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30 July 2020

TO: Eric Watrud, Forest Supervisor

ATTN: Objections, High Buck Project

VIA: <https://cara.ecosystem-management.org/Public/CommentInput?Project=53033>

**Subject: 36 CFR 218 objection of the High Buck Project**

Dear Forest Service:

In accordance with 36 CFR 218, Oregon Wild hereby objects to the project described below.

**DOCUMENT TITLE**: High Buck Vegetation Management Project Environmental Assessment, Finding of No Significant Impact, and Draft Decision Notice

<https://www.fs.usda.gov/project/?project=53033>

**PROJECT DESCRIPTION**: commercial harvest of 2,195 acres of thinning and regen using variable density and intermediate silvicultural treatments, 2,315 acres of non-commercial thinning, 2,770 acres of landscape prescribed fire, and 6 miles of temporary road construction

**PROJECT LOCATION (Forest/District)**: Umatilla National Forest, Walla Walla Ranger District

**NAME AND TITLE OF RESPONSIBLE OFFICIAL**: AARON GAGNON

Walla Walla District Ranger

**LEAD OBJECTOR:** Oregon Wild

**NARRATIVE DESCRIPTION OF THOSE ASPECTS OF THE PROPOSED DECISION ADDRESSED BY THE OBJECTION:**

Oregon Wild is focusing our objection on three primary issues:

1. The EA’s failure to take a hard look at the diverse benefits of conserving undeveloped/unroaded areas, and the adverse effects of commercial logging in undeveloped/unroaded areas south of the North Fork Umatilla River Wilderness, and
2. The EA’s failure to take a hard look at the diverse benefits of avoiding carbon emissions associated with logging and adverse effects of such carbon emissions and their contribution to cumulative overloading of greenhouse gases in the atmosphere causing global climate change and ocean acidification; and
3. The Forest Service’s failure to meet the letter and spirit of NEPA by not providing a public comment opportunity on the EA.

**SUGGESTED REMEDIES THAT WOULD RESOLVE THE OBJECTION:**

Oregon Wild respectfully requests that the Forest Service withdraw the recommended project and —

1. Issue a clear decision that allows natural processes to flourish in a subset of the project area and avoids commercial logging and road building in unroaded areas, and retain greater basal area of medium and large trees in order to store carbon to mitigate global climate change, as well as mitigate other adverse effects of logging on late successional habitat; or
2. Prepare a new EIS to address the significant impacts and unresolved conflicts and fully complies with the requirements of NEPA and the CEQ regulations and addresses the specific concerns expressed below, particularly related to carbon storage/emissions, climate change and logging in undeveloped areas.

Adopting alternative B would partially address our concerns.

**DESCRIBE HOW THE OBJECTIONS RELATE TO PRIOR COMMENTS:**

Oregon Wild’s 4-1-2020 scoping comments devoted substantial attention to the issues of roadless conservation, carbon storage, climate change, and basal area retention.

**SPECIFIC ISSUES RELATED TO THE PROPOSED ACTION:**

## The EA failed to adequately address Roadless/Undeveloped/Unroaded

The High Buck Project involves significant logging in *de facto* roadless areas along the south edge of the North Fork Umatilla River Wilderness Area, shown in dark blue polygons on the map below. Logging these areas may cause significant effects on wildlife habitat, carbon storage, and other ecosystem services.

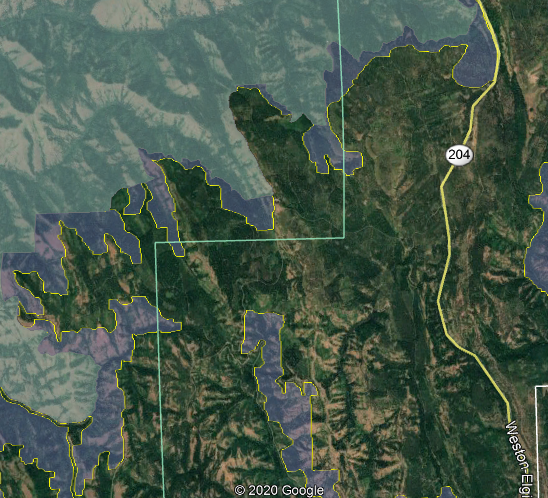
The High Buck EA violates NEPA and the APA by:

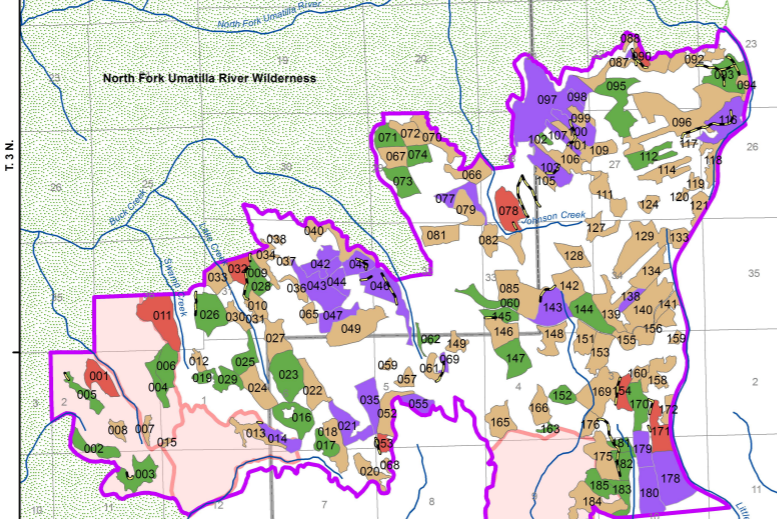
* Failing to recognize the compelling need to restore large blocks of unfragmented habitat and large watersheds with highly functional hydrology that is more characteristic of the natural range of variability;
* failing to accurately inventory these undeveloped/ unroaded areas. The inventory arbitrarily excludes functionally unroaded/undeveloped lands from unroaded inventory. Not all previous harvest documented in Forest Service records is disqualifying. Some stands may have been lightly logged many years ago and now function as undeveloped/unroaded lands. This requires site-specific review. Excluding 300 ft buffers along roads arbitrarily excludes lands with significant undeveloped/roadless character. Roadless character ends at the edge of the road prism. The FS approach to the inventory is inconsistent with FS directives to conduct an *inclusive* inventory;
* failing to provide a map of undeveloped/unroaded areas. The EA acknowledges the existence of several undeveloped areas but the EA does not provide any maps;
* failing to disclose the extent, character, and location of activities within undeveloped areas. The EA fails to show the overlap between its undeveloped inventory and the proposed logging activities. The FS cannot accurately analyze the effects of logging within undeveloped areas if the overlap is not clearly identified;
* failing to take a hard look at the significant effects of commercial logging these undeveloped areas. Potentially significant adverse effects include soil disturbance, water pollution, wildlife habitat degradation (especially snags, wildlife cover, and distance from roads), increased carbon emissions, increased fire hazard caused by opening the canopy and stimulating growth of ladder fuels, and degraded recreational and scenic values;
* failing to develop and consider an alternative that would better mimic natural processes by exclusively using tools such as non-commercial thinning and prescribed fire to achieve restoration objectives in the undeveloped/unroaded areas;
* failing to prepare an EIS to consider the significant impacts of logging on the disproportionate ecosystem services provided by undeveloped/unroaded areas, such as:
  + wildlife habitat (especially snags habitat that is poorly represented in managed areas),
  + mature forest that provide fire resilience,
  + high carbon storage that helps stabilize the climate during the ongoing climate emergency,
  + genetic diversity/natural selection,
  + high water quality and highly functional hydrology,
  + scenic and recreation values;
  + etc;
* failing to respond to 14 pages of scoping comments on this topic.

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# Protect the Values of Inventoried and Uninventoried Roadless and Low-Road-Density Areas

Large intact expanses of habitat were once quite common but are now rare. Species evolved in the context of the large habitat patches that result from the natural disturbance regime. As just one important example, big game need large patches of security cover which is best provided by large unroaded areas. New science confirms that roads and logging tend to be contagious on the landscape (managed areas beget more management until little remains unmanaged), so to conserve the habitat values associated with wild places we have to prevent the first intrusions. The purpose and need for this project should include protecting and restoring large unroaded areas consistent with the natural range of variability.

Boakes et al (2009) explained why it is important to retain large unroaded areas.

**Abstract:** Habitat clearance remains the major cause of biodiversity loss, with consequences for ecosystem services and for people. In response to this, many global conservation schemes direct funds to regions with high rates of recent habitat destruction, though some also **emphasize the conservation of remaining large tracts of intact habitat**. If the pattern of **habitat clearance is highly contagious**, the latter approach will help **prevent destructive processes gaining a foothold** in areas of contiguous intact habitat. Here, we test the strength of spatial contagion in the pattern of habitat clearance. Using a global dataset of land-cover change at 50x50 km resolution, we discover that intact habitat areas in grid cells are refractory to clearance only when all neighbouring cells are also intact. The **likelihood of loss increases dramatically as soon as habitat is cleared in just one neighbouring cell**, and remains high thereafter. **This effect is consistent for forests and grassland, across biogeographic realms and over centuries, constituting a coherent global pattern**. Our results show that landscapes become vulnerable to wholesale clearance as soon as **threatening processes begin to penetrate**, so actions to prevent any incursions into large, intact blocks of natural habitat are key to their long-term persistence.

Elizabeth H. Boakes, Georgina M. Mace, Philip J. K. McGowan and Richard A. Fuller 2009. Extreme contagion in global habitat clearance. Proceedings of the Royal Society B: Biological Sciences. November 25, 2009. doi: 10.1098/rspb.2009.1771. <http://rspb.royalsocietypublishing.org/content/royprsb/early/2009/11/25/rspb.2009.1771.full.pdf>

Ibisch et al (2016) said

The planet’s remaining large and ecologically important tracts of roadless areas sustain key refugia for biodiversity and provide globally relevant ecosystem services. … Global protection of ecologically valuable roadless areas is inadequate. International recognition and protection of roadless areas is urgently needed to halt their continued loss.

…

The impact of roads on the surrounding landscape extends far beyond the roads themselves. Direct and indirect environmental impacts include deforestation and fragmentation, chemical pollution, noise disturbance, increased wildlife mortality due to car collisions, changes in population gene flow, and facilitation of biological invasions (1–4). In addition, roads facilitate “contagious development,” in that they provide access to previously remote areas, thus opening them up for more roads, land-use changes, associated resource extraction, and human-caused disturbances of biodiversity (3, 4). With the length of roads projected to increase by >60% globally from 2010 to 2050 (5), there is an urgent need for the development of a comprehensive global strategy for road development if continued biodiversity loss is to be abated (6). To help mitigate the detrimental effects of roads, their construction should be concentrated as much as possible in areas of relatively low “environmental values” (7). Likewise, prioritizing the protection of remaining roadless areas that are regarded as important for biodiversity and ecosystem functionality requires an assessment of their extent, distribution, and ecological quality.

…

There is an urgent need for a global strategy for the effective conservation, restoration, and monitoring of roadless areas and the ecosystems that they encompass. Governments should be encouraged to incorporate the protection of extensive roadless areas into relevant policies and other legal mechanisms, reexamine where road development conflicts with the protection of roadless areas, and avoid unnecessary and ecologically disastrous roads entirely. In addition, governments should consider road closure where doing so can promote the restoration of wildlife habitats and ecosystem functionality (4).

…

To achieve global biodiversity targets, policies must explicitly acknowledge the factors underlying prior failures (13). Despite increasing scientific evidence for the negative impacts of roads on ecosystems, the current global conservation policy framework has largely ignored road impacts and road expansion.

…

In the much wider context of the United Nations’ Sustainable Development Goals, conflicting interests can be seen between goals intended to safeguard biodiversity and those promoting economic development (14).

…

Enshrined in the protection of roadless areas should be the objective to seek and develop alternative socioeconomic models that do not rely so heavily on road infrastructure. … Although we acknowledge that access to transportation is a fundamental element of human well-being, impacts of road infrastructure require a fully integrated environmental and social cost benefits approach (15). Still, under current conditions and policies, limiting road expansion into roadless areas may prove to be the most cost effective and straightforward way of achieving strategically important global biodiversity and sustainability goals.

Pierre L. Ibisch, Monika T. Hoffmann, Stefan Kreft, Guy Pe’er, Vassiliki Kati, Lisa Biber-Freudenberger, Dominick A. Dellasala, Mariana M. Vale, Peter R. Hobson, Nuria Selva. 2016. A global map of roadless areas and their conservation status. SCIENCE 16 DEC 2016 : 1423-1427. <http://science.sciencemag.org/content/354/6318/1423>

Our planet is in the midst of a significant extinction event caused by habitat destruction and climate change. Protecting existing wilderness-quality lands will pay huge dividends for biodiversity.

... we model the persistence probability of biodiversity, combining habitat condition with spatial variation in species composition, to show that retaining these remaining wilderness areas is essential for the international conservation agenda. Wilderness areas act as a buffer against species loss, as the extinction risk for species within wilderness communities is—on average—less than half that of species in non-wilderness communities.

Di Marco, M., Ferrier, S., Harwood, T.D. et al. Wilderness areas halve the extinction risk of terrestrial biodiversity. Nature 573, 582–585 (2019) doi:10.1038/s41586-019-1567-7. <https://www.nature.com/articles/s41586-019-1567-7>. See also, Keim, B. 2019. Wilderness areas could reduce extinction risks by more than half. Anthropocene Magazine. October 23, 2019 <http://www.anthropocenemagazine.org/2019/10/importance-of-wilderness/>

Roadless and unroaded areas also play a significant role in both climate change mitigation (through carbon storage) and climate change adaptation (by facilitating connectivity and resilience to disturbance).

**Transportation infrastructure and carbon sequestration**

The topic of the relationship of road restoration and carbon has only recently been explored. [and there are presumably similar carbon benefits from conserving unroaded areas and not building roads in the first place.] There is the potential for large amounts of carbon (C) to be sequestered by reclaiming roads.When roads are decompacted during reclamation, vegetation and soils can develop more rapidly and sequester large amounts of carbon. A recent study estimated total soil C storage increased 6 fold to 6.5 x 107g C/km (to 25 cm depth) in the northwestern US compared to untreated abandoned roads (Lloyd et al. 2013). Another recent study concluded that reclaiming 425 km of logging roads over the last 30 years in Redwood National Park in Northern California resulted in net carbon savings of 49,000 Mg carbon to date (Madej et al. 2013, Table 5).

**...**

**Benefits of roadless areas and roadless area networks to climate change adaptation**

Undeveloped natural lands provide numerous ecological benefits. They contribute to biodiversity, enhance ecosystem representation, and facilitate connectivity (Loucks et al. 2003; Crist and Wilmer 2002, Wilcove 1990, The Wilderness Society 2004, Strittholt and Dellasala 2001, DeVelice and Martin 2001), and provide high quality or undisturbed water, soil and air (Anderson et al. 2012, Dellasalla et al. 2011). They also can serve as ecological baselines to help us better understand our impacts to other landscapes, and contribute to landscape resilience to climate change.

Forest Service roadless lands, in particular, are heralded for the conservation values they provide. These are described at length in the preamble of the Roadless Area Conservation Rule (RACR)4 as well as in the Final Environmental Impact Statement (FEIS) for the RACR5 , and include: high quality or undisturbed soil, water, and air; sources of public drinking water; diversity of plant and animal communities; habitat for threatened, endangered, proposed, candidate, and sensitive species and for those species dependent on large, undisturbed areas of land; primitive, semi-primitive non- motorized, and semi-primitive motorized classes of dispersed recreation; reference landscapes; natural appearing landscapes with high scenic quality; traditional cultural properties and sacred sites; and other locally identified unique characteristics (e.g., include uncommon geological formations, unique wetland complexes, exceptional hunting and fishing opportunities).

The Forest Service, National Park Service, and US Fish and Wildlife Service recognize that protecting and connecting roadless or lightly roaded areas is an important action agencies can take to enhance climate change adaptation. For example, the Forest Service National Roadmap for Responding to Climate Change (USDA Forest Service 2011b) establishes that increasing connectivity and reducing fragmentation are short and long term actions the Forest Service should take to facilitate adaptation to climate change.6 The National Park Service also identifies connectivity as a key factor for climate change adaptation along with establishing “blocks of natural landscape large enough to be resilient to large-scale disturbances and long-term changes” and other factors. The agency states that: “The success of adaptation strategies will be enhanced by taking a broad approach that identifies connections and barriers across the landscape. Networks of protected areas within a larger mixed landscape can provide the highest level of resilience to climate change.”7 Similarly, the National Fish, Wildlife and Plants Climate Adaptation Partnership’s Adaptation Strategy (2012) calls for creating an ecologically-connected network of conservation areas.8

Crist and Wilmer (2002) looked at the ecological value of roadless lands in the Northern Rockies and found that protection of national forest roadless areas, when added to existing federal conservation lands in the study area, would 1) increase the representation of virtually all land cover types on conservation lands at both the regional and ecosystem scales, some by more than 100%; 2) help protect rare, species-rich, and often-declining vegetation communities; and 3) connect conservation units to create bigger and more cohesive habitat “patches.”

Roadless lands also are responsible for higher quality water and watersheds. Anderson et al. (2012) assessed the relationship of watershed condition and land management status and found a strong spatial association between watershed health and protective designations. Dellasalla et al. (2011) found that undeveloped and roadless watersheds are important for supplying downstream users with high-quality drinking water, and developing these watersheds comes at significant costs associated with declining water quality and availability. The authors recommend a light-touch ecological footprint to sustain the many values that derive from roadless areas including healthy watersheds.

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

The Forest Service defines unroaded areas as any area without the presence of classified roads, and of a size and configuration sufficient to protect the inherent characteristics associated with its roadless condition. [http://web.archive.org/web/20010729111100/http://roadless.fs.fed.us/documents/feis/glossary.shtml](http://web.archive.org/web/20010729111100/http:/roadless.fs.fed.us/documents/feis/glossary.shtml). Unroaded areas greater than about 1,000 acres, whether they have been inventoried or not provide valuable natural resource attributes that must be protected. These include: water quality; healthy soils; fish and wildlife refugia; centers for dispersal, recolonization, and restoration of adjacent disturbed sites; reference sites for research; non-motorized, low-impact recreation; carbon sequestration; refugia that are relatively less at-risk from noxious weeds and other invasive non-native species, and many other significant values. See Forest Service Roadless Area Conservation FEIS, November 2000.

Former Secretary of Agriculture Tom Vilsack recognizes the value of National Forest roadless areas: “Roadless areas preserve essential watersheds and help ensure an abundant supply of clean drinking water. These large areas of undisturbed forests provide diverse habitats for sensitive and endangered wildlife. In addition, roadless areas provide other critical ecological services, such as carbon storage, and operate as effective barriers to invasive species, while also providing social values such as scenic landscapes and a host of recreational opportunities. Let me assure you that USDA and the Forest Service will move forward to conserve and protect these lands and meet all legal obligations.” March 11, 2009 letter to Oregon Governor Ted Kulongoski.

Before logging roadless areas the agency should consider the impacts to all the values of roadless areas, including:

(1) High quality or undisturbed soil, water, and air;

(2) Sources of public drinking water;

(3) Diversity of plant and animal communities;

(4) Habitat for threatened, endangered, proposed, candidate, and sensitive species and for those species dependent on large, undisturbed areas of land;

(5) Primitive, semi-primitive non-motorized and semi-primitive motorized classes of dispersed recreation;

(6) Reference landscapes;

(7) Natural appearing landscapes with high scenic quality;

(8) Traditional cultural properties and sacred sites; and

(9) Other locally identified unique characteristics.

36 CFR §294.11 (2001). <https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5050459.pdf>

We are aware that the PNW Regional office issued a directive relative to uninventoried roadless areas, aka “undeveloped areas”. This 11-24-04 memo from Lisa Freedman wisely instructs the Forest Service to give consideration to “special” features of undeveloped areas regardless of size. However, this memo also has some troubling instructions that deserve mention. First, the memo instructs Forests not to "establish a permanent identity or inventory for these areas" which not only interferes with efficient management of information and natural resources but also violates the NFMA mandate to maintain an accurate and up-to-date inventory of the renewable resources of the National Forests. See 16 U.S.C. 1603 which says "the Secretary of Agriculture shall develop and maintain on a continuing basis a comprehensive and appropriately detailed inventory of all National Forest System lands and renewable resources. This inventory shall be kept current so as to reflect changes in conditions and identify new and emerging resources and values." Second, Forests are instructed to focus their analysis on the "effects of the proposed activity where the effects occur rather than on identification or inventory of the undeveloped area." How can the effects of management be adequately disclosed “where they occur” or anywhere else for that matter, UNLESS the qualities of the area are fully understood through identification and inventory. This memo essentially instructs the Forest Service to (i) routinely destroy factual information about resources under its management, and (ii) provide uninformed disclosure of the effects of proposed management action without collecting and considering contextual information about roadless/undeveloped areas that could be affected. If the Forest Service follows these instructions they will be violating NEPA, so don’t do it.

The Forest Service adopted new guidance concerning ecological restoration and resilience which urges managers to “Identify opportunities to sustain ecological refugia that may serve as vital sources of ecological diversity.” FSM 2020.3 – Policy. <http://web.archive.org/web/20090511091720/http://www.fs.fed.us/im/directives/fsm/2000/id_2020-2008-1.doc>. This is an opportunity to look at uninventoried roadless areas in a fresh new light.

“It is well established in this [9th] Circuit that logging in an unroaded area is an ‘irreversible and irretrievable’ commitment of resources and ‘could have serious environmental consequences.’” and therefore requires an EIS. Sierra Club v. Austin No 03-35419; DC No. CV-03- 00022 DWM (9th Circ. 2003), *citing* Smith v. Forest Service 33 F.3d 1072, 1078 (9th Circ. 1994). This project involves activities in such unroaded areas. The NEPA analysis for this project does not adequately discuss the impacts of proposed activities on all the many significant values of roadless/unroaded areas.

The 9th Circuit has held that the agencies have a NEPA obligation to consider the potential for future wilderness designation before conducting management activities in areas that may be eligible for wilderness, even if they are not inventoried roadless areas. The Lands Council v. Martin, (9th Circ, June 25, 2008). <http://www.ca9.uscourts.gov/datastore/opinions/2008/06/24/0735804.pdf> (The court enjoined salvage logging that would have affected uninventoried roadless areas less than 5,000 acres in size that were located adjacent and contiguous with an inventoried roadless area.)

The NEPA analysis should discuss whether the project will push the landscape toward or away from the natural range of variability for large-scale habitat patches. Landscape analysis based on historic disturbance patterns suggests that historically the majority of old forest occurred in large patches. See Wimberly, M. 2002. Spatial simulation of historical landscape patterns in coastal forests of the Pacific Northwest. Can. J. For. Res. 32:13-16-1328 (2002) <http://andrewsforest.oregonstate.edu/pubs/pdf/pub2859.pdf> (72% of the total mature forest in the Oregon Coast Range was concentrated in patches >1,000 ha). These large patches of older forests that native fish and wildlife species evolved with are now severely underrepresented on the forest landscape and must be protected and restored.

Roadless/unroaded area boundaries are an issue that has never been validated in any NEPA process. Only arbitrary Forest Service designation, outside of any public appeal opportunity, has set these boundaries. As part of this NEPA analysis, the roadless/unroaded boundaries should be validated. This is addressed clearly by the California v. Block decision and others.

An action does not have to occur inside a RARE II boundary to affect a roadless area, because RARE II is not the final word on roadless lands. As the Forest Service is abundantly aware, the court ruled in *California v. Block* that actions affecting wilderness status could not rely on RARE II. The court ruled that RARE II did not comply with NEPA and “was inadequate to support the non-wilderness designations of the disputed areas and therefore violated NEPA.” In the present case, the Forest Service is relying on an illegitimate RARE II boundary of this roadless area to support its contention that logging may occur in de facto roadless land without affecting future wilderness designation.

Further, the Forest Service Washington Office ruled in its appeal decision of the Idaho Panhandle Forest Plan Appeal that roadless areas must be evaluated individually when logging is to occur in them.

The fact that several of the units of this timber sale do not fall within the RARE II boundary but *do* fall adjacent to it and undivided from it by any road requires the Forest Service to address roadless/unroaded impacts per the NFMA and to acknowledge to the public the effects to the roadless/unroaded resource. Judging from the controversy surrounding roadless/unroaded lands these days, such an analysis would need to occur in an EIS.

An EIS is needed to consider the significant environmental impacts of proposed activities in roadless/unroaded areas.

## Be Inclusive in Identifying Roadless Boundaries

The EA says that the inventory of unmanaged areas excluded areas with any record of prior logging, and buffered all roads by 300 feet. This inventory method improperly excluded significant areas that are *de facto* undeveloped/unroaded. Some areas that were lightly logged a long time ago and function as undeveloped areas. The effects of past logging are not noticeable to a casual observer, but additional logging will cause cumulative loss of important values of unroaded areas such as snag habitat and carbon storage.

NEPA requires the agency to disclose the full effects of logging, not just an arbitrary subset of effects. NEPA requires high quality information and analysis. 40 CFR 1500.1(b), and “full and fair discussion of significant environmental impacts,” 40 C.F.R. § 1502.1. Unfortunately, there are significant problems with the methods and results of the Forest Service’s prior efforts to inventory and map roadless areas, and one problem stands out – prior efforts have consistently underestimated the extent of unroaded areas on the National Forest.

**Problems found on all National Forests**

Our analysis of roadless area mapping available from the Forest Service revealed several problems that are present to some degree on all National Forests. The most prevalent problem was great variation in where Forest Service inventoried roadless area boundaries are drawn. In some places Forest Service roadless area boundaries come to the edge (or even cross) roads that bound the roadless areas. In other places the boundary is kept over a mile away from any bounding road. Most Forest Service roadless area boundaries were drawn in a very imprecise fashion, and often appear to wander across the landscape without any credible rationale for their location. Forest Service roadless areas were delineated without any precise and repeatable criteria and methodology. There is little consistency between roadless areas within a National Forest and even less consistency between forests. The only real consistency that we were able to find between all the National Forests in Washington State was that they all underestimated the acreage of roadless land in areas over 5000 acres in size.

Many unroaded, unlogged and completely wild areas have been excluded from Forest Service inventoried roadless areas for no apparent reason. It appears that the boundaries of Forest Service inventoried roadless areas were often drawn to minimize their size, particularly where substantial timber is involved. There is also no consistency regarding what is included and what is excluded from Forest Service roadless areas. In some cases Forest Service roadless areas (and some designated Wilderness Areas) include old roads, bulldozer trails, logged areas and other development. But in most cases even the slightest hint of old logging appears to be an excuse for excluding an area from a Forest Service roadless area.

Peter Morrison, Susan Snetsinger and George Wooten 1998. Unprotected Wild Lands In Washington State An Analysis of Their Current Status and Future under Current Management Direction, A report by The Pacific Biodiversity Institute, February 1998 <http://www.okanogan1.com/research/roads/Roadless_Report_by_Morrison_et_al_2000.pdf>

The Forest Service should follow its internal guidance (effective 1/30/2015) for “broad and inclusive” identification of potential wilderness, and public involvement in that process. The FS Planning Handbook says:

The primary function of the inventory step is to efficiently, effectively, and transparently identify all lands in the plan area that may have wilderness characteristics as defined in the Wilderness Act.

The inventory is intended to be reasonably broad and inclusive, based on the inventory criteria set out in this section and additional information provided to the Responsible Official through the required opportunities for public and government participation (sec. 70.61 of this Handbook). The intent is to identify lands that may be suitable, so that they can be evaluated and to allow for public input and feedback …

…

Include in the inventory areas that contain the following road improvement attributes if the areas also meet the other inventory criteria…

1. Areas that contain forest roads maintained to level 1;
2. Areas with any routes that are decommissioned, unauthorized or temporary, or forest roads that are identified for decommissioning in a previous decision document, or identified as likely unneeded in a travel management plan …

…

f. Areas with historical wagon routes, historical mining routes, or other settlement era transportation features considered part of the historical and cultural landscape of the area.

…

[The following developments should also be included in the inventory]

2. Vegetation treatments that are not substantially noticeable.

3. Timber harvest areas where logging and prior road construction are not substantially noticeable.

4. Permanently installed vertical structures, such as electronic installations that support television, radio, telephone, or cellular communications, provided their impacts, as well as their maintenance and access needs, are minimal.

5. Areas of mining activity where impacts are not substantially noticeable.

…

10. Lands adjacent to development or activities that impact opportunities for solitude. The fact that nonwilderness activities or uses can be seen or heard from within any portion of the area, must not, of itself, preclude inclusion in the inventory. It is appropriate to extend boundaries to the edges of development for purposes of inclusion in the inventory.

…

The Responsible Official shall ensure that the Interdisciplinary Team documents the evaluation … The intent is to ensure that the process for inventory and evaluation is transparent and accessible to the public for input and feedback.

…

Evaluate the degree to which the area has outstanding opportunities for solitude or for a primitive and unconfined type of recreation. The word “or” means that an area only has to possess one or the other. The area does not have to possess outstanding opportunities for both elements, nor does it need to have outstanding opportunities on every acre.

2012 Planning Rule Directives. FSH 1909.12- Chapter 70 – Wilderness. <http://www.fs.usda.gov/detail/planningrule/home/?cid=stelprd3828310>

The FS must avoid using the contrary policy of excluding 300 foot buffers along roads even when those areas otherwise qualify as potential wilderness.

The 300 foot buffers often used by Region 6 to determine the boundaries of “potential wilderness areas” are exceedingly large and unsupported by logic and evidence. The FS must remember that they are preparing an inventory of “potential” wilderness, so they should be inclusive. Congress has on many occasionsestablished wilderness boundaries much closer than 300 feet from roads in many instances. The FS should not prejudge wilderness potential by excluding from its NEPA analysis areas that Congress might later decide to include in wilderness.

Habitat adjacent to roads may be somewhat modified by edge effects but it is still “roadless” right up to the edge of the road (e.g., soil and vegetation are essentially intact; wildlife movement is not encumbered; hydrology is generally functioning, the imprint of man is generally unnoticeable, etc). Tellingly, when constructing new roads, the FS never admits and discloses adverse effects extending 300 feet on either side of the road.

The 2007 FS Handbook also recommends “locat[ing] boundaries at prominent natural or semi-permanent human-made features to facilitate easy on-the-ground identification.” A road is a much more clearly identifiable boundary than an arbitrary line 300 feet away from the road.

To justify the wide, exclusionary buffers, the FS seems to rely on the fact that firewood cutting is allowed within 300 feet of roads; however, this does not justify eliminating huge swaths of otherwise roadless forests from the PWA analysis. Many roads are closed and not accessible to firewood cutters. Many open roads are not typically used for firewood access. Some areas adjacent to roads are too steep. There are conditions on firewood permits that limit the effects of firewood cutting. And most importantly, a few stumps visible within an unroaded area does not render the area ineligible for wilderness.

In its Sept 2012 appeal of the Umatilla NF’s South George Project, The Lands Council explained the problems with the purity doctrine that underpins the 300 foot buffer:

Moreover, the FEIS states at H-3 that a 300 ft. boundary was set on each side of forest roads, further eliminating potential wilderness lands (Map H-3), despite acknowledging that this criteria is inaccurate at H-3. This rigid application by the Forest Service has become known as the “purity doctrine,” in which any remote sign of past logging or road building will unequivocally preclude consideration of or recommendation for wilderness designation. There is, however, no foundation for such a rigid doctrine.

First, the FSH uses the permissive “may” when it states that “[a]reas may qualify for the inventory of potential wilderness even though they include the following types of areas or features: (9) Timber harvest areas where logging and prior road construction are not evident ….” Forest Service Handbook, 1909.12, 71.11(9). The Forest Service, however, failed to include any area that has been subject to logging as mapped in the District’s GIS harvest layer and systematically applied a 300 ft. buffer around all roads. Second, the Wilderness Act does not contain language that unequivocally requires no past management activities: “with the imprint of man’s work substantially unnoticeable” an “area of underdeveloped Federal Land” (as opposed to undeveloped). 16 U.S.C. § 1131(c). Third, numerous wilderness areas have been designated where past logging and other management activities are present. Finally, and perhaps most importantly, Congress has expressly asked the Forest Service to abandon the “purity doctrine.” In a Senate Report from the Committee on Energy and Natural Resources regarding the Endangered American Wilderness Act of 1977, the Committee stated: “Generally, the committee believes that the so-called ‘purity’ concept of wilderness long adhered to by the Forest Service, is unnecessarily restrictive and should be abandoned.” S. Rept. 95-490 on H.R. 3454. 95th Cong. 1st sess. October 11, 1977. As a result of the Forest Service’s rigid application of PWA criteria, 12,815 acres are not assessed under the Ninth Circuit’s requirement that roadless expanses are analyzed because of either “past timber harvest” or because “the boundary was set as 300 feet each side of the forest roads” (FEIS at 3-183 and Table 3-82).

Also, Congress rejected the argument that “outside sights and sounds” (such as those from adjacent roads) exclude an area from wilderness consideration. Senator Church quoted Senator Murray from the July 2, 1960 Congressional Record which noted that “wilderness character” is determined by looking at the very area under consideration, not by evaluating an adjacent area, even if some disturbances may emanate from that adjacent area. Church said, “Sights and sounds from outside the boundary do not invalidate a wilderness designation or make threshold exclusions necessary, as a matter of law”.

The Forest Service should strive to be more consistent with its prior policies dating back to 1960 relating to identification of roadless and potential wilderness areas. Application of a 300 foot buffer is an unprecedented and divergent policy that demands a compelling justification. Region 6 needs to justify why is chooses to apply a 300 foot buffer, when other regions use much smaller buffers that basically extend just to the edge of the road or the road prism. Region 1’s Roadless Area Inventory Protocol (11/20/96) applies a 50’ buffer from the centerline of roads. Region 4’s Protocol for Identifying and Evaluating Areas for Potential Wilderness (10/28/2004) recommends a 33 foot buffer from the centerline of roads. The FS must eliminate the large 300 foot buffers, and disclose how much logging is proposed in those areas.

## The EA Failed to Consider New information on Unroaded Areas >1,000 acres

The EA failed to disclose the significant adverse effects of logging on undeveloped areas, and failed to address new information on the disproportionate ecosystem services provided by undeveloped areas smaller than 5,000 acres.

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

First, it is important to recognize that about 30% of inventoried roadless areas (IRA) nationwide are smaller than 5,000 acres. It is therefore likely that the diverse and significant values of IRAs can be found within many other unroaded areas between 1,000 and 5,000 acres that were simply not inventoried. NEPA requires that these values be recognized and the effects of logging and roads be carefully disclosed and considered. Martin, DeVelice, Brown. 2001. Landscape Analysis and Biodiversity Specialist Report. Forest Service Roadless Area Conservation FEIS. November 2000. <http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsm8_035781.pdf>

Small areas are important for conserving biodiversity of species with small home ranges, species with special habitat needs, or for providing linkages between larger areas. … Of the more than 2,800 named inventoried roadless areas, about 70% of these areas are larger than 5,000 acres (USDA Forest Service 2000a).

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

Boakes et al (2009) explained why it is important to retain large unroaded areas.

**Abstract:** Habitat clearance remains the major cause of biodiversity loss, with consequences for ecosystem services and for people. In response to this, many global conservation schemes direct funds to regions with high rates of recent habitat destruction, though some also **emphasize the conservation of remaining large tracts of intact habitat**. If the pattern of **habitat clearance is highly contagious**, the latter approach will help **prevent destructive processes gaining a foothold** in areas of contiguous intact habitat. Here, we test the strength of spatial contagion in the pattern of habitat clearance. Using a global dataset of land-cover change at 50x50 km resolution, we discover that intact habitat areas in grid cells are refractory to clearance only when all neighbouring cells are also intact. The **likelihood of loss increases dramatically as soon as habitat is cleared in just one neighbouring cell**, and remains high thereafter. **This effect is consistent for forests and grassland, across biogeographic realms and over centuries, constituting a coherent global pattern**. Our results show that landscapes become vulnerable to wholesale clearance as soon as **threatening processes begin to penetrate**, so actions to prevent any incursions into large, intact blocks of natural habitat are key to their long-term persistence.

Elizabeth H. Boakes, Georgina M. Mace, Philip J. K. McGowan and Richard A. Fuller 2009. Extreme contagion in global habitat clearance. Proceedings of the Royal Society B: Biological Sciences. November 25, 2009. doi: 10.1098/rspb.2009.1771

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

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

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

• Habitat refugia for threatened species and those with restricted distributions (endemics)

• Aquatic strongholds for salmonids

• Undisturbed habitats for mollusks and amphibians

• Remaining pockets of old-growth forests

• Overwintering habitat for resident birds and ungulates

• Dispersal “stepping stones” for wildlife movement across fragmented landscapes

DellaSala, Dominick and James Strittholt. 2002. Scientific Basis For Roadless Area Conservation. World Wildlife Fund. Ashland, OR; Conservation Biology Institute. (June 2002 - Updated October 2003) <https://d2k78bk4kdhbpr.cloudfront.net/media/reports/files/Scientific_Basis_For_Roadless_Area_Conservation.pdf>.

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

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

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

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

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

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

Oct 24, 2013 Press release: EUROPEAN PARLIAMENT BACKS THE PROTECTION OF ROADFREE AREAS. <http://kritonarsenis.gr/eng/actions/view/european-parliament-backs-the-protection>. Federal land managers should recognize the tremendous carbon values in unroaded/unmanaged forests and avoid actions that would threaten these values. See also, William R. Moomaw, Susan A. Masino, and Edward K. Faison. 2019. Intact Forests in the United States: Proforestation Mitigates Climate Change and Serves the Greatest Good Front. For. Glob. Change, 11 June 2019 | <https://doi.org/10.3389/ffgc.2019.00027>; <https://www.frontiersin.org/articles/10.3389/ffgc.2019.00027/full>. See also, Kun, Z., DellaSala, D., Keith, H., Kormos, C., Mercer, B., Moomaw, W.R. and Wiezik, M. (2020), Recognising the importance of unmanaged forests to mitigate climate change. GCB Bioenergy. Accepted Author Manuscript. doi:10.1111/gcbb.12714 <https://onlinelibrary.wiley.com/doi/pdfdirect/10.1111/gcbb.12714>. (“The most effective means for keeping carbon out of the atmosphere to meet climate goals is to protect primary forests (Mackey et al. 2020) and continue growing secondary forests to accumulate additional carbon (proforestation) (Moomaw et al. 2019) while reducing emissions from all sources including bioenergy. … The importance of primary (unlogged) forests lies in the magnitude and longevity of their carbon stock. In order to reverse the decreasing forest carbon stocks in Europe (EEA, 2019), the largest forest carbon stores must be protected and additional forests must be allowed to continue accumulating carbon (proforestation).”).

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

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

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

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

In 1994, several scientific societies submitted a report to Congress and the President recommending conservation of roadless areas larger than 1,000 acres. This report is describe by the Interior Columbia Ecosystem Management Project as a “Major Stud[y] of Eastside Ecosystems and Management.”

Because roads crisscross so many forested areas on the Eastside, existing roadless regions have enormous ecological value. … Although roads were intended as innocuous corridors to ease the movement of humans and commodities across the landscape, they harm the water, soils, plants, and animals in those landscapes. [p 6]

…

**4. Do not construct new roads or log within existing (1) roadless regions larger than 1000 acres or (2) roadless regions smaller than 1000 acres that are biologically significant.**

Roadless regions constitute the least-human-disturbed forest and stream systems, the last reservoirs of ecological diversity, and the primary benchmarks for restoring ecological health and integrity. Roads fragment habitat; alter the hydrological properties of watersheds; discharge excessive sediment to streams; increase human access and thus disturbance to forest animals; and influence the dispersal of plants and animals, especially exotic species, across the landscape. Because many forested areas in eastern Oregon and Washington are heavily dissected by roads, the ecological value of existing roadless regions is especially high. [pp 8, 202]

…

Our analysis defined a roadless region as any region where all points within an LS/OG stand were at least 100 meters from a road or trail.

…

What remains of ponderosa pine and Douglas fir LS/OG is the least protected today. In the four national forests within the Blue Mountains, 48% of the land base above 6000 feet lies in wilderness areas, whereas only 10% of the land below 6000 feet, where ponderosa pine occurs, receives such protection … [p 110]

… Fifth, roads, whose impact on aquatic and terrestrial resources is well documented, are widely distributed in eastside forests. Road densities in western Colville, Winema, and Ochoco National Forests average 2.5, 3.5, and 3.7 miles per square mile, respectively. Densities reach 8.8 and 11.9 miles per square mile in some watersheds. In the national forests of Oregon's Blue Mountains (Table 5.2), less than 10% of roadless regions on slopes steeper than 60% are now protected, less than 15% on slopes of 30-60%. Moreover, roadless regions, like LS/OG patches, are extensively fragmented. In northern Ochoco National Forest, nearly one-third (38,882 acres) of 128,140 acres of roadless region consists of patches smaller than 1000 acres. (RARE II surveys underestimated total roadless area in this region [45,700 acres] because they considered only areas larger than 5000 acres.) [p 110]

…

CONCLUSIONS

Watersheds outside wilderness and roadless regions in eastern Oregon and Washington are highly degraded. Without an intensive restoration effort on federal and private lands, many native aquatic stocks and species risk extinction. [p 160]

…

Because the distribution of many native fishes in Oregon's national forests has receded into steep headwater areas, USPS has a vital role in protecting the few remaining watershed refugia and preventing further damage to already degraded habitats downstream. Critical to securing eastside [aquatic diversity areas] ADAs as aquatic refugia are the remaining roadless regions, sources of large wood from LS/OG forests, and the integrity of riparian corridors on national forestlands. [p 168]

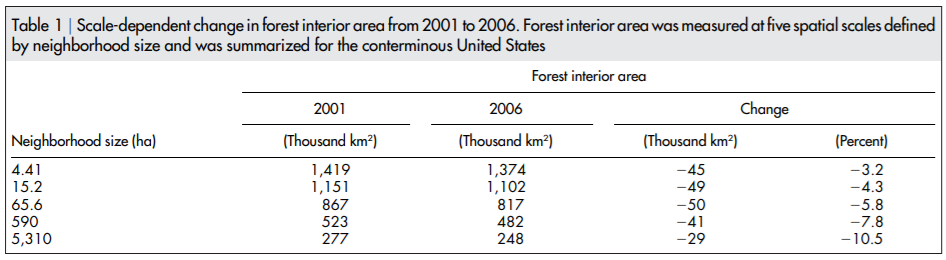
…

7. High road densities harm many forms of wildlife.

The ecological integrity of existing LS/OG patches and other roadless regions can only be maintained if these sites are not disturbed by the construction of roads. Roadless regions serve as critical refuges for terrestrial wildlife sensitive to human disturbance. Road densities in LS/OG patches that already have roads should be reduced to less than 1 mi/mi2. Achieving this goal is vital to rehabilitation of eastside fisheries and terrestrial resources. [p 197]

Henjum, M.G., J.R. Karr, D.L. Bottom, D.A. Perry, J.C. Bednarz, S.G. Wright, S.A. Beckwitt and E. Beckwitt. 1994. Interim Protection for Late-Successional Forests, Fisheries, and Watersheds: National Forests East of the Cascade Crest, Oregon and Washington. A Report to the Congress and President of the United States. Eastside Forests Scientific Society Panel.

The importance of conserving unroaded areas is highlighted by the finding that forest fragmentation in the U.S. continues to increase. Riitters et al (2012) 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.



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

## The EA Failed to Consider an Alternative That Would Allow Natural Processes to Flourish in Unroaded Areas

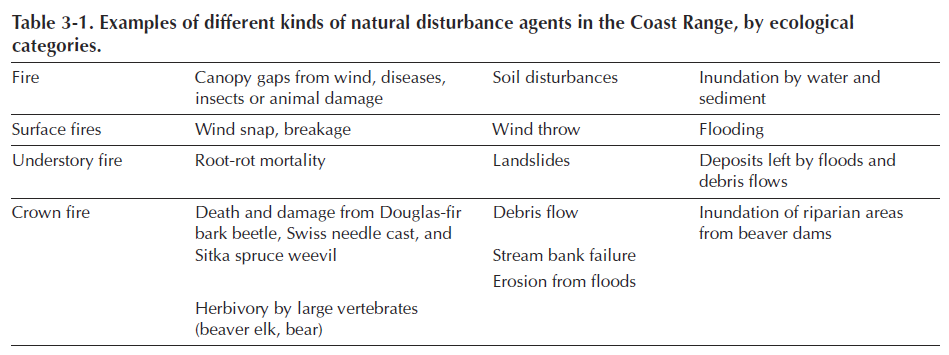
Unroaded/undeveloped areas are an important feature of the historic range of variability that needs to be restored. Such areas provide high quality water, soil, fish & wildlife habitat, carbon storage, recreation and scenic values, etc. The purpose and need should include restoration of unroaded/undeveloped areas (consistent with the natural range of variability) where natural processes can flourish.

The EA failed to consider an alternative that would better mimic natural processes by exclusively using tools such as non-commercial thinning and prescribed fire in the undeveloped/unroaded areas.

Unroaded areas are rare on the landscape and they are one of the places where human influence has been limited and the ecological building blocks remain in place, so it is reasonably possible to achieve restoration of desired ecological conditions by relying on natural self-correcting mechanisms. Natural processes have operated successfully for millennia to achieve dynamic balance between forest growth and mortality. Within unroaded areas the agency should focus on eliminating unnatural stressors (such as livestock and weeds) while reintroducing natural processes such as fire. There may be an opportunity to manually pre-treat fuels before reintroducing fire, but building miles of new roads and removing significant habitat structures would not be appropriate.

Unroaded areas often have mature forests which are developing and diversifying naturally. “**Mature Seral Stage** - This stage typically occurs between ages 81 and 195. Stand diversity is gradually increasing in response to openings in the canopy created by wind-throw, disease, insects, and stand mortality” Eugene BLM, 1995. Mohawk/McGowan Watershed Analysis.

Even when forests in roadless areas seem more uniform than desired, it is not always necessary to mechanically thin forests to increase diversity and complexity. Natural processes can do the job. Spies et al (2002) enumerate a variety of disturbance agents that can help diversify forest stands withouit logging.



Thomas A. Spies, David E. Hibbs, Janet L. Ohmann, Gordon H. Reeves, Robert J. Pabst,

Frederick J. Swanson, Cathy Whitlock, Julia A. Jones, Beverly C. Wemple,

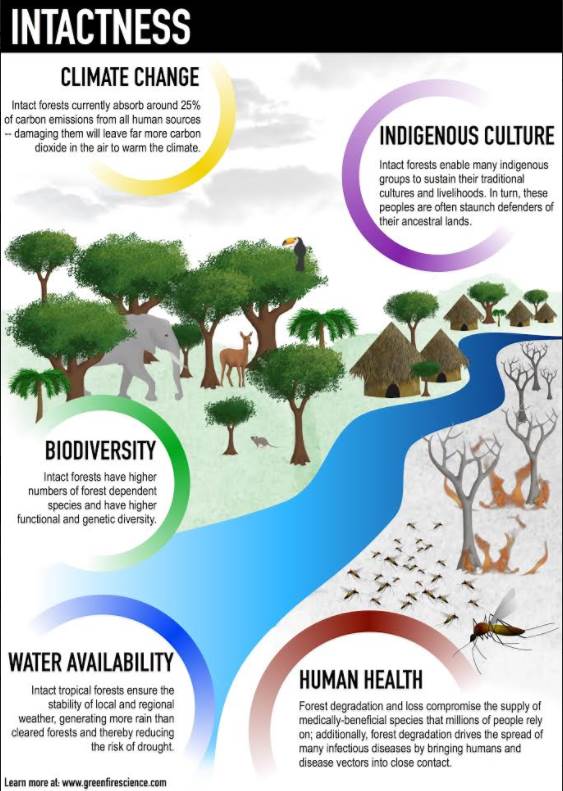
Laurie A.Parendes, and Barbara A. Schrader. 2002. The Ecological Basis of Forest Ecosystem Management in the Oregon Coast Range. <http://www.fsl.orst.edu/rna/Documents/publications/Flynn%20Creek%20spies_etal_2002_ecological_basis.pdf> *in* Hobbs, S. D. et al (2002). Forest and stream management in the Oregon coast range. Corvallis, Or: Oregon State University Press. <https://osupress.oregonstate.edu/book/forest-and-stream-management-in-oregon-coast-range>

One of the important but under-appreciated values of unroaded areas is the long-term creation and maintenance of dead wood habitat due to the fact that unmanaged areas are where natural processes are allowed to flourish. Unroaded areas are one of the few places where trees are allowed to fulfill their entire “lifecycle” (including their life-giving role as snags, dead wood, and soil builders) in the forest. Korol et al (2002) found that large snag habitat is below historic range of variability across the Interior Columbia Basin and they estimated that even if the agencies apply enlightened forest management on federal lands in the Interior Columbia Basin for the next 100 years, we will still reach only 75% of the historic large snag abundance, and most of the increase in large snags will occur in roadless and wilderness areas. Jerome J. Korol, Miles A. Hemstrom, Wendel J. Hann, and Rebecca A. Gravenmier. 2002. 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>. Since wilderness and unmanaged areas are the only place that a healthy population of snags is likely to be recruited and maintained over the long term, they represent invaluable and irreplaceable mitigation for all the places where snags are in short supply due to logging, hazard tree removal, and other management efforts designed to control and capture mortality.

Wisdom et al (2008) found that snag abundance in the Pacific northwest forests is inversely related to past harvest and proximity to roads. Wisdom, M.J., and Bate, L.J. 2008. Snag density varies with intensity of timber harvest and human access. For. Ecol. Manage. 255: 2085–2093. doi:10.1016/j.foreco.2007.12.027. <http://www.fs.fed.us/pnw/pubs/journals/pnw_2008_wisdom001.pdf> (“Our highest snag density … occurred in unharvested stands that had no adjacent roads. … Stands with no history of timber harvest had 3 times the density of snags as stands selectively harvested, and 19 times the density as stands having undergone complete harvest. Stands not adjacent to roads had almost 3 times the density of snags as stands adjacent to roads.”)

Low-impact restoration activities, including but not limited to prescribed fire, mowing, non-commercial thinning, and weed removal may be appropriate in roadless/unroaded areas as long as they will be substantially unnoticeable to the casual observer and leave the area suitable for future wilderness designation. The NEPA document should describe the roadless/unroaded area, the undeveloped values present, and the need for, and impacts of, the proposed restoration activities.

Commercial logging prescriptions are typically designed to exert significant control over fire behavior and tree mortality, and similar prescriptions have been and are being applied across quite a large area of our federal forests. By limiting treatments to low-impact, non-commercial activities in undeveloped areas we are still treating them, and still getting benefits in terms of fire and "forest heath," but we are relaxing our control just a bit and letting natural processes play a bigger role in that subset of the landscape.



Watson et al 2018. The exceptional value of intact forest ecosystems. Nature Ecology & Evolution (2018) <https://www.nature.com/articles/s41559-018-0490-x>

## The EA Failed to Consider Diverse and Distinct Benefits of Conserving Undeveloped/Unroaded Areas

It is important for the FS to clearly consider both wilderness values AND other unique values provided disproportionately by large unroaded/unmanaged areas.

An international group of scientists has identified a diverse array of important values provided by roadless areas, including:

**ROADLESS AREAS - biodiversity conservation**

* Preservation of native biodiversity
* Barrier against invasive species
* Preservation of genetic resources
* Maintenance of ecosystem connectivity and integrity
* Ensure habitat for viability of populations
* Provide migration corridors and stopovers

**ROADLESS AREAS - ecosystem services**

* Water regulation and supply
* Erosion control
* Air quality
* Climate regulation
* Disease control (e.g. Lyme disease)
* Pollination of crops
* High resilience to pest outbreak
* Recreation
* Education and scientific value

**ROADLESS AREAS - climate change**

* High resilience and buffering capacity
* Protection against catastrophic events (e.g. fires, landslides, floods)
* Carbon sequestration and decrease of greenhouse gases effects
* Support species adaptation

<http://www.roadless.online/roadless-areas/> And conserving roadless areas is an efficient and economical way to meet many of these goals. <http://www.roadless.online/wp-content/download/docs/Press%20Release%20Protecting%20Roadless%20Areas%20COP11%20CBD.pdf>. Impacts to these values should be carefully evaluated before logging, road building, or using heavy equipment in roadless areas.

Wilderness is just one among many reasons to protect unroaded areas. The FS needs to recognize that unroaded areas provide disproportionate public values such as clean water, biodiversity, carbon storage, resilience to climate change, recreation, and scenery. Watson et al (2018) –

summarize published evidence that intact forests support an exceptional confluence of globally significant environmental values relative to forests that have experienced those damaging human actions. We show that intact forests are indispensable not only for addressing rapid anthropogenic climate change, but also for confronting the planet’s biodiversity crisis, providing critical ecosystem services and supporting the maintenance of human health. We then show that the relative value of intact forests is likely to become magnified as already-degraded forests experience further intensified pressures (including anthropogenic climate change).

… [I]ntact forest protection can typically secure very high environmental values with often relatively low implementation and opportunity costs, which serves to reinforce the need for their direct inclusion in global environmental accords. …

… **The increasing significance of intact forests**

The differences in important environmental and social values of intact forests relative to degraded forests are likely to become magnified in the future due to two negative processes in degraded areas: progressive anthropogenic damage and reduced resilience to environmental change.

…

Retaining the integrity of intact forest ecosystems should be a central component of proactive global and national environmental strategies, alongside current efforts aimed at halting deforestation and promoting reforestation.

… An essential first step towards greater success is achieving widespread recognition that rapid loss of forest intactness represents a major threat to sustainable development and human well-being. Policymakers need to understand the challenge that the loss of forest intactness represents for achieving strategic goals outlined in key multilateral environmental agreements, including the Convention of Biological Diversity, the UNFCCC and the UN Sustainable Development Goals139,143, and this recognition needs to be translated into meaningful changes on the ground.

A fundamental constraint to progress is the fact that international definitions of forests have not differentiated among types of forest and, in most policy settings, they treat all forests, regardless of their condition, as equivalent1,144. As such, international policy processes seldom acknowledge the special qualities and benefits that flow from intact ecosystems as compared with those that are

degraded.

… There is evidence that the designation of ‘roadless areas’ in the USA, for example, has led to an effective expansion in the degree of ecoregional representation under protection and increases in the number of areas big enough to provide refugia for species needing large tracts relatively undisturbed by people.

…

**Conclusion**

There are still significant tracts of forest that are free from the damaging impacts of large-scale human activities. These intact forests typically provide more environmental and social values than forests that have been degraded by human activities. … The practical tools required to address this challenge are generally well understood and include well-located and managed protected areas, indigenous territories that exemplify sound stewardship regulatory controls and responsible behaviour by logging, mining, and agricultural companies and consumers, and targeted restoration. Currently these tools are insufficiently applied, and inadequately supported by governance, policy and financial arrangements designed to incentivize conservation. Losing the remaining intact forests would exacerbate climate change effects through huge carbon emissions and the decline of a crucial, under-appreciated carbon sink. It would also result in the extinction of many species, harm communities worldwide by disrupting regional weather and hydrology, and devastate the cultures of many indigenous communities. Increased awareness of the scale and urgency of this problem is a necessary pre-condition for more effective conservation efforts across a wide range of spatial scales.

Watson, Evans, Venter et al 2018. The exceptional value of intact forest ecosystems. Nature Ecology & Evolution (2018) <https://www.nature.com/articles/s41559-018-0490-x>



Watson et al (2018).

The NEPA analysis must not blur the distinction between the effect of logging on roaded areas and unroaded areas. The effects of logging unroaded areas are qualitatively different and more significant than logging areas previously affected by roads and logging. The NEPA analysis must clearly disclose the fact that water quality, habitat, scenic values, soil quality, and carbon storage are all better in unroaded areas than roaded areas, and logging will have disproportionately adverse effects on those values.

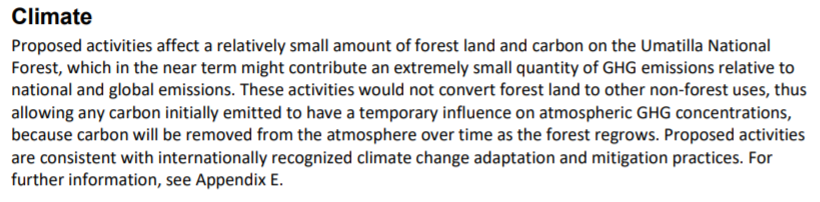
Natural disturbances such as wildfire are already playing a positive role in maintaining resiliency, makig mechanical intervention unnecessary. James D Johnston, John B. Kilbride, Garrett W. Meigs, Christopher J Dunn, and Robert E. Kennedy. *In Press, July 2021*. Does conserving roadless wildland increase wildfire activity in western U.S. national forests? Environmental Research Letters. <https://doi.org/10.1088/1748-9326/ac13ee>; <https://iopscience.iop.org/article/10.1088/1748-9326/ac13ee/pdf> (“Although fire patterns in roadless areas may pose challenges to land managers, the available evidence suggests that the greater extent of fire in roadless areas may confer resilience to these landscapes in the face of climate change”).

## The EA failed to take a hard look at the effects of commercial logging on carbon and climate change.

The EA failed to take a hard look at the effects of this project on carbon storage and climate change. The FS has a duty under NEPA to accurately disclose the effects of management. The EA failed to fulfill this duty by:

* Failing to quantify the carbon emissions of the different alternatives and no action;
* Providing a misleading analysis that failed to recognize the true nature of the climate problem and the cumulative carbon overload in the atmosphere and incorrectly assuming that small emissions are inconsequential;
* Providing a misleading analysis that failed to recognize that all carbon emissions are detrimental, including all emissions from forestry, not just deforestation;
* Providing a misleading analysis that failed to recognize that logging does not increase forests productivity or increase forests capacity for carbon storage;
* Providing a misleading analysis that failed to recognize that the carbon emissions associated with logging exceed the carbon emissions associated with forest disturbance (even when logging is intended to limit or control disturbance, because there is a very low probability that forest treatments will interact with natural disturbance);
* Providing a misleading analysis that failed to distinguish between activities that might help forests prepare for climate change, and activities that might help mitigate climate change by storing more carbon, and failing to develop an alternative that harmonizes these two goals;
* Providing a misleading analysis that failed to recognize that the proper comparison of carbon emissions and carbon storage associated with logging is to compare the carbon effects of each alternative, including no action, NOT to compare carbon storage before logging and after some period of regrowth;
* Providing a misleading analysis that failed to recognize that it is more effective to leave carbon in the forest than to try to store carbon in wood products, especially in a forest like this that exhibits relatively high productivity. When view using lifecycle analysis, it is clear that wood products represent not a net *sink* for carbon, but rather a significant net *source* of carbon emissions. When a forest is logged to produce wood products, only a small fraction of the carbon from the forest ends up stored in wood products; the vast majority of carbon in a logged forest ends up on an accelerated path to the atmosphere.

Our scoping comments raised significant concerns about the effects of logging on carbon emissions and global climate change. The FS response to scoping said “The EA will address climate change.” However, the EA provided just one paragraph on the topic and that paragraph failed to address specific issues raised in Oregon Wild scoping comments.



The EA climate analysis also refers to an “Appendix E” that is not specific to this project at all. It’s just a regurgitation of the deeply flawed climate boilerplate that the regional office distributes. This appendix fails to address the numerous compelling criticisms provided by Oregon Wild in our scoping comments, and supplemented below.

The EA response to scoping comments suggests that our scoping comments are “the exception to the commonly accepted scientific consensus”. However, we would suggest that the FS analysis is misusing the science and presenting a misleading analysis that does not accurately represent best available science. Also, the FS has a duty to consider and weigh reasonable opposing viewpoints about the effects of logging on carbon and climate which it has entirely failed to do.

The social, economic, and environmental costs of unmitigated climate change are astronomical. With a recognition that nature-based carbon storage can help mitigate those costs, it is becoming clear that conservation of nature, especially forests, creates far more value than natural resource extraction. Bradbury, R.B., Butchart, S.H.M., Fisher, B. et al. The economic consequences of conserving or restoring sites for nature. Nat Sustain (2021). <https://doi.org/10.1038/s41893-021-00692-9>. <https://rdcu.be/cgpdK> (“At $31/tonne [of carbon] the nature-focused state NPV was greater than the alternative state NPV at 100% of forest sites. … [W]hile these patterns hold for all goods combined and for non-excludable goods, the alternative state was often more valuable when only excludable goods were considered. Our findings thus provide a strong economic justification for incentives to encourage private landowners towards decisions that favour nature-focused land management to enhance overall social value.”).

The EA failed to quantify the CO2e emissions associated with logging and other activities associated with this project. This is not a difficult task. There are numerous credible methods readily available to the agency. Quantifying carbon emissions from logging can be challenging but can be done.

The loss of biomass and resulting carbon emissions related to logging is due to: (a) the loss from trees that are harvested (“extracted log emissions”); (b) the incidental damage caused to surrounding trees during harvesting (“logging damage factor”); and (c) the infrastructure built for removing the logs out of the forest (“logging infrastructure factor”). The latter includes skidding trails (caused by use of bulldozers or other equipment to transport the logs from the felling area to roads), logging decks or landings (areas where the logs skidded out from the forest are piled awaiting transport) and logging roads (Pearson et al, 2014). Based on these three forms of loss, it is possible to establish a “total emissions factor” for any given logging operation …

Peter Wood 2018. Sustainability of commercial forest management in tropical rainforest -

A report prepared for the Rainforest Foundation Norway. October 9, 2018.

<https://d5i6is0eze552.cloudfront.net/documents/RF_report_0919_print.pdf?mtime=20190920102251>. Expert opinions and qualitative or relativistic descriptions of environmental effects are by themselves inadequate. NEPA analysis must be quantifiable and objective and explain the factual basis for conclusions regarding environmental effects, so that the general public can understand and provide meaningful comment. An October 2004 decision of the 9th Circuit Court of Appeals says:

The problem with the entire table is that it does not provide any objective quantification of the impacts. Instead, the reader is informed only that a particular environmental factor will be “unchanged,” “improved,” or “degraded” and whether that change will be minor” or “major.” The reader is not told what data the conclusion was based on, or why objective data cannot be provided.Such an analysis does not satisfy the admonition in *Neighbors of Cuddy Mountain* that “[g]eneral statements about possible effects and some risk do not constitute a hard look absent a justification regarding why more definitive information could not be provided.” 137 F.3d at 1380.

…

Idaho Sporting Cong. v. Thomas, 137F.3d 1146, 1150 (9th Cir. 1998) “[A]llowing the Forest Service to rely on expert opinion without hard data either vitiates a plaintiff’s ability to challenge an agency action or results in the courts second guessing an agency’s scientific conclusions. As both of these results are unacceptable, we conclude that NEPA requires that the public receive the underlying environmental data from which a Forest Service expert derived her opinion.”). Indeed, under the CEQ regulations, agencies are told that “public scrutiny [is] essential,” 40 C.F.R. § 1500.1(b), and are charged to “encourage and facilitate public involvement in decisions,” id. § 1500.2(d), so that “environmental information is available to public officials and citizens before decisions are made,” id. § 1500.1(b). They are also told that NEPA documents “shall be written in plain language... so that decision-makers and the public can readily understand them.” 40 C.F.R. § 1502.8. Even accepting the BLM’s representation that “specialists” can understand the information in these EAs, the documents are unacceptable if they are indecipherable to the public.

*Klamath-Siskiyou Wildlands Center v. BLM*

<http://web.archive.org/web/20070203054229/http://www.ca9.uscourts.gov/ca9/newopinions.nsf/B5D60B389785284288256F3B00544169/$file/0335461.pdf?openelement> While the above decision was written to apply directly to cumulative effects analysis, the same rules should apply to all NEPA analyses of environmental effects.

The 9th Circuit has also warned that —

… general statements about "possible" effects and "some risk" do not constitute a "hard look" absent a justification regarding why more definitive information could not be provided."

Blue Mountains Biodiversity Project v. Blackwood, (9th Circ, Dec 1998) <https://caselaw.findlaw.com/us-9th-circuit/1180061.html> *citing* Neighbors of Cuddy Mountain v. United States Forest Service, 137 F.3d 1372, 1380 (9th Cir. 1998).

The DOE highlights the need for NEPA documents to quantify carbon emissions:

The recommended 10-step approach takes into consideration the existing provisions of the NEPA regulations, recent court decisions, and various state programs. The steps conform to the main elements of a NEPA document.

**Affected Environment**

Step 1 – Describe the existing global context in which climate change impacts are occurring and are expected to continue to occur in the future.

Step 2 – Summarize any relevant state laws that address climate change.

Step 3 – Describe any relevant national, statewide, and regional GHG inventories to which the project will contribute.

**Environmental Consequences**

Step 4 – Quantify the project’s direct and indirect GHG emissions.

Step 5 – Convert the GHG emissions into carbon equivalents using an established “carbon calculator.”

Step 6 – Discuss whether the project would enhance or impede the attainment of applicable state GHG reduction.

Step 7 – Describe the cumulative global climate change impacts to which the proposed action would contribute, i.e., the impacts of the project on climate change. (This may use the same information as in Step 1.)

Step 8 – Describe how the impacts of global climate change could manifest themselves in the geographic area in which the project is proposed, and therefore potentially affect the project, i.e., the impacts of climate change on the project (e.g., sea level rise could affect a coastal project).

**Alternatives**

Step 9 – Include alternatives that would meet the project objectives but would also reduce GHG emissions.

**Mitigation Measures**

Step 10 – Identify mitigation measures that would reduce GHG emissions, including both project design or operational changes and potential compensatory mitigation (e.g., carbon offsets).

DOE 2009. NEPA and Climate Change: “Don’t Do Nothing” NEPA Lessons Learned - Quarterly Report. June 1, 2009. <http://energy.gov/sites/prod/files/LLQR-2009-Q2.pdf> *citing* Ron Bass 2008. Evaluating Greenhouse Gases and Climate Change Impacts Under NEPA: Ten Steps to Taking a Hard Look. ICF/Jones & Stokes. Impact Report Nov. 2008. <http://www.icfi.com/insights/white-papers/2008/evaluating-greenhouse-gases-and-climate-change-impacts-under-nepa-ten-steps-to-taking-a-hard-look>.

It is important to quantify the total carbon emissions from logging then use proxies such as the social cost of carbon dioxide emissions to help explain the effects of those emissions. Another powerful proxy is provided by Bressler (2021) which shows that 4,434 tonnes of CO2e emissions is estimated to result in 1 premature human death. Bressler, R.D. The mortality cost of carbon. Nat Commun 12, 4467 (2021). https://doi.org/10.1038/s41467-021-24487-w. <https://www.nature.com/articles/s41467-021-24487-w.pdf>. The agency should calculate and disclose how many people they are killing with their logging plans.

The Biden Administration says it is *essential* that federal decision-making consider the full cost of agency actions that may harm the climate:

**Sec. 5. Accounting for the Benefits of Reducing Climate Pollution**. (a) It is essential that agencies capture the full costs of greenhouse gas emissions as accurately as possible, including by taking global damages into account. Doing so facilitates sound decision-making, recognizes the breadth of climate impacts, and supports the international leadership of the United States on climate issues. The “social cost of carbon” (SCC), “social cost of nitrous oxide” (SCN), and “social cost of methane” (SCM) are estimates of the monetized damages associated with incremental increases in greenhouse gas emissions. They are intended to include changes in net agricultural productivity, human health, property damage from increased flood risk, and the value of ecosystem services. An accurate social cost is essential for agencies to accurately determine the social benefits of reducing greenhouse gas emissions when conducting cost-benefit analyses of regulatory and other actions. …

(b) There is hereby established an Interagency Working Group on the Social Cost of Greenhouse Gases …

(ii) Mission and Work. The Working Group shall, as appropriate and consistent with applicable law:

(A) publish an interim SCC, SCN, and SCM within 30 days of the date of this order, which agencies shall use when monetizing the value of changes in greenhouse gas emissions resulting from regulations and other relevant agency actions until final values are published;

(B) publish a final SCC, SCN, and SCM by no later than January 2022;

Biden 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/>. Experts offered 8 steps to restating the social cost of carbon dioxide emissions. Gernot Wagner, David Anthoff, Maureen Cropper, Simon Dietz, Kenneth T. Gillingham,

Ben Groom, J. Paul Kelleher, Frances C. Moore & James H. Stock. 2021. Eight priorities for calculating the social cost of carbon. Nature | Vol 590 | pp 548-550 | 25 February 2021. <https://media.nature.com/original/magazine-assets/d41586-021-00441-0/d41586-021-00441-0.pdf>. (1. Reverse Trump’s changes. 2. Seek broad input. 3. Update damage functions. 4. Reappraise climate risks. 5. Address equity. 6. Review discount rates. 7. Update socio-economic pathways. 8. Clarify limitations.).

Gifford Pinchot said "Where conflicting interests must be reconciled, the question shall always be answered from the standpoint of the greatest good of the greatest number in the long run." The social cost of carbon dioxide emissions is a useful yardstick for measuring “the greatest good to the greatest number” because it allows the agency to compare the centralized economic value of timber to the decentralized economic costs of greenhouse gases emissions from logging.

## Do not rely on the flawed boilerplate climate analyses

As explained below, the Forest Service’s standardized NEPA language regarding carbon and climate change fails to take a hard look that NEPA requires. The analysis makes several highly misleading statements about forest carbon and climate change. The analysis inappropriately mischaracterizes the role of individual logging projects in the cumulative problem of global GHG emissions. The analysis misstates the effects of logging related carbon emissions that are not related to “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 NEPA analysis should consider the adverse climate consequences of GHG emissions caused directly and indirectly by logging. The Forest Service should not rely on the boilerplate NEPA language from the regional office which is flawed in many ways. Instead the Forest Service:

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

## Cumulative Impacts of GHG Emissions Must not be Minimized

The NEPA analysis minimizes this project’s contribution to carbon emissions and global warming by saying the effects of this project would be “negligible” on a global scale. This is not an appropriate framework for analyzing the effects of GHG emissions. Global climate change and ocean acidification are the result of the **cumulative** effects on the **global** carbon cycle which is spatially distributed. There is no single culprit, nor is there a silver bullet solution. All emissions are part of the problem, and all land management decisions must be part of the solution. Since the global carbon cycle is spatially distributed, carbon storage and carbon emissions will always we spread out around the globe, and the carbon flux at any given place and time may appear small, but *cumulatively* they help determine the temperature of our climate and the pH of our oceans. Given the current carbon overload in the atmosphere and oceans, the carbon consequences of every project must be carefully considered (rather than dismissed as negligible).

The agency may argue that logging a few small patches of forest won’t make a difference in the global scheme of the climate problem, but as Voltaire said, "No snowflake in an avalanche ever feels responsible.” The NEPA analysis must recognize that global warming will not be solved by one miraculous technological fix or by changing one behavior or one economic activity. The whole global carbon cycle must be managed to reduce carbon emissions and increase carbon uptake. Recent evidence supports the conclusions that all net emissions of greenhouse gases are adverse to the climate. None can be considered *de minimus*. “We show first that a single pulse of carbon released into the atmosphere increases globally averaged surface temperature by an amount that remains approximately constant for several centuries, even in the absence of additional emissions. We then show that to hold climate constant at a given global temperature requires near- zero future carbon emissions. Our results suggest that future anthropogenic emissions would need to be eliminated in order to stabilize global-mean temperatures. As a consequence, any future anthropogenic emissions will commit the climate system to warming that is essentially irreversible on centennial timescales.” H. Damon Matthews and Ken Caldeira. 2009. Stabilizing climate requires near-zero emissions. Nature Vol 455 | 18 September 2008 | doi:10.1038/nature07296.

Former D.C. Circuit Judge Wald wrote in a 1990 dissenting opinion, which was recently quoted with unanimous approval by the Ninth Circuit in Center *for Biological Diversity v. NHTSA*:

[W]e cannot afford to ignore even modest contributions to global warming. If global warming is the result of the cumulative contributions of myriad sources, any one modest in itself, is there not a danger of losing the forest by closing our eyes to the felling of the individual trees?

538 F.3d at 1217. Similarly, the U.S. Supreme Court’s decision in *Massachusetts v. EPA* noted that one cannot avoid responsibility to reduce and mitigate the climate problem by attempting to minimize the scale of one’s contribution to the problem. ("While it may be true that regulating motor-vehicle emissions will not by itself reverse global warming, it by no means follows that we lack jurisdiction to decide whether EPA has a duty to take steps to slow or reduce it.... In sum, … [t]he risk of catastrophic harm, though remote, is nevertheless real. That risk would be reduced to some extent if petitioners received the relief they seek." 127 S.Ct. 1438, 1455 (2007) [http://web.archive.org/web/20080610172128/http://www.supremecourtus.gov/opinions/06pdf/05-1120.pdf](http://web.archive.org/web/20080610172128/http:/www.supremecourtus.gov/opinions/06pdf/05-1120.pdf))

[The Prime Minister] claims that we [Australians] are responsible for just 1.3% of global carbon dioxide emissions, as if we are irrelevant. ...

...

Even though Scott Morrison’s logic for climate inaction has been debunked many times, let’s do it again, ...

...

The “too small to matter” argument is logically absurd, but it is also morally bankrupt and economically reckless.

We all know that throwing one piece of litter out the window wouldn’t ruin the environment, but if all did we’d soon be surrounded by rubbish.

How about voting? It is a foundation of our democracy that nobody’s voice is so small as to be meaningless.

Likewise, if any one taxpayer stopped paying tax we all know it wouldn’t make a measurable difference to the government’s bottom line, but if everyone stopped paying tax it would smash consolidated revenue.

Simon Holmes à Court 2020. When it comes to emissions, the 'too small to matter' argument is absurd, reckless and morally bankrupt. The UK Guardian 8 Jan 2020. <https://www.theguardian.com/australia-news/2020/jan/09/when-it-comes-to-emissions-the-too-small-to-matter-argument-is-absurd-reckless-and-morally-bankrupt?CMP=twt_a-environment_b-gdneco>.

The responsibility to reduce emissions no matter how small is recognized in international law such as the European Convention on Human Rights.

The fact that the amount of the Dutch emissions is small compared to other countries does not affect the obligation to take precautionary measures in view of the State’s obligation to exercise care. After all, it has been established that any anthropogenic greenhouse gas emission, no matter how minor, contributes to an increase of CO2 levels in the atmosphere and therefore to hazardous climate change.

*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>.

CEQ draft guidance on NEPA and climate change recognizes that disclosure of the incremental nature of GHG emissions attributable to any given project is merely a restatement of the nature of the climate problem itself and NEPA does not allow agencies to avoid disclosure and consideration of alternatives and mitigation.

CEQ recognizes that many agency NEPA analyses to date have concluded that GHG emissions from an individual agency action will have small, if any climate change effects. Government action occurs incrementally, program-by-program and step-by-step, and climate impacts are not attributable to any single action, but are exacerbated by a series of smaller decisions, including decisions made by the government. Therefore, the statement that emissions from a government action or approval represent only a small fraction of global emissions is more a statement about the nature of the climate change challenge, and is not an appropriate basis for deciding whether to consider climate impacts under NEPA.

Moreover, these comparisons are not an appropriate method for characterizing the potential impacts associated with a proposed action and its alternatives and mitigations. This approach does not reveal anything beyond the nature of the climate change challenge itself: The fact that diverse individual sources of emissions each make relatively small additions to global atmospheric GHG concentrations that collectively have huge impact.

77 Fed. Reg. 77802, 77825. (Dec. 24, 2014).

Agency NEPA analyses often say that the "Literature, however, has not yet defined any specifics on the nature or magnitude of any cause and effect relationship between greenhouse gases and climate change. [and] it is currently beyond the scope of existing science to identify a specific source of greenhouse gas emissions or sequestration and designate it as the cause of specific climate impacts at a specific location."​ The agency should stop saying this. Such statements are obviously part of the agency’s dismissive boilerplate about climate change but they add nothing to the analysis, but they imply that things are far more uncertain than they are, and that logging-related GHG emissions can't be connected to the crime of global climate change, which is nonsense. What we know is that climate change is caused by cumulative effects. All GHG emissions become globally distributed in our well-mixed atmosphere, so all emissions are related to all harms and effects of global climate change. These effects are set forth in great detail in the scientific literature and IPCC reports. So, GHG emissions are bad and CO2 uptake by forests is good, and the agency's logging program increases GHG emissions and reduces CO2 uptake.

Because individual contributions to climate change are so small, but the cumulative problem is so large, meaningfully disclosing the impact of greenhouse gas emissions requires some tool beyond merely identifying physical changes in the environment attributable to an individual project’s emissions.

Climate change is the quintessential cumulative impact problem, and a good way to disclose the incremental effects of individual contributions to the cumulative problems is to monetize the effects using tools that quantify the social cost of carbon dioxide emissions. Social Cost of Carbon 2010, <https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/foragencies/Social-Cost-of-Carbon-for-RIA.pdf>.

Individual physical changes that will result from any particular action will inevitably appear insignificant. Just as the public and decisionmakers “cannot be expected to convert curies or mrems into such costs as cancer deaths,” the EIS’s readership cannot be expected to understand whether an individual project’s miniscule marginal increase contribution to increased temperature, sea levels, etc. is cause for concern. *Natural Res. Def. Council, Inc. v. U. S. Nuclear Regulatory Comm’n*, 685 F.2d 459, 487 n.149 (D.C. Cir. 1982) rev’d on other grounds sub nom. *Baltimore Gas & Elec. Co. v. Natural Res. Def. Council, Inc.*, 462 U.S. 87, 106-107 (1983).

Estimates of the social cost of carbon dioxide emissions are based on reasonable forecasts of the actual physical effects that each incremental unit of greenhouse gas emissions will have on the environment, including temperature, sea level rise, ecosystem services, and other physical impacts, together with assessments of how these physical changes will impact agriculture, human health, etc. The social cost protocol identifies the social cost imposed by a ton of emissions’ pro rata contribution to these environmental problems. This either amounts to an assessment of physical impacts or the best available generally accepted alternative to such an assessment; either way, the tool is appropriate for use under NEPA. 40 C.F.R. § 1502.22(b)(4).

Any assertion that it is impossible to discuss the impact or significance of the Project’s greenhouse gas emissions is arbitrary. Agencies must use available generally accepted tools to address the impact of these emissions, 40 C.F.R. 1502.22, and employ reasonable forecasting in its analysis. The agency’s refusal to use available modeling tools, such as the estimates of the social cost of carbon and other greenhouse gases, violates NEPA.

## Forest Degradation just as bad as Deforestation

The EA dodges responsibility for carbon emissions by claiming that this project does not involve “deforestation.” The agency often says “This project does not fall within any of these main contributors of greenhouse gas emissions. … The main activity in this [forestry] sector associated with GHG emissions is deforestation, which is defined as removal of all trees, most notably the conversion of forest and grassland into agricultural land or developed landscapes (IPCC 2000).” The agency is again minimizing the effects of its activities and avoiding its dual responsibilities to produce accurate NEPA analysis and help store carbon in forests. All emissions are a problem. Categories do not really matter. The atmosphere sees each molecule of CO2 and other GHG equally. Climate authorities recognize “forest degradation” is just as bad as deforestation. In fact, the urgency to maintain and enhance biogenic terrestrial carbon stores has long been recognized and is reflected in the inclusion of the land sector in the report of the United Nations Framework Convention on Climate Change (UNFCCC). The official title of UN program related to reducing GHG emissions from land use includes the words deforestation AND “forest degradation” i.e., Reducing Emissions from Deforestation and Forest Degradation (REDD). This clearly refutes the agency’s assertion that forest management activities that fall short of deforestation are not among the categories of concern regarding global GHG emissions.

The Copenhagen Accord recognizes the need to avoid dangerous climate change and the role of forests in climate mitigation.

“…To achieve the ultimate objective of the Convention to stabilize greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, we shall, recognizing the scientific view that the increase in global temperature should be below 2 degrees Celsius … enhance our long-term cooperative action to combat climate change. We recognize the crucial role of reducing emission from deforestation **and forest degradation** and the need to enhance removals of greenhouse gas emission by forests and agree on the need to provide positive incentives to such actions”

<http://www.climatesciencewatch.org/file-uploads/Copenhagen_Accord.pdf>. This likely requires reducing atmospheric CO2 concentrations below 350 ppm[[1]](#footnote-1) and avoiding logging that would increase atmospheric carbon emissions. Boucher, D., and K. Belletti-Gallon, 2015. Halfway There? What the Land Sector Can Contribute to Closing the Emissions Gap. Union of Concerned Scientists. <http://www.ucsusa.org/sites/default/files/attach/2015/01/ucs-halfway-there-2015-full-report.pdf> (“Enormous amounts of carbon are released into the atmosphere when forests are cleared. “**Forest degradation” activities, such as selective logging, … are also significant emissions sources**.”)

**Forest degradation should be defined from a climate change perspective to include any human land-use activity that reduces the carbon stocks of a forested landscape relative to its carbon carrying capacity**. The climate change imperative demands that we take a fresh look at our forest estate. The carbon impacts of all land uses, including commercial logging, must be brought explicitly into our calculations in terms of their direct and indirect effects on forest degradation.

Brendan G. Mackey, Heather Keith, Sandra L. Berry and David B. Lindenmayer. 2008. Green Carbon: The role of natural forests in carbon storage. Part 1. A green carbon account of Australia’s south-eastern Eucalypt forests, and policy implications. Australian National University. <http://epress.anu.edu.au/green_carbon/pdf/whole_book.pdf>.

The agency must account for all forest carbon loses, not just from deforestation, but also degradation. Sophie Yeo 2015. Blog - **Forest degradation as bad for climate as deforestation**, says report. 08 Apr 2015, <http://www.carbonbrief.org/blog/2015/04/forest-degradation-as-bad-for-climate-as-deforestation,-says-report/>

​A study by Erb et al (2017) shows that deforestation represents only about half of the cumulative carbon emissions from land use. Most of the other half is from forest degradation. **​**

**Scientists just presented a sweeping new estimate of how much humans have transformed the planet**

By Chris Mooney, Washington Post  
December 20 , 2017

<https://www.washingtonpost.com/news/energy-environment/wp/2017/12/20/scientists-present-a-sweeping-new-estimate-of-how-much-humans-have-altered-the-planet/>

...  
Razing forests or plowing grasslands puts carbon in the atmosphere just like burning fossil fuels does.  
Now, new research provides a surprisingly large estimate of just how consequential our treatment of land surfaces and vegetation has been for the planet and its atmosphere.  
...  
[T]he study also presented an even larger and perhaps more consequential number: 916 billion tons. That’s the amount of carbon, the research calculated, that could reside in the world’s vegetation — so not in the atmosphere — if humans somehow entirely ceased all uses of land and allowed it to return to its natural state. The inference is that current human use of land is responsible for roughly halving the potential storage of carbon by that land.  
...  
The study found that there are two far-less-recognized components of how humans have subtracted from Earth’s potential vegetation — and that in combination they are just as substantial as deforestation. Those are large-scale grazing and other uses of grasslands, as well as forest “management.” With the latter, many trees and other types of vegetation are subtracted from forests — often the larger and older trees due to logging — but the forests as a whole don’t disappear. They’re just highly thinned out.  
“This effect is quite massive, more massive than we expected actually,” Erb said.  
...  
The research means that so-called degraded land — not fully deforested but not “natural” or whole, either — is a phenomenon to be reckoned with.  
“It suggests that the amount of carbon released to the atmosphere from land use is approximately equal to the amount still retained,” said Tom Lovejoy, an ecologist at George Mason University who was not involved in the work. “That means the restoration agenda is even more important than previously thought and highlights the enormous amount of degraded land in the world.”  
...  
“Scenarios that limit global warming to 1.5 or 2 degrees [Celsius] require not only rapid cessation of greenhouse gas emissions but also removal of somewhere between about 100 and 300 billion tons of carbon from the atmosphere,” Phil Duffy, president of the Woods Hole Research Center, said in an email.  
“This paper suggests that restoring vegetation around the world could in principle achieve that,” Duffy continued, noting that if all the potential vegetation were restored it would offset some 50 years of global carbon emissions. While “the full theoretical potential will never be realized in practice … this paper indicates that restoring vegetation could make an extremely important contribution to controlling global climate change.”

See Karl-Heinz Erb et al. 2017. Unexpectedly large impact of forest management and grazing on global vegetation biomass. Nature. Published online 20 Dec 2017. doi:10.1038/nature25138.

[https://www.nature.com/articles/nature25138.epdf](https://www.nature.com/articles/nature25138.epdf?referrer_access_token=AmG5brx_IASERhmJverWl9RgN0jAjWel9jnR3ZoTv0NirJkvwWx4SyxNfQ6HSmxzxqqZAANXNnLuatTe8oLumy8xaQxUd_1g_013OmtCbricjv4GoVo9VJ5ssO5K2RQhmSYii7rJeYoxF8Lkb5CIKhsm1yIsw9QNdNDCRtpvmHMCXVOH0UBHSE_DrTpHZiCWSTLd6ApZpSjkNsiY9ZHeqtaUmcdUx5Yu4LBybsurghysOsdm_vFJMfGB8cjKXGTIaRonXgp1tIGTaqA58oo3Cns4w6fxeIeJVX7bZEgSq6uhnaQeb9omahqkNN2K5IcqN-Kuk5Ag41jw6LsRh_8FOpKBxwXBUs8nniPkZbc4t0sij5tEnRwnL8wxHwM4rSK_h33VtNvWUjC_q3ZbJPZ0oA%3D%3D&tracking_referrer=www.washingtonpost.com)

Arneth et al (2017) showed that global vegetation models often make unrealistic assumptions about forests (such as that areas maintained in forest cover suffer no decline in carbon storage) and therefore underestimate both the carbon flux from logging as well as the carbon benefits of forest conservation.

… Dynamic global vegetation model simulations suggest that CO2 emissions from land-use change have been substantially underestimated because processes such as tree harvesting and land clearing from shifting cultivation have not been considered. As the overall terrestrial sink is constrained, a larger net flux as a result of land-use change implies that terrestrial uptake of CO2 is also larger, and that terrestrial ecosystems might have greater potential to sequester carbon in the future. Consequently, reforestation projects and efforts to avoid further deforestation could represent important mitigation pathways, with co-benefits for biodiversity. …

…

**Wood Harvesting**

Until recently, global DGVM studies that accounted for LULCC concentrated on the representation of conversion of natural lands to croplands and pastures, whereas areas under forest cover were represented as natural forest, and hence by each model’s dynamics of establishment, growth and mortality. Two-thirds to three-quarters of global forests have been affected by human use, which is mainly due to timber harvest; but forests are also a source of firewood or secondary products; or used for recreational purposes13. Between 1700 and 2000  an estimated 86  PgC has been removed globally from forests due to wood harvesting (WH)14. WH leads to reduced carbon density on average in managed forests15 and can ultimately result in degradation in the absence of sustainable management strategies. Furthermore, the harvesting of wood can reduce litter input, which lowers soil pools13. Bringing a natural forest under any harvesting regime probably will lead to net-CO2 emissions to the atmosphere — with a magnitude and time-dependency conditional on harvest intensity and frequency, regrowth and the fate and residence time of the wood products.

**Impacts of land-management processes on the carbon cycle**

The few published DGVM studies that account for the management of land more realistically16,19–21 consistently suggest a systematically larger FLULCC over the historical period compared to estimates that ignored these processes, with important implications for our understanding of the terrestrial carbon cycle and its role for historical (and future) climate change. …

…

**Implications for the future land carbon mitigation potential**

Our calculated increases in FLULCC, in absence of a clear understanding of the processes underlying FRL, notably strengthen the existing arguments to avoid further deforestation (and all ecosystem degradation) — an important aspect of climate change mitigation, with considerable co-benefits to biodiversity and a broad range of ecosystem service supply.

Arneth, A., Sitch, S., Pongratz, J. et al (2017) Historical carbon dioxide emissions caused by land-use changes are possibly larger than assumed. NATURE GEOSCIENCE | VOL 10 | FEBRUARY 2017. <http://bstocker.net/wp-content/uploads/2016/09/arneth17natgeo.pdf>.

When forest carbon accounting looks only at forest clearing, significant forgone carbon sequestration caused by forest degradation are overlooked. “[N]ew research shows that we should be taking much better care of our last great intact forests because doing so has remarkable climate benefits. ... A single episode of serious damage can lead to decades of ‘lost earnings’ in the carbon accounts.” Tom Evans, Sean Maxwell 2019. The Carbon Bomb - A new report shows that deforestation released a shocking 626 percent more CO2 between 2000 and 2013 than previously thought. Scientific American. November 8, 2019. <https://blogs.scientificamerican.com/observations/the-carbon-bomb/> *citing* Sean L. Maxwell, Tom Evans, James E. M. Watson et al 2019. Degradation and forgone removals increase the carbon impact of intact forest loss by 626%. Science Advances 30 Oct 2019: Vol. 5, no. 10, eaax2546. DOI: 10.1126/sciadv.aax2546. <https://advances.sciencemag.org/content/5/10/eaax2546>. (“[W]e encourage national governments to better account for the full carbon impact of intact forest retention. For example, emission baselines that account for selective logging and other more cryptic degradation processes would reduce the disproportionate emphasis on recent forest clearance”).

## Logging Does Not Increase Capacity for Growing Trees

The NEPA analysis 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 FS builds roads, compacts soil, removes biomass, etc.

In the context of carbon and climate change, the agency cannot define “improve forest conditions” in way that justifies logging that increases 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.”).

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—largely free from human intervention except primarily for trails and hazard removals—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 reforestationand 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—termed proforestation—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 ≥1 cm in diameter at breast height (DBH)] accounted for half of above ground living biomass (The largest 1% accounted for ∼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 (Buée et al. 2007, Jones et al. 2010, Rineau and Courty 2011). Therefore, on the one hand, high diversity in the mycorrhizal fungal community is of great importance for forest trees to optimally exploit soil resources through the different functional abilities of single species. On the other hand, a high diversity allows the mycorrhizal community to respond to changing environmental conditions and disturbances by modifying the community towards better-adapted species that maintain important ecosystem functions. ... With climate warming, it is expected that the severity and duration of drought will increase, and therefore the maintenance of intact mycorrhizal networks will become more critical to the stability of forest ecosystems (Simard and Austin 2010). ... Several factors, such as natural disturbances, forest management, and anthropogenic pollution, impact this diversity and structure, in most cases by changing the competitiveness and dominance of the species present. Under severe disturbances, species richness is impacted, lowering the potential resistance to additional stresses or even reducing ecological function. ... Although the effect of climate change factors and their interaction on mycorrhizal communities is complex and difficult to predict, it is likely that these communities will help stabilize forest ecosystems under the predicted climatic scenarios (Simard and Austin 2010). Management practices should therefore consider the functional importance of mycorrhizal fungi and their networks in the natural regeneration and resilience of forests.

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

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

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 –

• We review the effect of forest management practices on fungal diversity.

• Fungal diversity is positively related with canopy cover, basal area and tree species diversity.

• Diversity of deadwood size and decomposition stage is positively related to richness of wood-inhabiting fungi.

• 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, José Antonio Bonet, Carles Castaño, 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>.

## Risk reduction logging does not help store carbon.

The EA suggests that density reduction via logging increase both climate adaptation and climate mitigation. This is incorrect. Logging is always a net source of carbon emissions.

Forest Service NEPA analyses often include the following assertion - “The release of carbon associated with this project is justified given the overall change in condition increases forest resistance to release of much greater quantities of carbon from wildfire, drought, insects/disease, or a combination of these disturbance types (Millar 2007)” This is inaccurate and misleading.

Logging proponents often claim that logging will increase carbon storage in the forest by limiting carbon emissions caused by natural processes such as fire and insect-induced mortality. This is simply counter-factual. In most cases, managing forests in an effort to control natural processes that release carbon will only make things worse by releasing MORE carbon. This is mostly because no one can predict where fire or insects will occur, so the treatments must be applied to broad landscapes, yet the probability of fire or insects at any given location remains low, and only a small fraction of the treated areas will actually experience fire or insects. As a result, many acres will be treated "unnecessarily" and therefore the cumulative carbon emissions from logging to control fire and insects (plus the carbon emissions from fire and insects that occur in spite of control efforts) are greater than emissions from fire and insects alone. A careful analysis shows that logging to control fire and expecting to increase carbon storage is analogous to rolling a die and expecting to roll a six every time.

This is an example of the “base rate fallacy” or “neglecting priors” from Bayesian statistics. The probability of a forest stand NOT burning are far greater than the probability of a forest stand burning. Attempts to address a problem that is unlikely to occur, such as by thinning a forest that is unlikely to burn, runs a high risk that unintended negatives effects will overwhelm beneficial effects. <https://en.wikipedia.org/wiki/Base_rate_fallacy>

[T]here is no guarantee that thinning across vast landscapes will stabilize carbon stores. Rather the best available scientific study has shown that thinning reduces carbon stores more than fire itself and reduces carbon stores whether or not fire burns that particular forest.

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).

The 2018 US Forest Service Northwest Forest Plan Science Synthesis concluded that fuel reduction is unlikely to be an effective climate mitigation strategy.

Some studies from other regions in the Western United States (i.e., the Southwest and Sierra Nevada) suggest that thinning and fuel reduction can mitigate carbon loss from fire. Fuel reduction may reduce losses of carbon at stand levels compared with the consequences of high-severity wildfire burning in stands with high fuel loads (Finkral and Evans 2008; Hurteau and North 2009; Hurteau et al. 2008, 2011, 2016; North and Hurteau 2011; North et al. 2009, Stephens et al. 2009). However, because the probability of treated areas burning is generally low (Barnett et al. 2016), and most biomass is not consumed by fire, slight differences in losses resulting from combustion in fire compared with losses from fuel reduction are unlikely to make fuel reduction a viable mitigation strategy (Ager et al. 2010, Campbell et al. 2012, Kline et al. 2016, Mitchell et al. 2009, Restaino and Peterson 2013, Spies et al. 2017).

USDA 2018. Synthesis of Science to Inform Land Management Within the Northwest Forest Plan Area. General Technical Report. PNW-GTR-966 Vol. 1. June 2018. <https://www.fs.fed.us/pnw/pubs/pnw_gtr966_vol1.pdf>.

Let’s start with a simple truism of risk management:

Speculative negative emissions technologies may be worse than chimeras if they result in the false comfort that continued … emissions can simply be offset, thereby diverting financial and policy resources from conventional mitigation. This would be reckless. It is clearly less risky not to emit a tonne of CO2 in the first place, than to emit one in expectation of being able to sequester it for an unknown period of time, at unknown cost, with unknown consequences, at an unknown date and place in the future.

Carbon Brief staff 2016. In-depth: Experts assess the feasibility of ‘negative emissions’ *citing* Rob Bailey, Director of Energy, Environment and Resources, Chatham House. <http://www.carbonbrief.org/in-depth-experts-assess-the-feasibility-of-negative-emissions#bailey>

Law & Harmon (2011) conducted a literature review and concluded …

Thinning forests to reduce potential carbon losses due to wildfire is in direct conflict with carbon sequestration goals, and, if implemented, would result in a net emission of CO2 to the atmosphere because the amount of carbon removed to change fire behavior is often far larger than that saved by changing fire behavior, and more area has to be harvested than will ultimately burn over the period of effectiveness of the thinning treatment.

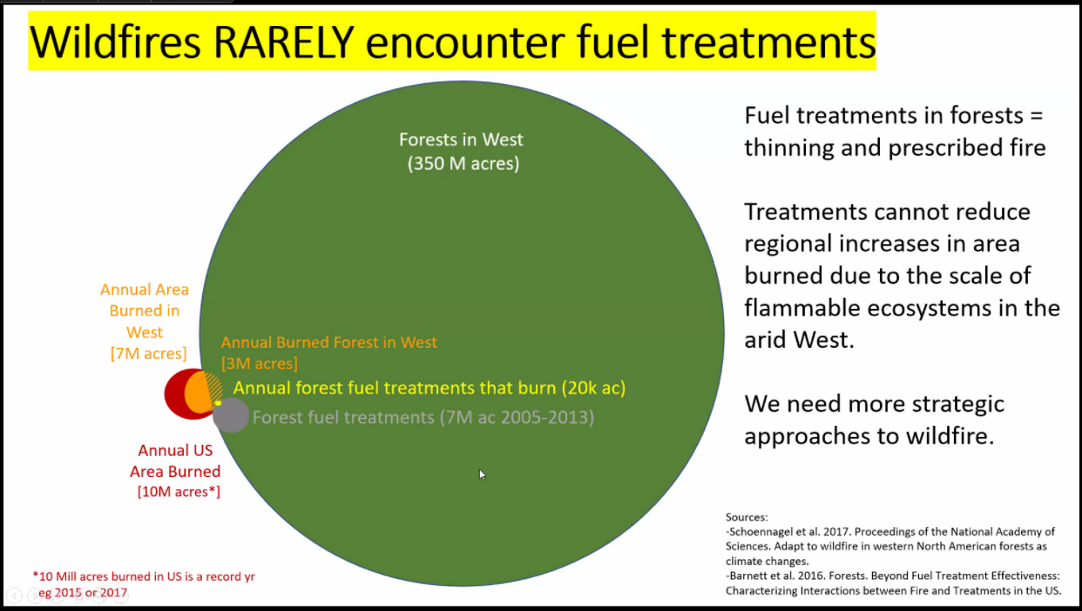
Law, B. & M.E. Harmon 2011. Forest sector carbon management, measurement and verification, and discussion of policy related to mitigation and adaptation of forests to climate change. Carbon Management 2011 2(1). <https://content.sierraclub.org/ourwildamerica/sites/content.sierraclub.org.ourwildamerica/files/documents/Law%20and%20Harmon%202011.pdf>.

Campbell and Agar (2013) conducted a sensitivity analysis and found robust results indicating that fuel reduction does not increase forest carbon storage.

… we attempt to remove some of the confusion surrounding this subject by performing a sensitivity analysis wherein long-term, landscape-wide carbon stocks are simulated under a wide range of treatment efficacy, treatment lifespan, fire impacts, forest recovery rates, forest decay rates, and the longevity of wood products. Our results indicate a surprising insensitivity of long-term carbon stocks to both management and biological variables. After 80 years, … a 1600% change in either treatment application rate or efficacy in arresting fire spread resulted in only a 10% change in total system carbon. This insensitivity of long-term carbon stocks is due in part by the infrequency of treatment/wildfire interaction and in part by the controls imposed by maximum forest biomass. None of the fuel treatment simulation scenarios resulted in increased system carbon.

Campbell, J, Agar, A (2013) Forest wildfire, fuel reduction treatments, and landscape carbon stocks: A sensitivity analysis. Journal of Environmental Management 121 (2013) 124-132 <http://fes.forestry.oregonstate.edu/sites/fes.forestry.oregonstate.edu/files/PDFs/Campbell_2013_JEM.pdf>

This graph shows that logging for fuel reduction rarely interacts with wildfire, which explains why the carbon emissions from widespread fuel reduction logging vastly exceeds the carbon emissions avoided in the rare cases where fuel reduction does interact favorably with wildfire.



There are now webtools available that can help the agencies deal with uncertainty surrounding the efficacy of fuel reduction. For instance, this web-based spreadsheet (<http://getguesstimate.com/>) allows users to create models with confidence intervals around input variables. Then it runs thousands of Monte Carlo simulations to come up with estimates of model behavior. The agencies could use this to better estimate the improbability that fuel treatments would interact with fire and estimate the improbable carbon benefits of fuel reduction logging.

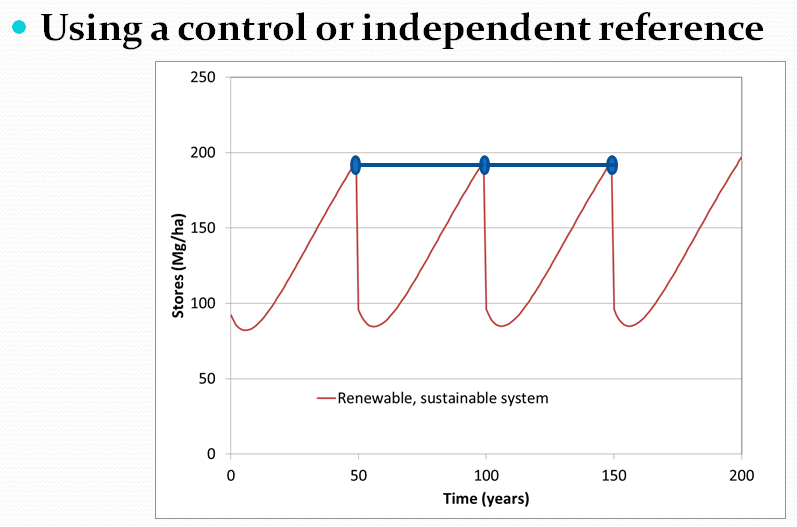
Before attributing carbon benefits to fuel reduction logging please consider the conclusions of:

* John L Campbell, Mark E Harmon, and Stephen R Mitchell. 2011. Can fuel-reduction treatments really increase forest carbon storage in the western US by reducing future fire emissions? Front Ecol Environ 2011; doi:10.1890/110057 <http://forestpolicypub.com/wp-content/uploads/2011/12/campbell-2011.pdf>. (Results suggest that the protection of one unit of C from wildfire combustion comes at the cost of removing three units of C in fuel treatments.)
* Mitchell, Harmon, O’Connell. 2009. Forest fuel reduction alters fire severity and long-term carbon storage in three Pacific Northwest ecosystems. Ecological Applications. 19(3), 2009, pp. 643–655. <http://www.fs.fed.us/pnw/pubs/journals/pnw_2009_mitchell001.pdf>. (“…reducing the fraction by which C is lost in a wildfire requires the removal of a much greater amount of C, since most of the C stored in forest biomass (stem wood, branches, coarse woody debris) remains unconsumed even by high-severity wildfires. For this reason, all of the fuel reduction treatments simulated for the west Cascades and Coast Range ecosystems as well as most of the treatments simulated for the east Cascades resulted in a reduced mean stand C storage…. We suggest that forest management plans aimed solely at ameliorating increases in atmospheric CO2 should forego fuel reduction treatments …”)
* Reinhardt, Elizabeth, and Lisa Holsinger 2010. Effects of fuel treatments on carbon-disturbance relationships in forests of the northern Rocky Mountains. Forest Ecology and Management 259 (2010) 1427–1435. <http://www.fs.fed.us/rm/pubs_other/rmrs_2010_reinhardt_e002.pdf> (“Although wildfire emissions were reduced by fuel treatment, the fuel treatments themselves produced [carbon] emissions, and the untreated stands stored more carbon than the treated stands even after wildfire. … Our results show generally long recovery times …”)
* 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://content.sierraclub.org/ourwildamerica/sites/content.sierraclub.org.ourwildamerica/files/documents/Law%20and%20Harmon%202011.pdf> (“Thinning forests to reduce potential carbon losses due to wildfire is in direct conflict with carbon sequestration goals, and, if implemented, would result in a net emission of CO2 to the atmosphere because the amount of carbon removed to change fire behavior is often far larger than that saved by changing fire behavior, and more area has to be harvested than will ultimately burn over the period of effectiveness of the thinning treatment.”)
* Restaino, Joseph C.; Peterson, David L. 2013. Wildfire and fuel treatment effects on forest carbon dynamics in the western United States. Forest Ecology and Management 303:46-60. <http://www.fs.fed.us/pnw/pubs/journals/pnw_2013_restiano001.pdf> (“… C costs associated with fuel treatments have can exceed the magnitude of C reduction in wildfire emissions, because a large percentage of biomass stored in forests (i.e., stem wood, branches, coarse woody debris) remains unconsumed, even in high-severity fires (Campbell et al., 2007; Mitchell et al., 2009). … Wildfire occurrence in a given area is uncertain and may never interact with treated stands with reduced fire hazard, ostensibly negating expected C benefits from fuel treatments. Burn probabilities in treated stands in southern Oregon are less than 2%, so the probability that a treated stand encounters wildfire and creates C benefits is low (Ager et al., 2010).)”
* Goslee, K., Pearson, T., Grimland, S., Petrova, S., Walls, J., Brown, S., 2010. Final Report on WESTCARB Fuels Management Pilot Activities in Lake County, Oregon. California Energy Commission, PIER. DOE Contract No.: DE-FC26-05NT42593. <http://uc-ciee.org/downloads/Fuels_Management_LakeCo.pdf>; AND Pearson, T.R.H., Goslee, K., Brown, S., 2010. Emissions and Potential Emission Reductions from Hazardous Fuel Treatments in the WESTCARB Region. California Energy Commission, PIER. CEC-500-2014-046. <http://www.energy.ca.gov/2014publications/CEC-500-2014-046/CEC-500-2014-046-AP.pdf>. (Summarized by Restaino & Peterson (2013) as follows: “Pearson et al. (2010) and Goslee et al. (2010) developed methodologies to evaluate C dynamics associated with fuel treatment projects in low to mid-elevation forest in northern California and Oregon. The authors, with consultation from teams of scientists, quantify C storage and release within the context of a six-point conceptual framework: annual fire risk, treatment emissions, fire emissions, forest growth and re-growth, re-treatment, and the shadow effect (i.e., treatment effect outside the treated area). Results indicate that the mean annual probability of wildfire for the study region is less than 0.76%/year, and treatments reduce C stocks by an average of 19%. Where timber is removed, 30% of extracted biomass is stored in long-lasting wood products. Wildfire emissions in treated stands, quantified with the Fuel Characteristic Classification System, are reduced by 6% relative to untreated stands. Growth estimates for a 60-year simulation horizon, derived from FVS, indicate that in the absence of wildfire, untreated stands sequester 17% more C than treated stands. However, in simulations that include wildfire, treated stands sequester 63% more C than untreated stands. The shadow effect is unlikely to be large enough to affect net GHG emissions. In summary, initial reductions in C stocks (e.g., thinning), combined with low annual probability of wildfire, preclude C benefits associated with fuel treatments, even if harvest residues are used for biomass energy.”)
* Chiono, Lindsay 2011. Balancing the Carbon Costs and Benefits of Fuels Management. Research Synthesis for Resource Managers. Joint Fire Science Program Knowledge Exchange. <http://static1.squarespace.com/static/545a90ede4b026480c02c5c7/t/5527ebd9e4b0f620d0cb5b58/1428679641640/CFSC_Chiono_Carbon_and_Fuel_Mngmt.pdf> (“[T]he net carbon impact of fuel treatments is further complicated by the probabilistic nature of wildfire occurrence and the impermanence of post-treatment stand conditions … [T]reatment activities produce an immediate carbon emission while future wildfire emissions are uncertain … Depending on the intensity of treatment, the quantity of carbon removed may be substantial enough to negate gains from avoided wildfire emissions. … cumulative emissions from fuels reduction activities repeated in order to maintain low hazard conditions over time can overwhelm avoided wildfire emissions, resulting in a net carbon loss.”)
* Dina Fine Maron 2010. FORESTS: Researchers find carbon offsets aren't justified for removing understory (E&E Report 08/19/2010, reporting on the WESTCARB Project) <https://pacificforest.org/pft-in-the-media-2010-climatewire-8-19-10.html>. (“’The take-home message is we could not find a greenhouse gas benefit from treating forests to reduce the risk of fire,’ said John Kadyszewski, the principal investigator for the terrestrial sequestration projects of the West Coast Regional Carbon Sequestration Partnership. WESTCARB, ... Since there is a relatively low risk of fire at any one site, large areas need to be treated -- which release their own emissions in the treatment process. The researchers have concluded that the expected emissions from treatments to reduce fire risk exceed the projected emissions benefits of treatment for individual projects.”)
* Rachel A. Loehman, Elizabeth Reinhardt, Karin L. Riley 2014. Wildland fire emissions, carbon, and climate: Seeing the forest and the trees – A cross-scale assessment of wildfire and carbon dynamics in fire-prone, forested ecosystems. Forest Ecology and Management 317 (2014) 9–19. <http://www.fs.fed.us/rm/pubs_other/rmrs_2014_loehman_r001.pdf> (“… management of carbon in fire-prone and fire-adapted forests is more complex than simply minimizing wildfire carbon emissions and maximizing stored carbon in individual stands. The stochastic and variable nature of fires, the relatively fine scale over which fuels treatments are implemented, and potentially high carbon costs to implement them suggest that fuel treatments are not an effective method for protecting carbon stocks at a stand level (Reinhardt et al., 2008; Reinhardt and Holsinger, 2010).”)
* Jim Cathcart, Alan A. Ager, Andrew McMahan, Mark Finney, and Brian Watt 2009. Carbon Benefits from Fuel Treatments. USDA Forest Service Proceedings RMRS-P-61. 2010.
* Chiono, L. A., D. L. Fry, B. M. Collins, A. H. Chatfield, and S. L. Stephens. 2017. Landscape-scale fuel treatment and wildfire impacts on carbon stocks and fire hazard in California spotted owl habitat. Ecosphere 8(1):e01648. 10.1002/ecs2.1648. <http://onlinelibrary.wiley.com/doi/10.1002/ecs2.1648/full> (“We used a probabilistic framework of wildfire occurrence to (1) estimate the potential for fuel treatments to reduce fire risk and hazard across the landscape and within protected California spotted owl (Strix occidentalis occidentalis) habitat and (2) evaluate the consequences of treatments with respect to terrestrial C stocks and burning emissions. Silvicultural and prescribed fire treatments were simulated on 20% of a northern Sierra Nevada landscape in three treatment scenarios … [A]ll treatment scenarios resulted in higher C emissions than the no-treatment scenarios.”)

## Avoid “before-and-after” carbon accounting

The EA says that carbon emissions will be “erased” by future forest growth. This suggestion that logging is *carbon neutral* because the forest captures and stores the same pre-harvest amount of carbon after a period of regrowth is highly misleading. The proper analysis requires comparison of the amount of carbon *with* the project and *without* the project, not *before* and *after* logging. This is not only required to accurately determine the effect of vegetation removal on forest carbon storage but it is also consistent with NEPA requirements to compare *action* and *no action* alternatives.

Comparing carbon in the system at two points in time is unscientific. A proper analysis requires measuring carbon in the system of interest over time compared to a reference or control.



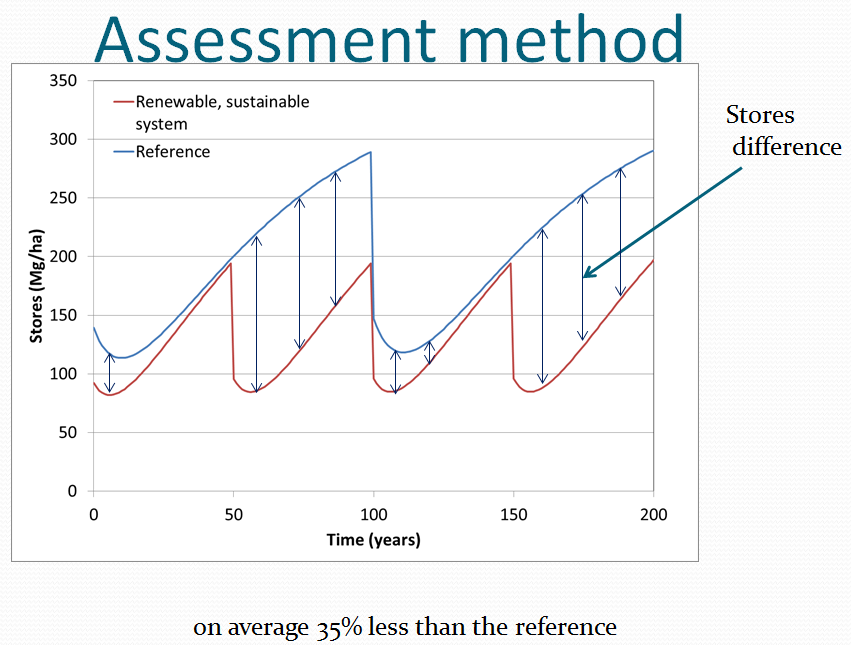
The approach shown above is improper. As explained by Mark Harmon:

All too often explanations of forest carbon dynamics are not science-based. Why? They involve using the system as its own reference or control. That is not a scientific assessment method. So while it sounds scientific to explain how after a harvest the forest regrows and hence there is no carbon impact, one cannot tell the impact. We can tell over time that the amount returns to the original level, but we still cannot assess the impact scientifically. The fact the system is renewable and sustainable is largely irrelevant in answering the question of whether the system is carbon neutral.

Mark Harmon 2020. Forest Carbon Basics: Five Key Guidelines, Presentation to Many Rivers Group of the Sierra Club, Banking on Carbon Webinar, Oct 13, 2020.

A better approach is shown below, and explained by Mark Harmon:

Here is an example in which there is an independent control or alternative. We can see that there is a difference between the two systems and that the so-called renewable, sustainable system stores on average 35% less than the reference. So if we switch from the reference system to the renewable, sustainable system we must lose carbon from that part of the system.



NEPA requires comparison of alternatives based on high quality information and accurate scientific analysis, which requires evaluating the carbon consequences of different forest management systems and comparing that to the carbon consequences of not logging.

Similarly, Cardellichio et al (2010) explain:

The only way to properly evaluate the net carbon impacts of energy from forest biomass [or any vegetation management] is to estimate … net change in atmospheric CO2 levels over time *with* and *without* the harvest of wood biomass for energy. …[I]t is necessary to construct a baseline, or control, scenario (that is no biomass harvest). … Once a baseline is established, one can assess how switching to wood biomass would change atmospheric carbon levels. … [T]he information provided by only comparing forest carbon stocks before and after biomass harvest could be a very misleading indicator of the impact of biomass energy on the atmosphere.

Cardellichio, P., Walker, T. 2010. Commentary: The Manomet Study Got the Biomass Carbon Accounting Right. The Forestry Source. 4 Nov 2010. <https://web.archive.org/web/20110420145203/http://www.nxtbook.com:80/nxtbooks/saf/forestrysource_201011/index.php>.

Even a before-after ecological study design should employ a control. See Krebs, C. J. 1999. Ecological methodology. Second edition. Addison Wesley Longman Inc, Menlo Park, California, USA.

## The Carbon Value of Wood Products is Over-estimated.

Forest Service NEPA analyses often state “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 –

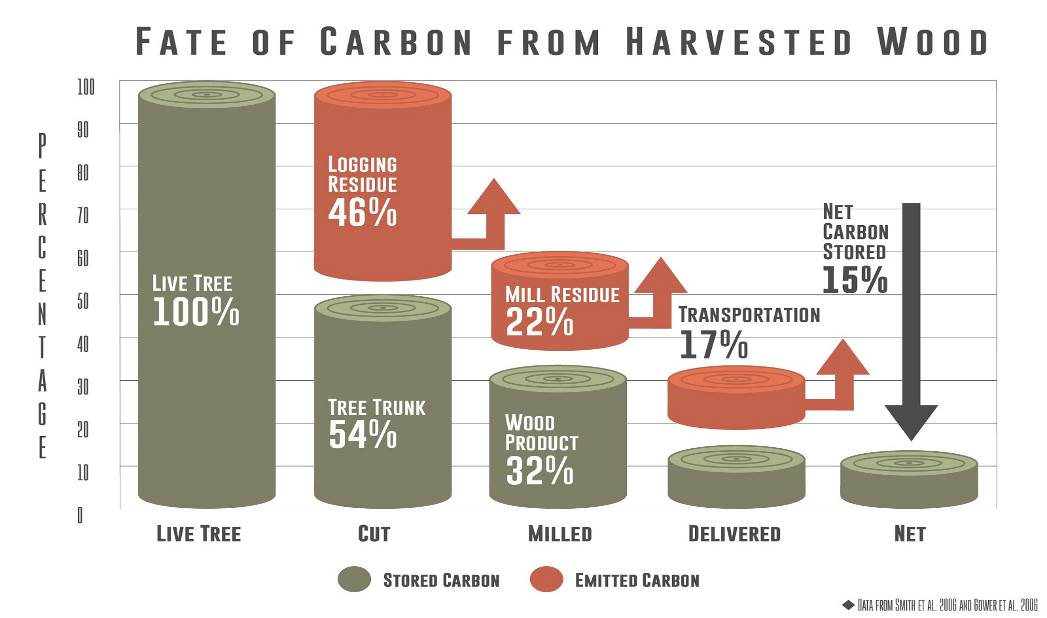
We find no scientific evidence to support increased logging to store more carbon in wood products, such as dimensional lumber or cross-laminated timber (CLT) for tall buildings, as a natural climate solution. The growing consensus of scientific findings is that, to effectively mitigate the worst impacts 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).

Over 200 Top U.S. Climate and Forest Scientists Urge Congress: Protect Forests to Mitigate Climate Crisis, May 13, 2020. <https://johnmuirproject.org/wp-content/uploads/2020/05/200TopClimateScientistCongressProtectForestsForCimateChange13May20.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…” 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.



*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://content.sierraclub.org/ourwildamerica/sites/content.sierraclub.org.ourwildamerica/files/documents/Law%20and%20Harmon%202011.pdf> (“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 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.

…

[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, …

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. … 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. … 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.”).

*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 WOPR 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> (“… 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 ∼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.”)

*A lot of wood products are “stored” in landfills where they emit methane which has a global warming effect much greater than CO2.* 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. … 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 … 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.

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 & 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 off-set construction using alternative materials such as steel and cement that may release more CO2during 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](http://www.corrim.org/reports/2005/swst/140.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.

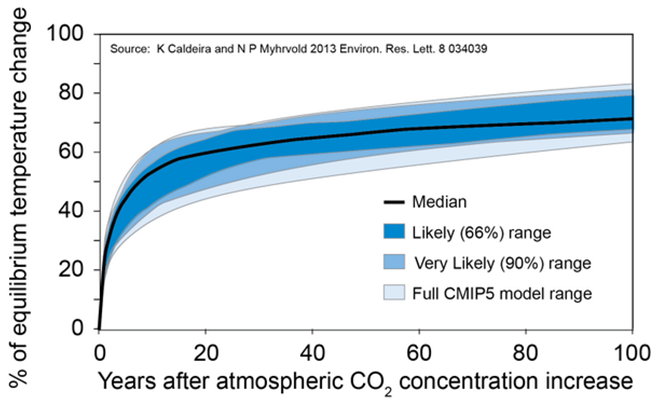
2) Buildings made of steel and concrete have longer useful lifespans than wood and might outperform wood, over the long term. A credible analysis of substitution must account for factors such as the time it takes to reabsorb the carbon after forests are logged, differences in the useful lifespan of different 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 abosorbs CO2 during it’s 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 CO2, 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—An electrolyzer-based process for decarbonating CaCO3 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>. See also, Just Have a Think - Fossil Free Steel - Another giant step towards net carbon zero? <https://youtu.be/ywHJt88H5YQ> Dec 13, 2020, and 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/>

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 ocea 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):

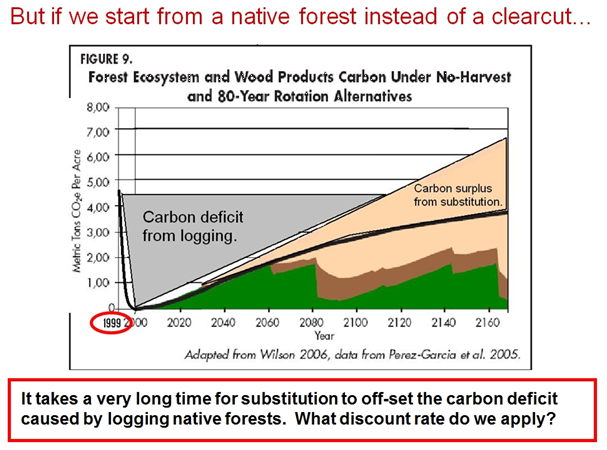


Related: the IPCC made a policy decision to place more value on the near-term because the majority of warming happens within 10-20 years after emissions. If it is true that we need to be more concerned about the near-term, then we can also say that forests are more valuable as places to store carbon 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 repayed until the distant future when the replacement forest grows (not to the poin 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 °C and 2 °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>.

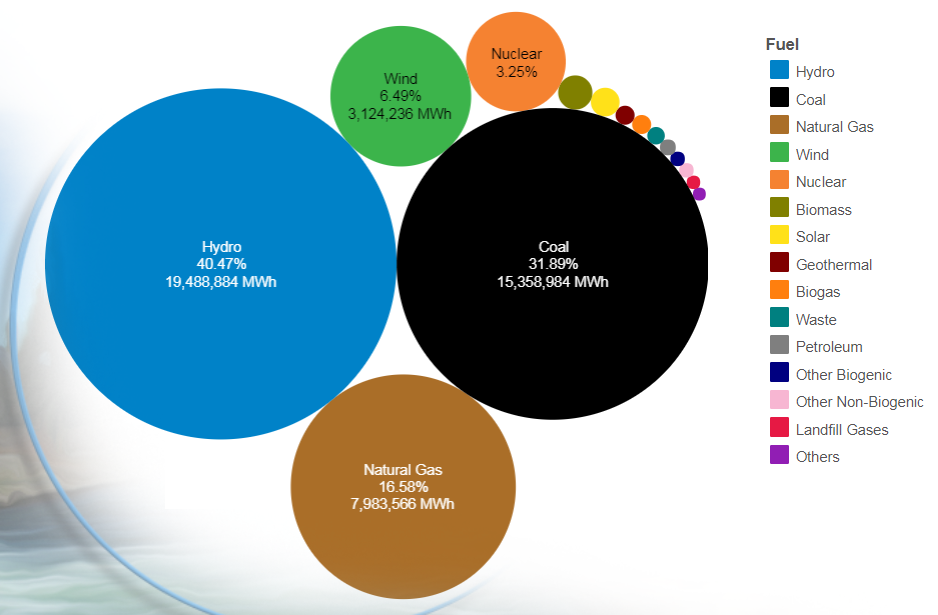
7) Many analyses of substitution fail to account for the carbon debt associated with logging. They do this by starting with "bare ground" instead of an existing forest, which biases the analysis by crediting wood products with growing the forest in the first place instead of debiting wood products for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



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 instqance, here in Oregon, only about 32% of electricity is from coal:



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

A company backed by Bill Gates called Solidia has a new cement product that requires less energy to produce and rapidly cures with CO2 instead of water, and it’s stronger than regular cement, so it could be used to put carbon waste streams into lonmg-term storage. FACTSHEET: Solidia Impact Statement. <https://assets.ctfassets.net/jv4d7wct8mc0/4LwjKXYDVgu9KVuDbrMcEq/6119b7ef7efdb4aba7b1dab5b1b1fa5b/Solidia_Technologies_Impact_Statement_9.6.19.pdf>; FACTSHEET: The Science Behind Solidia. <https://assets.ctfassets.net/jv4d7wct8mc0/5DwEAeEYqsFAYA9UC53EF7/4f8b7566221a8d9cb38f970867003226/Solidia_Science_Backgrounder_11.21.19__5_.pdf>; Jeffrey Rissman 2018. CEMENT’S ROLE IN A CARBON-NEUTRAL FUTURE. Energy Innovation LLC. NOVEMBER 2018. <https://energyinnovation.org/wp-content/uploads/2018/11/The-Role-of-Cement-in-a-Carbon-Neutral-Future.pdf>

See also, Johanna Lehne and Felix Preston. 2018. Making Concrete Change - Innovation in Low-carbon Cement and Concrete. Chatham House Report. <https://www.chathamhouse.org/sites/default/files/publications/2018-06-13-making-concrete-change-cement-lehne-preston-final.pdf>; Maddie Stone 2019. CONCRETE JUNGLE - Cement has a carbon problem. Here are some concrete solutions. Grist Nov 20, 2019. <https://grist.org/article/cement-has-a-carbon-problem-here-are-some-concrete-solutions/>; Oberhaus, D. 2019. A Solar 'Breakthrough' Won't Solve Cement's Carbon Problem - A Bill Gates–backed startup called Heliogen uses concentrated solar power to produce cement. Wired 11-22-2019. <https://www.wired.com/story/a-solar-breakthrough-wont-solve-cements-carbon-problem/>

Additionally, researchers have been incorporating bacteria into concrete formulations to absorb carbon dioxide from the air and to improve its properties. Start-ups pursuing “living” building materials include BioMason in Raleigh, N.C., which “grows” cementlike bricks using bacteria and particles called aggregate. And in an innovation funded by DARPA and published in February in the journal Matter, researchers at the University of Colorado Boulder employed photosynthetic microbes called cyanobacteria to build a lower-carbon concrete. They inoculated a sand-hydrogel scaffold with bacteria to create bricks with an ability to self-heal cracks.

Mariette DiChristina 2020. Low-Carbon Cement Can Help Combat Climate Change - Microbes will help decarbonize the construction industry. Scientific American, November 10, 2020, <https://www.scientificamerican.com/article/low-carbon-cement-can-help-combat-climate-change/>.

People must give fair treatment to the merits of the competing ideas by disclosing the flaws and caveats associated with the substitution argument.

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](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 enduser 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 CO2 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.

… 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 …

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:  
·  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;  
·   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;  
·  Dead wood and soil carbon stores are either not included or assumed to be constant;  
·  In one LCA, dead wood is not present in older forests, contrary to findings in the extensive ecological literature;  
·  The wood product pool is assumed to be an increasing carbon stock over time.

…

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 CO2 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.

…

**Life cycle analysis (including substitution, proposed considerations)**

…

·       **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 2011 2(1). <https://content.sierraclub.org/ourwildamerica/sites/content.sierraclub.org.ourwildamerica/files/documents/Law%20and%20Harmon%202011.pdf>.

## Harmonize climate change mitigation and adaptation

“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; … to reduce greenhouse gas emissions; to bolster resilience to the impacts of climate change; … 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/>.

The President has established a clear policy mandate to minimize and mitigate 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.

… Sec 2. Definitions … (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.

…

Sec. 3. Establishing Federal Principles for Mitigation. … (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.

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).

…

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.

…

Some of the most obvious synergies between adaptation and mitigation are those aimed at enhancing carbon stocks in natural forests, … 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. … 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.

…

It is not always obvious, however, when conservation and climate mitigation efforts might be in alignment or in conflict. … Although there are clear synergies between adaptation and mitigationfocused 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. 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.

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.

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; Jiménez 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; Jiménez 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 (Jiménez 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 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 NEPA analysis needs 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 NEPA document.

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/](http://ecoshare.info/projects/central-cascade-%20adaptive-management-partnership/workshops/restoring-westside-%20dry-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 Niño frequency long after 1.5 °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. 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 signalling 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>

## Basal Area Retention

The EA failed to consider an alternative that would retain greater basal area to help mitigate several adverse trade-offs caused by commercial logging, including greenhouse gas emissions, wildlife cover and connectivity, long-term snag recruitment, and slash production and disposal.

Basal Area retention is an important ecological consideration that must be disclosed *quantitatively* in the NEPA analysis. The NEPA analysis should consider alternative levels of basal area retention that resolve trade-offs in different ways. The NEPA document should disclose how recommended basal area retention levels will provide assurance that enough trees are being retained to meet ecological needs for live and dead trees now and in the future.

Where there are lots of small trees we recommend variable density thinning to 60-80 sq ft/acre basal area, retaining the largest trees that will become the next generation of old growth. Since larger trees have a higher ratio of basal area to leaf area, sites with abundant large trees can sustain higher basal areas, and we recommend retaining 100-140+ sq ft/acre.

Basal area retention should be variable but not be too low in any one unit. Enough trees need to be retained to retain and recruit large and old trees and snags now and in the future. Basal area targets should be adjusted higher to account for the following actors:

* Prescribed basal area retention should be weighted to accommodate relatively greater retention in stands with large trees and desirable clumps of trees that contribute to LOS structural conditions.
* All things being equal, large and old trees are more sustainable and resilient than small trees, so where large and old trees are abundant, the site can sustain higher basal area and the mature and old trees do not need to be thinned.
* Retention patches should be excluded from the basal area calculation. Basal area should not be averaged across the stand, but rather across the treated portion of the stand. We recommended 3-4 clumps per acre of 2-10 individual trees as well as the skips to emulate natural historic stand structures.
* Basal area can be higher in riparian areas, area with higher water table, north slopes, etc...

The agency should avoid reducing stand density lower than is appropriate to meet the full suite of ecological objectives, including wildlife cover, perpetuating mortality processes that create and sustain valuable habitat features, etc.

We are concerned that the agencies’ stocking guides were created and intended to be used as a tool to avoid mortality which is clearly inconsistent with ecosystem management. (“To preclude serious tree mortality from mountain pine beetle, western dwarf mistletoe and perhaps western pine beetle, stand densities should be maintained below the upper limit of the management zone” Powell 1999, <https://fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_016034.pdf>) Healthy forests require dead trees, sometimes in abundance, in order to meet the needs of diverse wildlife and provide full suite of ecosystem functions. 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>

A comprehensive restoration approach requires focusing not just on live trees, but also on the full suite of ecological processes including density dependent mortality processes that create and recruit snags and dead trees as a valuable feature of eastside forests. We urge the agency not to manage for tree vigor and minimum stocking levels because it will not provide enough green trees for recruitment of snags through time. This is a critical issue given that the current standards for snag habitat are outdated and fail to provide adequate levels of snags and dead wood, and adequate levels of green trees needed to recruit those snags through time.

Cutting basal area down to 30-40 ft2/acre is too low. We urge the agency to retain at least 60-120 ft2/acre of basal area. 30-40 ft2/acre might be OK in small patches within units as part of a variable prescription, but the average over a unit must be much higher than that in order to ensure adequate cover for wildlife, and adequate dead wood recruitment through time.

## The Forest Service failed to provide an opportunity to comment on an informative Environmental Assessment.

The NEPA process for this project included an opportunity to comment on a scoping notice, but not an opportunity to comment on an informative NEPA document such as an EA or EIS.

The Forest Service must provide an opportunity for public comment on real NEPA documents, not just “proposed actions.” The CEQ regulations and voluminous case law which requires all federal agencies to provide public comment on Environmental Assessments. The proposed action generally does not include any description of the affected environment or any analysis of environmental effects upon which the public can base their opinions and comments. Failure to provide information about the affected environment and failure to provide comment on the analysis of effects undermines a core purpose of NEPA which is to inform the public. Without an informed public, the decision-maker is denied the benefit of informed comments from the public, and the quality of final decisions will suffer.

“[A]n agency cannot exempt itself from duties plainly imposed by law; it cannot decide that only one of two statutes governs its activities when the laws themselves... clearly show that both apply.” *Seattle Audubon Soc’y v. Evans*, 952 F.2d 297, 302 (9th Cir. 1991). The Eastern District Court of California reviewed a timber sale where the Forest Service failed to provide public comment on an EA and said, “The court finds that although the CEQ regulations do not require circulation of a draft EA, they do require that the public be given as much environmental information as is practicable, prior to completion of the EA, so that the public has a sufficient basis to address those subject areas that the agency must consider in preparing the EA. … [T]he agency must offer significant pre-decisional opportunities for informed public involvement in the environmental review process by releasing sufficient environmental information about the various topics that the agency must address in the EA, such as cumulative impacts, before the EA is finalized.” Sierra Nevada Forest Protection Campaign v. Weingardt. CIV-S-04-2727 DFL KJM; CIV-S-05-0093 DFL JFM. (E.D. Cal.) June 30, 2005. As a result of this decision, the North 49 project on the Lassen National Forest, and the Eagle Ranch, Edson, and Powder projects on the Shasta-Trinity NF were all enjoined pending further public involvement and NEPA compliance.

Public participation is also best when the public is well-informed and can have a real influence on decisions. Public involvement is essential at all stages of decision-making but it is essential at the stage of commenting on well-developed NEPA documents. Scoping by itself is too early in the process. (The propose action is not yet well-developed so the public does not know what they are commenting on.) The Objection process is too late. (The agency has already made up its mind and the public’s views will likely be dismissed. Also, any members of the public would be willing to comment, but are unwilling to “object” so the new rules discourage public involvement through intimidation.)

A relevant court decision has rejected the agency’s use of shortcuts such as taking comment on abbreviated documents such as “proposed actions” instead of more rigorous public involvement mechanisms. The court said:

These [CEQ] regulations require give and take between an agency and members of the public. See 40 C.F.R. §§ 1500.1(b) (“public scrutiny [is] essential”), 1500.2(d) (the agency must “encourage and facilitate public involvement”), 1501.4 (the agency must “involve the public, to the extent practicable, in preparing [EAs]”), 1506.6 (the agency must “make diligent efforts to involve the public” in preparing environmental documents, give “public notice of... the availability of environmental documents so as to inform those persons... who may be interested or affected,” and “solicit appropriate information from the public.”) (2004). The CEQ Regulations are mandatory, not hortatory. CBF, 341 F.3d at 970. They require that an agency give environmental information to the public and then provide an opportunity for informed comments to the agency. See 40 C.F.R. §§ 1501.4, 1506.6. This process of disclosing information to the public must occur before the agency has reached its final decision on whether to go forward with the project. Id. § 1500.1(b).

…

The court finds that although the CEQ regulations do not require circulation of a draft EA, they do require that the public be given as much environmental information as is practicable, prior to completion of the EA, so that the public has a sufficient basis to address those subject areas that the agency must consider in preparing the EA. Depending on the circumstances, the agency could provide adequate information through public meetings or by a reasonably thorough scoping notice. The way in which the information is provided is less important than that a sufficient amount of environmental information -- as much as practicable -- be provided so that a member of the public can weigh in on the significant decisions that the agency will make in preparing the EA. Of course, to be on the safe side, the agency can never go wrong by releasing a draft EA, and supporting documents, as was the practice until recently. See 36 C.F.R. § 215.5(b)(2)(i) (1994).

…

… [W]hat seems fairly drawn from the case law and the CEQ regulations is that the agency must offer significant pre-decisional opportunities for informed public involvement in the environmental review process by releasing sufficient environmental information about the various topics that the agency must address in the EA, such as cumulative impacts, before the EA is finalized.

…

… failure to provide essential information, already in the hands of the agency, does not comply with the agency’s requirement of involving the public “to the extent practicable.” 40 C.F.R. § 1501.4.

Sierra Nevada Forest Protection Campaign v. Weingardt. 376 F. Supp. 2d 984. (E.D. Cal. June 30, 2005). The new pre-decisional objection rules are similary flawed in that they allow the FS to take public comment duing scoping but not take public comment on the more fully developed and informative EA.

Regardless of the objection regulations, the Forest Service has a separate and enforceable duty to follow the CEQ regulations which require that all federal agencies to involve the public and provide for public comment on Environmental Assessments.

To fulfill the purposes of NEPA, the decision-maker needs to have the benefit of public comment on the effects analysis. “Accurate scientific analysis, expert agency comments, and **public scrutiny** **are essential to implementing NEPA**.” 40 CFR 1500.1(b). and “Federal agencies shall to the fullest extent possible: … (b) Implement procedures to **make the NEPA process more useful to decision-makers and the public**; … (c) **Integrate the requirements of NEPA with other planning and environmental review procedures** required by law or by agency practice so that all such procedures run concurrently rather than consecutively. (d) **Encourage and facilitate public involvement** in decisions which affect the quality of the human environment.” 40 CFR 1500.2.

40 CFR § 1501.2 states that: “Each agency shall:” … “(b) Identify environmental effects and values in adequate detail so they can be compared to economic and technical analyses. Environmental documents and appropriate analyses shall be circulated and reviewed at the same time…” Environmental Document is defined at 40 CFR § 1508.10: “’Environmental document’ includes the documents specified in § 1508.9 (environmental assessment)…”   
  
40 CFR § 1506.6(a) also requires the Forest Service to “Make diligent efforts to involve the public in preparing and implementing their NEPA procedures.” CEQ’s 40 Questions (Question 38) clarify this by stating, “Section 1506.6 requires agencies to involve the public in implementing their NEPA procedures, and this includes public involvement in the preparation of EAs and FONSIs.”   
  
Nothing in the FS regulations states or implies that environmental documents shall no longer be circulated for review and comment to the extent practicable before decisions are made. FS regulations do not trump or invalidate the Forest Service’s obligations to comply with the CEQ’s regulations implementing NEPA (40 CFR § 1500-1508). 40 CFR §1500.2, § 1501 and § 1506 set forth a broader mandate that the whole environmental document shall be circulated as early as practicable in the NEPA process for comment by interested parties, Agencies, and those who requested it before a decision is made.

The courts have consistently ruled in favor of public comment on EAs.

“Regulations promulgated by the Council on Environmental Quality provide factors that agencies must consider in deciding whether to prepare an EIS and emphasize the importance of involving the public in NEPA evaluations. 40 C.F.R. §§ 1500.2, 1502.4(b). The public must be given an opportunity to comment on draft EAs and EISes, and public hearings are encouraged to facilitate input on the evaluation of proposed actions. See 40 C.F.R §§ 1503.1, 1506.6.” Anderson v. Evans, 350 F.3d 815, 831 (9th Cir. 2002).

“Citizens were deprived of the opportunity to comment on the USDA’s EA and FONSI at all points in the rulemaking process. This deprivation violated their rights under the regulations implementing NEPA. See 40 C.F.R. § 1501.4(b) (‘The agency shall involve the public, to the extent practicable, in preparing [EAs]....’); id. § 1506.6 (‘Agencies shall... make diligent efforts to involve the public in preparing and implementing their NEPA procedures[,]... provide public notice of... the availability of environmental documents so as to inform those persons... who may be interested or affected[,] [and]... solicit appropriate information from the public.’). But cf. Pogliani v. United States Army Corps of Eng'rs, 306 F.3d 1235, 1238-39 (2d Cir. 2002) (per curiam) (holding that environmental plaintiffs have no right to see and comment on EAs/FONSIs before they issue, unless 40 C.F.R. § 1501.4(e) applies).

“We reject the USDA’s dismissal of these regulatory requirements as ‘hortatory.’ Although it is true that ‘an EA need not conform to all the requirements of an EIS,’ S. Or. Citizens Against Toxic Sprays, Inc. v. Clark, 720 F.2d 1475, 1480 (9th Cir. 1983), this requirement does not mean that 40 C.F.R. §§ 1501.4(b) and 1506.6 are without substance. We have previously interpreted these regulations to mean that ‘the public must be given an opportunity to comment on draft EAs and EISs.’ Anderson v. Evans, 314 F.3d 1006, 1016 (9th Cir. 2002). The Second Circuit has held that § 1501.4 is satisfied when the agency ‘conducted public hearings and received written comments on every draft environmental assessment [and] circulated for comment its Preliminary Analysis of the environmental assessment,’ even though it did not circulate for public comment a follow-up independent analysis it prepared in response to public comments. Town of Rye v. Skinner, 907 F.2d 23, 24 (2d Cir. 1990) (*per curiam*); see also Hanly v. Kleindienst, 471 F.2d 823, 836 (2d Cir. 1972) (‘Before a preliminary or threshold determination of significance is made the responsible agency must give notice to the public of the proposed major federal action and an opportunity to submit relevant facts which might bear upon the agency's threshold decision.’).

“Although we have not established a minimum level of public comment and participation required by the regulations governing the EA and FONSI process, we clearly have held that the regulations at issue must mean something. Cf. Hart v. McLucas, 535 F.2d 516, 519 (9th Cir. 1976) (‘In the construction of administrative regulations..., it is presumed that every phrase serves a legitimate purpose....’). It is evident, therefore, that a complete failure to involve or even inform the public about an agency’s preparation of an EA and a FONSI, as was the case here, violates these regulations. This wholesale neglect of the regulations’ mandatory inclusion of the public in the process results in a procedural injury. Moreover, it undermines the very purpose of NEPA, which is to ‘ensure[ ] that federal agencies are informed of environmental consequences before making decisions and that the information is available to the public.’ Okanogan Highlands Alliance v. Williams, 236 F.3d 468, 473 (9th Cir. 2000).”

Citizens for Better Forestry v. USDA, 341 F.3d 961, 970-71 (9th Cir. 2003).

<http://openjurist.org/341/f3d/961/citizens-for-better-forestry>.

NEPA requires federal agencies to, in the fullest extent possible, “[e]ncourage and facilitate public involvement in decisions which affect the quality of the human environment.” 40 C.F.R. § 1500.2(d); see also National Park and Conservation Ass’n v. Federal Aviation Admin., 998 F.2d 1523, 1531 (10th Cir. 1993) (“Congress, through... NEPA, has determined that the public has a right to participate in actions affecting public lands.”); Sierra Club v. Hodel, 848 F.2d 1068, 1093 (10th Cir. 1988) (NEPA “provides for broad-based participation” and requires “a cross-pollinization of views.”). Specifically, NEPA’s public participation regulations require the Forest Service to “(a) [m]ake diligent efforts to involve the public in preparing and implementing their NEPA procedures” and to “(b) [p]rovide public notice of NEPA-related hearings, public meetings, and the availability of environmental documents so as to inform those persons and agencies who may be interested or affected.” 40 C.F.R. § 1506.6(b).

Procedures implementing the National Environmental Policy Act (“NEPA”) “must insure that environmental information is available to public officials and citizens before decisions are made and before actions are taken.” 40 C.F.R. § 1500.1(b).

Congress designed NEPA to ensure a process of information disclosure and not a particular result. *SeeInland Empire Public Lands Council v. United States Forest Serv.*, 88 F.3d 754, 758 (9th Cir. 1996). NEPA requires informed agency decision-making through informed public participation. *See id*.; *Robertson v. Methow Citizens Council*, 490 U.S. 332, 349, 104 L. Ed. 2d 351, 109 S.Ct. 1835 (1989); *Citizens for Better Forestry v. USDA*, 341 F.3d 961, 970-71 (9th Cir. 2003) (“CBF”), quoting *Okanogan Highlands Alliance v. Williams*, 236 F.3d 468, 473*(*9th Cir. 2000*)* (“[T]he very purpose of NEPA... is to ensure [] that federal agencies are informed of environmental consequences before making decisions and that the information is available to the public.’”).

The Council on Environmental Quality (“CEQ”) promulgated regulations to ensure that the policies and requirements of NEPA will be carried out by federal agencies. *See* 42 U.S.C. § 4344. Those regulations require give and take between an agency and members of the public. *See*40 C.F.R. §§ 1500.1(b) (“public scrutiny [is] essential”), 1500.2(d) (the agency must “encourage and facilitate public involvement”), 1501.4 (the agency must “involve the public, to the extent practicable, in preparing [EAs]”), 1506.6 (requiring agencies to make diligent efforts to involve the public in preparing and implementing their NEPA procedures) (2004). The CEQ regulations implementing NEPA are mandatory. *See* *CBF v. USDA*, 341 F.3d at 970. They require that an agency give environmental information to the public and then provide an opportunity for informed comments to the agency. *See* 40 C.F.R. §§ 1501.4, 1506.6. This process of information disclosure to the public must occur before the agency has reached a final decision on whether to implement a proposed action. *Id*. § 1500.1(b).

HFRA § 104 says: “(g) ENVIRONMENTAL ANALYSIS AND PUBLIC COMMENT.—In accordance with section 102(2) of the National Environmental Policy Act of 1969 (42 U.S.C. 4332(2)) and the applicable regulations and administrative guidelines, the Secretary shall provide an opportunity for public comment during the preparation of any environmental assessment or environmental impact statement for an authorized hazardous fuel reduction project.”

36 CFR §218.24 Notification of opportunity to comment on proposed projects and activities.

(a) Responsible official. The responsible official shall:

(1) Provide legal notice of the opportunity to comment on a proposed project or activity implementing a land management plan.

(2) Determine the most effective timing and then publish the legal notice of the opportunity to comment ...

Sincerely,



Doug Heiken

[ATTACH REFERENCES]

1. Rockström, J., W. Steffen, K. Noone, Å. Persson, F. S. Chapin, III, E. Lambin, T. M. Lenton, M. Scheffer, C. Folke, H. Schellnhuber, B. Nykvist, C. A. De Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sörlin, P. K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R. W. Corell, V. J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen, and J. Foley. 2009. Planetary boundaries:exploring the safe operating space for humanity. *Ecology and Society* 14(2): 32. [online] URL: <http://www.ecologyandsociety.org/vol14/iss2/art32/>. <http://www.stockholmresilience.org/download/18.1fe8f33123572b59ab800012568/pb_longversion_170909.pdf>. <http://www.ecologyandsociety.org/vol14/iss2/art32/figure6.html>. [↑](#footnote-ref-1)