harvests, decreased carbon stores in forests, and differences in carbon to energy ratios could persist for decades to centuries, implying a significant temporal lag in net carbon uptake (Fargione et al., 2008; Searchinger et al., 2009). Third, being offsets, the effectiveness of both biofuel and product substitution will vary with the duration of the offset; the longer the delay in releasing fossil fuel carbon, the more effective offsets become: An offset with a 1 year delay would have little impact on atmospheric CO_2 concentrations, whereas an offset of hundreds of years would have a much greater impact. Unfortunately, the duration of offsets is not well understood at this point, but it is unlikely to be infinite as tacitly assumed in many current analyses. Finally, while offsets are often counted as carbon stores, they are difficult to directly inventory because they are not physically in an identifiable location, whereas carbon stored in forests can be more directly inventoried and quantified.

Sarah L. Shafer, Mark E. Harmon, Ronald P. Neilson, Rupert Seidl, Brad St. Clair, Andrew Yost 2011. Oregon Climate Assessment Report (OCAR) http://occri.net/ocar Chapter 5. The Potential Effects of Climate Change on Oregon's Vegetation. http://occri.net/wp-content/uploads/2011/04/chapter5ocar.pdf.

If the agency wishes to rely on substitution to justify carbon emissions from logging, they cannot assume the project will result in the theoretical maximum substitution benefits. They must instead consider and analyze the real world substitution effects based on several key factors. Fain et al (2018) explain--

[S]ubstitution is a key variable in determining cumulative carbon benefits over time. Franklin et al. discuss 6 key factors in determining the magnitude of substitution effects through time: (1) the amount of product-in-use created from the harvest, (2) the displacement factor, (3) percent of the harvest that will substitute for non-wood products like concrete or steel, (4) the cumulative nature of the substitution effects, (5) the length of time the substitution effect accumulates, and (6) the effect on the average lifespan of buildings if wood is substituted for fossil fuel intensive materials. ... The displacement factor ... varies depending on the building system and the embedded GHG emissions factor within displaced materials. ... [E]ngineering studies found the average displacement factor value to be 2.1, ... [T]his number is a global reference average and likely not accurate for any given place and time. Uniquely local and dynamic biological and socio-economic factors such as, silvicultural systems, tree species, form and age of trees, amount of wood degrade, mortality rates, market demand, economics of transporting to processing facilities, and supply quota agreements, greatly influence commercial wood products and thus any attempts to quantify substitution rates and life cycles. ... [A]s technology, wood use, and energy sources evolve into the future, so will the displacement factor associated with substitution, most likely declining.

Fain, S.J.; Kittler, B.; Chowyuk, A. Managing Moist Forests of the Pacific Northwest United States for Climate Positive Outcomes. Forests 2018; 9(10):618. https://www.mdpi.com/1999-4907/9/10/618 citing Franklin, J.; Johnson, N.; Johnson, D. Ecological Forest Management; Waveland Press: Long Grove, IL, USA, 2018.

[hellip] benefits attributed to product substitution are commonly overestimated. Substituting wood for aluminum and steel can displace fossil fuel emissions, but the displacement period needs to be part of the accounting. Displacement occurs until the building is replaced, and then the substitution can be renewed by a new building or it can be lost by using a material with a higher energy cost. In addition, it is often assumed that product substitution will reduce the demand for fossil fuel. However, due to human behavior and current economic systems that ignore adverse externalities, reducing resource consumption through substitution or improvements

in efficiency rarely reduce fossil fuel use (York, 2012). Therefore, benefits may be substantially lower and the payback period much longer and smaller for the carbon debt from intensified management and avoided fossil fuel combustion than commonly assumed (Haberl et al., 2013).

Law, B.E., Waring, R.H. 2015. Review and synthesis - Carbon implications of current and future effects of drought, fire and management on Pacific Northwest forests. Forest Ecology and Management 355 (2015) 4-14. http://people.forestry.oregonstate.edu/richard-waring/sites/people.forestry.oregonstate.edu.richard-waring/files/publications/Law%20and%20Waring%202015.pdf

Law & Harmon conducted a literature review and concluded [hellip]

Most LCA [life cycle analysis] studies rely heavily on wood product substitution for GHG benefits, and these have been grossly overestimated, with many ambiguous assertions that gloss over forest carbon dynamics; for example:

[middot] Biofuel emissions are assumed to be zero because they are balanced by net growth, yet this would depend on the state of the preceding forest system - they could be positive, neutral or negative;

[middot] Old forests are assumed to always be carbon sources, while young forests are always assumed to be carbon sinks, contrary to forest carbon dynamics findings;

[middot] Dead wood and soil carbon stores are either not included or assumed to be constant;

[middot] In one LCA, dead wood is not present in older forests, contrary to findings in the extensive ecological literature;

[middot] The wood product pool is assumed to be an increasing carbon stock over time.

[hellip]

Substitution of more energy-intensive building materials with a less energy intensive one can, in theory, result in a fossil fuel offset; for example, when wood replaces a construction material with higher emissions (e.g., concrete or steel), the fossil CO_2 emission avoided by choosing wood is credited as an offset. Thus, harvest of forest carbon and placement into buildings can impact the overall carbon balance of the forest sector [33,42]. However, several additional factors need to be considered. First, changes in the carbon stores of the forest ecosystem have to be considered relative to a base case that includes a lower level of harvests. As noted above, decreasing the interval between harvests, or increasing harvest intensity will lower the carbon store in the forest [9-11,31]; the question is whether stores in forest products combined with substitution offsets surpass losses from shorter rotations. Since the forest has a maximum carrying capacity, just the growth in carbon stores and offsets would seem to eventually exceed old forest carbon, although it could take centuries to happen, even using the most generous substitution effects. With more realistic substitution effects, it may never happen. In some cases, the amount of live and dead biomass in unharvested forests was grossly underestimated leading to an overestimation of the relative benefits of substitution. Second, in substitution effects calculations, it is often tacitly assumed that wood that is removed from forests and used in long-term wood products, specifically buildings, continues to accumulate infinitely over time. While building carbon stores have increased in many areas (e.g., the USA), this is largely because more forest area is being harvested and not because the harvest-related stores per harvest area are increasing. The trend that is being used as evidence of increasing building stores is based on the fact that because a greater area has been harvested, the total store has increased. This is not the same thing as the increase associated with a particular area of forest. A fixed per area basis is how substitution effects have largely been evaluated in the past, so arguing on an expanding area basis is inappropriate. The reason that wood products saturate is that housing and other wood products have a finite lifespan and are eventually replaced [43].

Although there can be some reuse of wood, essentially assuming an infinite lifespan or 100% reuse of wood products is completely unrealistic. Carbon is always lost as wood products are used or disposed of, which means release of CO2 to the atmosphere. Since long-term storage in forest products saturates over time (i.e., eventually does not increase), the effect of substituting wood for fossil fuel energy is also likely to saturate. Third, in most cases, the substitution offset was calculated based on the assumption that each time a house is to be built, the preference is for nonwood materials. This results in an estimate of the maximum substitution effect possible, but does not account for actual preferences for building materials. Granted, preferences vary by region and over time, but without accounting for these one cannot possibly estimate realistic substitution benefits. Fourth, current substitution accounting appears to violate a key principle of carbon offsets, namely permanence. In fact the ever-increasing substitution offset presented in these analyses appears to depend on impermanence of wooden buildings. Fifth, most, if not all, current analyses of substitution effects ignore the effects of additionality and whether wooden buildings are initially present. Given that many forests have already been harvested to produce wood products, replacing wooden buildings with more wooden buildings results in no additional substitution effect. Finally, these studies assume that it is a permanent benefit to GHG removal from the atmosphere. That is, they assume there is a continual increase in the carbon credit, and maintenance of a sustainable productive forest dedicated to providing substitutes for nonwood fuels and materials [44].

These caveats all suggest that while there is likely to be some building material substitution effect that is valid, it is far lower than generally estimated and as subject to saturation as other forest-related carbon pools. In summary, the substitution effect appears to have been grossly overestimated. Substitution is an offset, not a store. Offsets depend on the use of appropriate accounting rules. Until rules such as permanence, additionality and leakage are followed, the values being presented in many analyses are not credible.

[hellip]

Life cycle analysis (including substitution, proposed considerations)

[hellip]

[middot] Substitution of more energy intensive building materials with less energy intensive ones can in theory result in a fossil fuel offset, but important considerations suggest that the substitution effect is substantially lower than estimated, and is subject to saturation.

Beverly Elizabeth Law & Mark E Harmon 2011. Forest sector carbon management, measurement and verification, and discussion of policy related to mitigation and adaptation of forests to climate change. Carbon Management. https://archives.corvallisoregon.gov/public/ElectronicFile.aspx?dbid=0&docid=4256162.

Harmonize climate change mitigation and adaptation

The agency has decided that meeting the purpose of this project requires logging that will emit greenhouse gases to the atmosphere and which will exacerbate global climate change (and ironically increase the climate stress imposed on the forest). These are very significant effects that require an EIS and consideration of mitigating alternatives. The agency can mitigate the effects of logging-related GHG emissions by retaining more trees, thinning less aggressively, forgoing logging in some areas, etc.

NEPA mandates that an agency "shall to the fullest extent possible: use the NEPA process to identify and assess the reasonable alternatives to proposed actions that will avoid or minimize adverse effects of these action upon the quality of the human environment." 40 C.F.R. [sect] 1500.2(e). NEPA also requires the agency to "study, develop, and describe appropriate alternatives to the recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources as provided by section 102(2)(E) of the Act [NEPA]."40 C.F.R. [sect] 1501.2 (c). All reasonable alternatives must receive a "rigorous exploration and objective evaluation ..., particularly those that might enhance environmental quality or avoid some or all of the adverse environmental effects." Id. [sect] 1500.8(a)(4).

The agency need to rethink its focus on climate adaptation/resilience actions (such as density reduction with commercial log removal) that will actually increase carbon emissions and exacerbate global climate change and reduce climate resilience, not just in the treated stands but around the world. The agencies instead need to design preferred alternaitves that meaningfully harmonize climate change adaptation and climate change mitigation, such as non-commercial thinning + prescribed fire, increased riparian protection, conservation of mature, old-growth and unroaded areas, road system rescaling and storm-proofing.

The agency should develop alternatives that harmonize potentially competing objectives of climate change mitigation, and climate change adaptation. Climate change mitigation involves keeping carbon in the forest and avoiding GHG emissions to the atmosphere from logging. Climate change adaptation may involve a variety of actions that range from reducing stand density to reduce water stress in a warming world to providing habitat redundancy and connectivity, and maintaining cool/moist habitat refugia for wildlife that thrive in dense forests.

The Biden Administration has adopted a policy to both mitigate AND prepare for global climate change.

"It is, therefore, the policy of [the Biden] Administration to listen to the science; to improve public health and protect our environment; to ensure access to clean air and water; [hellip] to reduce greenhouse gas emissions; to bolster resilience to the impacts of climate change; [hellip] To that end, this order directs all executive departments and agencies (agencies) to immediately review and, as appropriate and consistent with applicable law, take action to address the promulgation of Federal regulations and other actions during the last 4 years that conflict with these important national objectives, and to immediately commence work to confront the climate crisis."

Executive Order on Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis. JANUARY 20, 2021 https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/executive-order-protecting-public-health-and-environment-

and-restoring-science-to-tackle-climate-crisis/. This requires careful balancing of sometimes competing objectives, such as retaining trees to store carbon, and thinning to reduce climate stresses. The best harmony among these objectives is to retain medium and large trees that store the most carbon and provide the greatest ecosystem services, while thinning small trees removal of which will reduce climate stresses on the larger trees while emitting less carbon.

President Obama established a clear policy mandate to avoid, minimize, and rectify impacts of federal land use:

Section 1. Policy. It shall be the policy of the Departments of Defense, the Interior, and Agriculture; the Environmental Protection Agency; and the National Oceanic and Atmospheric Administration; and all bureaus or agencies within them (agencies); to avoid and then minimize harmful effects to land, water, wildlife, and other ecological resources (natural resources) caused by land- or water-disturbing activities, and to ensure that any remaining harmful effects are effectively addressed, consistent with existing mission and legal authorities. Agencies shall each adopt a clear and consistent approach for avoidance and minimization of, and compensatory mitigation for, the impacts of their activities and the projects they approve.

[hellip] Sec 2. Definitions [hellip] (f) "Mitigation" means avoiding, minimizing, rectifying, reducing over time, and compensating for impacts on natural resources. As a practical matter, all of these actions are captured in the terms avoidance, minimization, and compensation. These three actions are generally applied sequentially, and therefore compensatory measures should normally not be considered until after all appropriate and practicable avoidance and minimization measures have been considered.

[hellip]

Sec. 3. Establishing Federal Principles for Mitigation. [hellip] (b) Agencies' mitigation policies should establish a net benefit goal or, at a minimum, a no net loss goal for natural resources the agency manages that are important, scarce, or sensitive, or wherever doing so is consistent with agency mission and established natural resource objectives. When a resource's value is determined to be irreplaceable, the preferred means of achieving either of these goals is through avoidance, consistent with applicable legal authorities. Agencies should explicitly consider the extent to which the beneficial environmental outcomes that will be achieved are demonstrably new and would not have occurred in the absence of mitigation (i.e. additionality) when determining whether those measures adequately address impacts to natural resources.

Presidential Memorandum: Mitigating Impacts on Natural Resources from Development and Encouraging Related Private Investment. Nov 3, 2015. https://www.whitehouse.gov/the-press-office/2015/11/03/mitigating-impacts-natural-resources-development-and-encouraging-related In the context of climate change this means that greenhouse gas emissions should be avoided and that the climate forcing effects of any emissions that do occur must be mitigated.

Stein et al (2014) make the distinction between climate change mitigation and adaptation and the potential conflict between the two.

Climate change adaptation is the discipline that focuses on addressing these impacts. In contrast, climate change mitigation addresses the underlying causes of climate change, through a focus on reductions in greenhouse gas concentrations in the atmosphere. Confronting the climate crisis requires that we both address the underlying causes of climate change and simultaneously prepare for and adapt to current and future impacts. Accordingly, adaptation and mitigation must be viewed as essential complements, rather than as alternative approaches. Because greenhouse gas emissions and concentrations will dictate the type and magnitude of impacts to which we will need to adapt, the ability to successfully accomplish adaptation over the long term will be linked to the success of climate mitigation efforts (Warren et al. 2013).

[hellip]

Climate-smart conservation strategies must also take climate mitigation considerations into account. Although adaptation is about addressing the impacts of rapid climate change, adaptation actions should not aggravate the underlying problem of global warming. Indeed, minimizing the carbon footprint of adaptation actions can help society avoid the "worst-case" scenarios for climate change, which would make successful adaptation in human and natural systems difficult, if not impossible, to achieve. Ideally, adaptation efforts should contribute to meeting climate mitigation goals both by minimizing or reducing the greenhouse gas emissions from project operations, including from any construction and ongoing maintenance, as well as by managing natural systems in ways that sustain or enhance their ability to cycle, sequester, and store carbon.

[hellip]

Some of the most obvious synergies between adaptation and mitigation are those aimed at enhancing carbon stocks in natural forests, [hellip] Strategies for increasing the capture and storage of forest carbon include: avoiding deforestation; afforestation (i.e., establishment of trees in areas have not been forests or where forests have not been present for some time); decreasing forest harvest; and increasing forest growth (McKinley et al. 2011). Managing natural systems to provide carbon benefits must be carefully balanced, however, with other conservation and adaptation goals. [hellip] Recent research, however, indicates that old trees "do not act simply as senescent carbon reservoirs" but actively fix larger amounts of carbon than smaller trees (Stephensen et al. 2014). This recognition highlights the important role that biodiversity-rich old-growth forests can play in sequestering carbon.

[hellip]

It is not always obvious, however, when conservation and climate mitigation efforts might be in alignment or in conflict. [hellip] Although there are clear synergies between adaptation and mitigation focused activities, managers will also need to carefully consider any trade-offs.

Stein, B.A., P. Glick, N. Edelson, and A. Staudt (eds.). 2014. Climate-Smart Conservation: Putting Adaptation Principles into Practice. National Wildlife Federation, Washington, D.C. https://www.nwf.org/~/media/PDFs/Global-Warming/2014/Climate-Smart-Conservation-Final_06-06-2014.pdf.

Sometimes climate change mitigation and adaptation are in complete harmony, such as protecting riparian forests that both store carbon and buffer streams from hydrological extremes caused by climate change. See Justice et al. 2017. Can stream and riparian restoration offset climate change impacts to salmon populations? Journal of Environmental Management 188 (2017) 212e227 https://www.critfc.org/wp-content/uploads/2017/01/JournalPost_Justice_etal2017.pdf. However, there are also times when efforts directed at climate change adaptation conflict with climate change mitigation goals. For instance, some people argue that we should reduce the density of federal forests so they are more resilient to soil-water stress caused by global warming. However, forest density reduction will accelerate the transfer of carbon from the forest to the atmosphere where it will contribute to global climate change.

Logging and the entire wood products supply chain causes significant emissions of CO_2, this makes fire worse in several ways. It not only warms the atmosphere and extends the fire season, CO_2 is also a "floating fertilizer" that stimulates the growth of hazardous fuels. When the agency says they are logging to make the forest more resilient to climate change, they must address these countervailing risks, and consider alternatives that better harmonize climate change resilience/adaptation and climate change mitigation (emissions avoidance). Allen, R. J., Gomez, J., Horowitz, L. W., & Shevliakova, E. (2024). Enhanced future vegetation growth with elevated carbon dioxide concentrations could increase fire activity. Communications Earth & Environment, 5(1), 1-15. https://doi.org/10.1038/s43247-024-01228-7. ("[hellip] the spatial pattern of the NPP response is quite similar to the corresponding spatial pattern of the fFire response (Fig. 2)-not only for 1% per year CO_2 and 1% per year CO_2-bgc, but interestingly also for 1% per year CO_2-rad. This is also the case for other vegetation parameters, including leaf area index (LAI; Supplementary Figs. 10-11 and Supplementary Note 4). This implies that the increase in fFire is largely due to the increase in biomass production (i.e., more fuel to burn) and likewise for decreases. The corresponding correlations (between the NPP and fFire responses) across grid boxes yield significant positive MMM correlations at 0.34, 0.26 and 0.17 for 1% per year CO_2, 1% per year CO_2-bgc, and 1% per year CO_2-rad, respectively. ").

Federal agencies must strive to harmonize climate change mitigation (carbon storage or avoided emissions) and climate change adaptation (making ecosystems more resilient to climate change). For example, if the agency uses climate change adaptation as a rationale for forest thinning, they must not only fully disclose the increased GHG emissions caused by their proposal, they must also consider alternatives that harmonize these competing goals, such as by thinning very lightly and retaining all of the medium and large trees that store most of the carbon.

The Forest Service recognizes the need to optimize, rather than maximize, objectives on the National Forests.

Climate adaptation

Actions that provide adaptation benefits through reduced risk of unintended climate impacts can provide carbon benefits through avoided carbon emissions. Some disturbances or forest health issues may also decrease carbon uptake through plant growth. While not all adaptation actions provide carbon benefits, there are many actions that address risks to ecosystem health that sustain or improve the capacity of systems to sequester carbon.

Carbon optimization

While national forests and grasslands can play an important role in climate change mitigation through land management, balancing the numerous environmental benefits provided by healthy ecosystems is paramount to achieving our mission. Carbon stewardship aims to optimize carbon benefits on the landscape in a way that recognizes the importance of achieving other management objectives. Maximizing ecosystem carbon stocks can create undesirable tradeoffs with other environmental benefits, and in some landscapes may result in lower carbon benefits where carbon stability is compromised. Maximizing carbon is therefore not necessary, and is often counter to, achieving effective carbon stewardship.

USDA Forest Service 2024. Sustainability and Climate website. https://www.fs.usda.gov/managing-land/sustainability-and-climate/carbon. The Silvicultural Prescription (and the NEPA analysis) need to reflect these nuances by harmonizing competing objectives. For instance, climate adaptation can be advanced in various ways, some of which emit more carbon (such as commercial logging), while others emit less carbon (such as noncommercial thinning and prescribed fire). The Silvicultural Prescription (and the NEPA analysis) should consider and weigh alternatives that highlight and resolve these trade-offs. There may be climate benefits from thinning but there will also be climate trade-offs in the form of carbon emissions, unless thinning is done very early in stand development. Schaedel et al (2017) said --

Thinning in second growth forests is often suggested as a climate change adaptation strategy (Bradford and D'Amato, 2012; Churchill et al., 2013), because thinning can be used to promote the development of complex stand structures resilient to disturbances and drought. However, these climate change adaptation outcomes attainable with thinning generally require a tradeoff with climate change mitigation objectives: most studies have shown decreased forest C storage in thinned stands (Bradford and D'Amato, 2012).

...

We found that: (1) fifty-four years after PCT total aboveground C is similar across treatments, due primarily to the increase in mean tree C of trees grown at lower stand densities; (2) deadwood legacies from the pre-disturbance forest still play an important role in long-term C storage 62 years after current stand initiation, accounting for approximately 20-25% of aboveground C stores; and (3) given enough time since early thinning, there is no trade-off between managing stands to promote individual tree growth and development of understory vegetation, and maximizing stand level accumulation of aboveground C over the long term. We infer that early PCT can be used to simultaneously achieve climate change mitigation and adaptation objectives, provided treatments are implemented early in stand development before canopy closure and the onset of intense intertree competition.

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) 187-198. https://www.fs.fed.us/rm/pubs_journals/2017/rmrs_2017_schaedel_m001.pdf. There are actually conflicting results on pre-commercial thinning ...

... precommercial thinning (PCT) when the thinned trees have no commercial value, show inconsistent results. Some PCT studies of this type found that decreasing stand density decreased total forest C stores (Skovsgaard et al., 2006; Jim[eacute]nez et al., 2011), while others noted that the increased growth rate of trees grown at lower densities can maintain or increase live tree C (Hoover and Stout, 2007; Dwyer et al., 2010), especially in the case of longer-term responses to thinning (Horner et al., 2010). Short-term studies of PCT effects on aboveground C have shown consistent decreases in aboveground C (Campbell et al., 2009; De las Heras et al., 2013; Jim[eacute]nez et al., 2011; Dwyer et al., 2010), indicating that low densities of small trees do not fully occupy the site (Turner et al., 2016). Given these conflicting results, it is still unclear whether PCT is compatible with the climate change mitigation goal of forest C storage (Jim[eacute]nez et al., 2011).

This is important because, even if thinning provides climate benefits in future decades, short-term carbon emissions conflict with climate policy priorities. The next few decades are critical to achieving goals related to decarbonizing our economy. Delayed climate benefits should be strongly discounted because we should have decarbonized our economy by then, so future effects are not nearly as important as near-term effects. If thinning causes a short-term pulse of GHG emissions, that's a problem.

The Oregon Global Warming Commission's Roadmap to 2020

(https://www.keeporegoncool.org/roadmap-to-2020/) guides the state's efforts to meet its legislatively mandated GHG emissions reduction goals, including broad objectives for increasing carbon storage in Oregon forests.

The Roadmap also set out general strategies for dry forests east of the Cascade Mountains versus moist west of the Cascades. Based on improved understanding of the carbon storage capacity of the state's forests, the 2017 Global Warming Commission Report explained that, "The Roadmap sees 'Eastside forests . . . managed primarily for ecosystem restoration, safety and climate adaptation with a minimum of incurred carbon (loss). West-side forests (are) managed . . . to increase carbon storage . . . private forestlands (are) managed primarily for production of timber and wood products . . . ' with carbon stores remaining stable or increasing".

Fain, S.J.; Kittler, B.; Chowyuk, A. Managing Moist Forests of the Pacific Northwest United States for Climate Positive Outcomes. Forests 2018; 9(10):618. https://www.mdpi.com/1999-4907/9/10/618. Following this strategy will require the agencies to retain all medium and large trees that store carbon and that do not pose a substantial fire hazard.

The Forest Service's 2022 Climate Adaptation Strategy says that harmonizing climate change mitigation and climate change adaption is "complex problem" that requires "frank discussions." This indicates a need for an EIS that carefully weighs and balances trade-offs:

Many forests with old-growth characteristics have a combination of higher carbon density and biodiversity that contributes to both carbon storage and climate resilience. They are often viewed as ideal candidates for increased conservation efforts, [hellip] Even so, as climate continues to deviate from historical norms, many of these forests are expected to be at increasing risk from acute and chronic disturbances such as drought, wildfires, and insect and disease outbreaks. As a result, climate-amplified disturbances like these have become the primary threat to old-growth stands on national forests. In response, Executive Order 14072 Strengthening the Nation's Forests, Communities, and Local Economies emphasizes the climate-informed stewardship of mature and old-growth forests on Federal lands, as part of a science-based approach to maintain valued characteristics and reduce wildfire risk. There is no single "right answer" in addressing the complex problem, but the spirit and practice of shared stewardship can help us generate the frank discussions necessary to consider values and risks as we find the best paths forward.

[hellip]

Unfortunately, many forests are increasingly vulnerable to climate-amplified impacts and stressors. If a forest is vulnerable, so is its carbon. Thoughtful carbon stewardship does not seek to maximize carbon at the expense of forest health but rather to optimize carbon within the context of ecosystem integrity and climate adaptation. Some forests, such as those at risk for high severity wildfire, might require hazardous fuels treatments and other forest health interventions that reduce carbon storage in the short term [hellip]

USDA FOREST SERVICE CLIMATE ADAPTATION PLAN. FS-1196 | July 2022. https://www.usda.gov/sites/default/files/documents/4_NRE_FS_ClimateAdaptationPlan_2022.pdf. Any effort to optimize requires weighing the competing values. The Silvicultural Prescription (and the NEPA analysis) must document this process. The last sentence suggests that carbon emissions from fuel reduction are justified, but it can also be said that forgoing fuel reduction is justified in order to retain carbon and avoid GHG emissions. The Strategy offers no tools to resolve these competing views. Weighing these issues is an appropriate subject for a hard look under NEPA.

The agencies often claim that density reduction treatments are expected to increase the resiliency of treated stands to the projected effects of climate change. But this small increase in resiliency comes at a tremendous cost. The Silvicultural Prescription (and the NEPA analysis) need to disclose and consider the fact that logging will result in greenhouse gas emissions that make climate change worse. Think about that trade-off. Logging might make a small area more resilient to climate change while making climate conditions (and ocean acidification) worse for ecosystems all over the rest of the world. This significant trade-off needs to be carefully evaluated in the Silvicultural Prescription (and the NEPA document).

There is evidence that tree mortality is controlled more by low humidity than soil water availability, so thinning to increase soil water availability and drought resilience won't do much good. Karla M. Jarecke, Linnia R. Hawkins, Kevin D. Bladon, Steven M. Wondzell 2023. Carbon uptake by Douglas-fir is more sensitive to increased temperature and vapor pressure deficit than reduced rainfall in the western Cascade Mountains, Oregon, USA. Agricultural and Forest Meteorology, Volume 329, 15 February 2023, 109267. https://www.sciencedirect.com/science/article/abs/pii/S0168192322004543. This undercuts the idea that logging is useful to increase forest resilience and adaptation to climate change. Such logging just emits a lot of carbon and exacerbates climate change without actually increasing forests resilience. This is a highly unfavorable trade-off.

Even well-intentioned logging also has impacts that make ecosystems less resilient to climate change. For instance, (i) roads and soil degradation make watershed less resilient to the expected effects of the amplified hydrologic cycle; (ii) reduction of complex forest structure and dense forest conditions makes certain species populations less resilient to climate change, including species associated with relatively dense forests and species associated with snags and dead wood. These species are already stressed by the cumulative effects of non-federal land management and fragmentation caused by past and ongoing management on federal lands; (iii) Also, "High overstory density can be resilient" when ladder fuel are absent and there is a gap between surface and canopy fuels. Terrie Jain (2009) Logic Paths for Approaching Restoration: A Scientist's Perspective, from Workshop: Restoring Westside Dry Forests - Planning and Analysis for Restoring Westside Cascade Dry Forest Ecosystems: A focus on Systems Dominated by Douglas-fir, Ponderosa Pine, Incense Cedar, and so on. May 28, 2009. http://ecoshare.info/projects/central-cascade- adaptive-management-partnership/workshops/restoring-westside- dry-forests/. New information indicates that El Ninos will likely become stronger even if we are able to limited warming to 1.5 degrees C. Guojian Wang, et al. 2016. Continued increase of extreme El Ni[ntilde]o frequency long after 1.5 [deg]C warming stabilization. Nature Climate Change (2017). doi:10.1038/nclimate3351. https://www.nature.com/nclimate/journal/vaop/ncurrent/full/nclimate3351.html. A bet-hedging strategy should retain trees of all sizes and stands of various densities. "Removal of most small trees to reduce wildfire risk may compromise the bet-hedging resilience, provided by small trees and diverse tree sizes and species, against a broad array of unpredictable future disturbances." William L. Baker and Mark A. Williams. 2015. Bet-hedging dry-forest resilience to climate-change threats in the western USA based on historical forest structure. Front. Ecol. Evol., 13 January 2015 | doi: 10.3389/fevo.2014.00088. http://journal.frontiersin.org/Journal/10.3389/fevo.2014.00088/full.

Forests are already highly adaptable to climate change. There is evidence that a wide variety of different forest types are capturing and storing more carbon from the current CO_2 enriched atmosphere. Davis, E.C., Sohngen,

B. & Lewis, D.J. The effect of carbon fertilization on naturally regenerated and planted US forests. Nat Commun 13, 5490 (2022). https://doi.org/10.1038/s41467-022-33196-x. The temperate forest environment is and has always been highly dynamic. Forest species evolved over long periods that include significant changes in climate. The large and complex genomes of forest species may include the memory of which genes to turn on or off to increase survival during climate stress. Forest disturbance can take many forms and almost always creates new opportunities for better-adapted species to establish and thrive. Mortality from any cause thins the forest, reducing total demand for light, water, and nutrients, and increasing availability of those resources to surviving trees. Several mechanisms can trigger forest vegetation to adjust stomatal opening and use water more efficiently, e.g., due to CO2 enrichment of the atmosphere (Law, B.E., Waring, R.H. 2015. Review and synthesis - Carbon implications of current and future effects of drought, fire and management on Pacific Northwest forests. Forest Ecology and Management 355 (2015) 4-14. http://people.forestry.oregonstate.edu/richard-waring/sites/people.forestry.oregonstate.edu.richard-waring/files/publications/Law%20and%20Waring%202015.pdf), and due to chemical signaling of drought conditions. Xu, B., Long, Y., Feng, X. et al. GABA signaling modulates stomatal opening to enhance plant water use efficiency and drought resilience. Nat Commun 12, 1952 (2021). https://doi.org/10.1038/s41467-021-21694-3; https://www.nature.com/articles/s41467-021-21694-3.pdf. For all these reasons, it is wise to focus on climate mitigation by conserving forests and allowing them to store more carbon. Climate adaptation will take care of itself. Forests are self-organizing systems that adapt to changing conditions without the need for logging.

Also, wildfire is mostly climate driven, not fuel driven, and the actual effects of fuel reduction on the spatial extent of wildfires is highly variable and fairly modest. "Analysis of simulation results from the 14 wildfires indicates that fuels treatments reduced the average size of any given wildfire by an estimated 7.2%, with amount of change correlated with the proportion of the landscape treated (Spearman's correlation p=0.692, n=14; P=0.008)." M. A. Cochrane, C. J. Moran, M. C. Wimberly, A. D. Baer, M. A. Finney, K. L. Beckendorf, J. Eidenshink, and Z. Zhu. 2012. Estimation of wildfire size and risk changes due to fuels treatments. International Journal of Wildland Fire. http://dx.doi.org/10.1071/WF11079. http://www.publish.csiro.au/?act=view_file&file_id=WF11079.pdf. This raises a serious question whether the modest increase in resilience really justifies the adverse effects of landscape fuel treatments on climate, wildlife, soil, water, etc. When all these trade-offs are considered, we feel that climate change mitigation should receive emphasis over climate adaptation on federal land management (especially when adaptation efforts come with significant trade-offs). When climate change mitigation and adaptation may be in conflict, the agency needs to focus on reducing GHG emissions (or maintaining carbon stores). These mitigation actions are more important because (i) mitigation is shown to be more challenging (institutionally) and it is perennially under-achieved, (ii) mitigation has global benefits, and (iii) mitigation ultimately reduces the need for adaptation. An emphasis on mitigation is in accord with international law, e.g. the European Convention on Human Rights:

The court emphasises that the [State's duty of care] first and foremost should concern mitigation measures, as adaptation measures will only allow the State to protect its citizens from the consequences of climate change to a limited level. If the current greenhouse gas emissions continue in the same manner, global warming will take such a form that the costs of adaptation will become disproportionately high. Adaptation measures will therefore not be sufficient to protect citizens against the aforementioned consequences in the long term. The only effective remedy against hazardous climate change is to reduce the emission of greenhouse gases.

Urgenda Foundation v. The State of the Netherlands. Hague Court of Appeal. October 9, 2018. https://uitspraken.rechtspraak.nl/inziendocument?id=ECLI:NL:RBDHA:2015:7196

"According to a recently published analysis, increasing carbon storage could lead to more favorable conditions for northern spotted owls, pileated woodpeckers, olive-sided flycatchers, Pacific marten and red tree voles. These species may benefit from management policies that favor less intensive logging and longer periods between tree harvests." Nick Houtman 2016. Storing more carbon in western Cascades forests could benefit some wildlife species, not others. Phys.org News. November 17, 2016. http://phys.org/news/2016-11-carbon-western-cascades-forests-benefit.html, http://onlinelibrary.wiley.com/doi/10.1002/eap.1358/abstract

Stenzel et al (2021) highlighted the complex nature of the trade-offs between climate adaptation (density reduction/drought tolerance) and climate mitigation (maintaining carbon storage/reducing carbon emissions) in the context of thinning.

Carbon balance tradeoffs between reduced biomass density and increased forest resilience to disturbance are uncertain in large part due to the uncertainty of future natural disturbances occurring in treated areas. Our simulated mass mortality scenarios indicated that 2050 thinning emissions approximately equaled the 2050 emissions from stand mortality events greater than 75% and occurring after 2035. In these experiments, the gradual decomposition of large pools of killed biomass remaining on site highlighted that the emissions consequences of near-term natural disturbances will in part be realized beyond current GHG reduction timelines (e.g., 2035 or 2050, IPCC, 2018). Thus, when managing for forest carbon storage, the timing and magnitude of potential carbon gains or losses, which may be offset in time from disturbance events, must be considered. In our simulations, the near-parity in carbon emissions from thinning and high natural disturbance late in the simulation period occurred at the stand level. However, at the landscape level, the encounter rates between treatments and disturbance are typically low (J. L. Campbell et al., 2012). Greater areas of forest must therefore be treated than will encounter a disturbance, in turn increasing any carbon cost to benefit ratio estimated at the stand scale. Due to the infeasibility of landscape level treatment experiments, landscape level predictions of disturbance impacts are generally simulated with earth systems models (Buotte, Levis, et al., 2020), which remain limited in their ability to represent stochastic disturbance such as wildfire

Stenzel, J. E., Berardi, D. B., Walsh, E. S., & Hudiburg, T. W. (2021). Restoration thinning in a drought-prone Idaho forest creates a persistent carbon deficit. Journal of Geophysical Research: Biogeosciences, 126, e2020JG005815. https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2020JG005815. The agency needs to take a hard look at these trade-offs and develop alternatives that harmonize divergent climate goals in light of the evidence for (and against) benefits on both sides of the adaptation/mitigation ledger.

CARBON AS ONE OF MANY MANAGEMENT OBJECTIVES

Management objectives dictate the decisions land managers make. These objectives vary widely based on the landowner as well as the conditions of the ecosystem in question, and objectives may include any number of desired ecosystem benefits: water protection, wood production, wildlife, specific recreational opportunities, aesthetics, privacy, and more. Greenhouse gas mitigation is thus part of a wider array of management aims for forests and grasslands. Managers may choose to incorporate greenhouse gas mitigation as a management objective for a number of reasons, including increasing forest productivity or deriving benefits from participating in carbon markets. However, focusing solely on carbon could lead to non-optimal management decisions, and, in some situations, managing for carbon benefits may be at odds with other goals. The tradeoffs inherent in balancing multiple management goals necessitate the recognition that it may not be possible to meet all goals, including those for carbon, in a single stand or at a single point in time (Ryan et al. 2010). Consideration of the effects of management actions on carbon require thinking broadly across large spatial scales and long timeframes to determine the true effects on atmospheric greenhouse gases (Harmon 2001).

Janowiak, M.; Connelly, W.J.; Dante-Wood, K.; Domke, G.M.; Giardina, C.; Kayler, Z.; Marcinkowski, K.; Ontl, T.; Rodriguez-Franco, C.; Swanston, C.; Woodall, C.W.; Buford, M. 2017. Considering Forest and Grassland Carbon in Land Management. Gen. Tech. Rep. WO-95. Washington, D.C.: United States Department of Agriculture, Forest Service. 68 p. https://www.fs.usda.gov/research/publications/gtr/gtr_wo95.pdf.

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Sincerely,

Doug Heiken (he/him)

SEE LETTER SUBMISSION: Letter was reviewed for coding, and most of the contents are outside the scope of the Forest Service Manual. Therefore, the entirety of the letter was not coded. Review letter to understand contents.