TO: Oregon Board of Forestry and State Forester
FROM: Beyond Toxics
DATE: November 17, 2021
RE: Herbicide Application on State-Managed Forest Lands

Dear Chair Kelly, State Forester Mukumoto and members of the Board:

Please consider the following comments related to herbicide application on state-managed forest lands submitted on behalf of Beyond Toxics, a statewide environmental justice organization with offices in Lane and Jackson Counties.

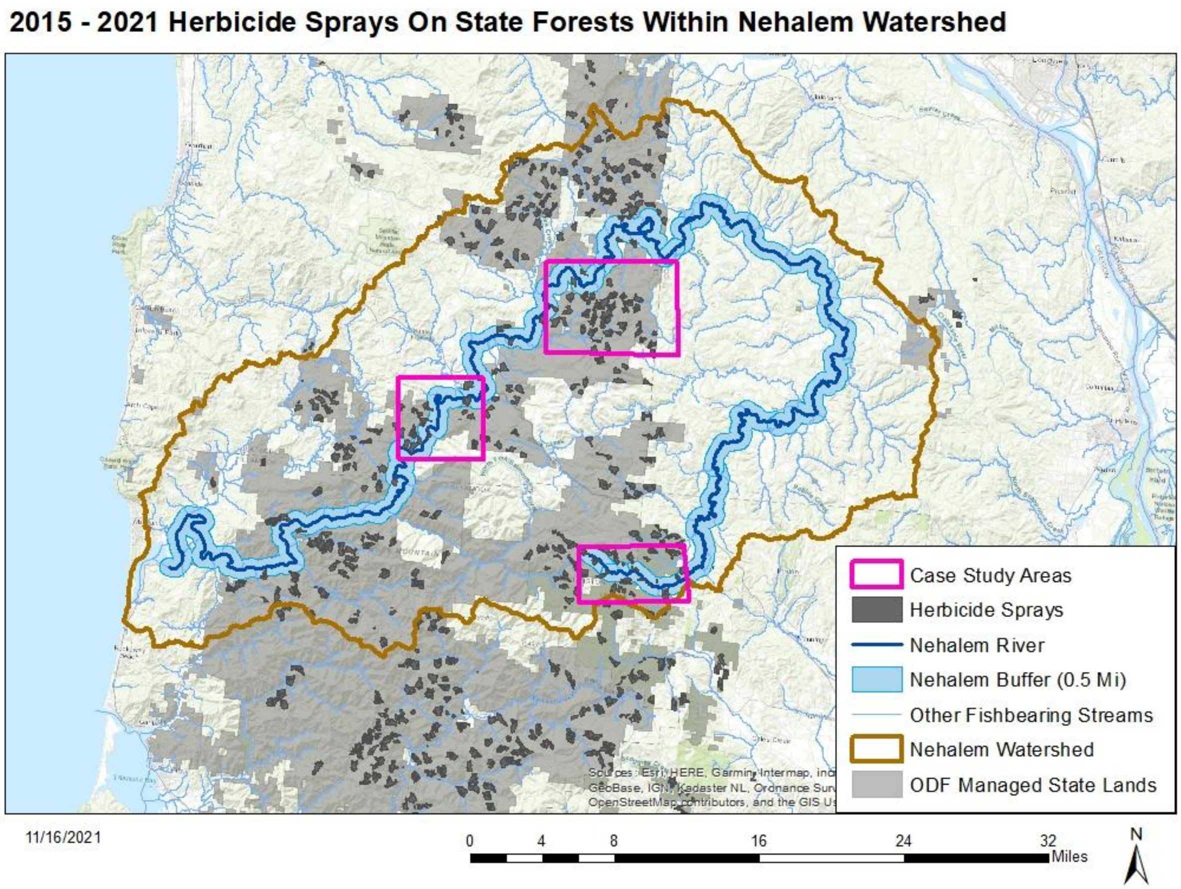
At the September 8, 2021, Board of Forestry meeting, we presented findings to the Board summarizing herbicide applications on Oregon State Forests from January 1, 2020, to August 30, 2021. In that brief 20 month period, 326 tank mixes were applied to all state-managed forest lands. Of those, at least 34% of all sprays on state forest lands were aerial herbicide sprays. Out of the total 326 herbicide applications, 227 or 69.6% contained tank mixes of three or more active ingredients. And in 175 or 54% of the tank mixes used, an additional four or five adjuvants were added.

At the November 3, 2021, Board of Forestry meeting, we provided oral comments following up on our initial data analysis of herbicide sprays in state forests. We now submit to the record the following maps created using data obtained from FERNS depicting pesticide applications in the Nehalem Watershed from 2015-2021, including Astoria, Tillamook, and Forest Grove Districts. We also describe potential impacts of pesticides to fish populations and climate considerations associated with continued reliance on pesticide use. We hope this case study focused on the headwaters and other stretches of the Nehalem River can help the Board, Department staff, and public visualize where pesticide sprays take place, note their close proximity to important fish-bearing streams, and consider related impacts.

We ask that the Board consider the data we have compiled and ultimately call for a moratorium on aerial herbicide sprays and initiate an evaluation of the full range of impacts of herbicide sprays, particularly aerial herbicide applications, on state-managed forest lands on drinking water quality, greenhouse gas emissions, essential fish habitat, and community health and wellbeing.

1. **Case Study of Herbicide Sprays within the Nehalem River Watershed**

    a. **Entire Nehalem Watershed**



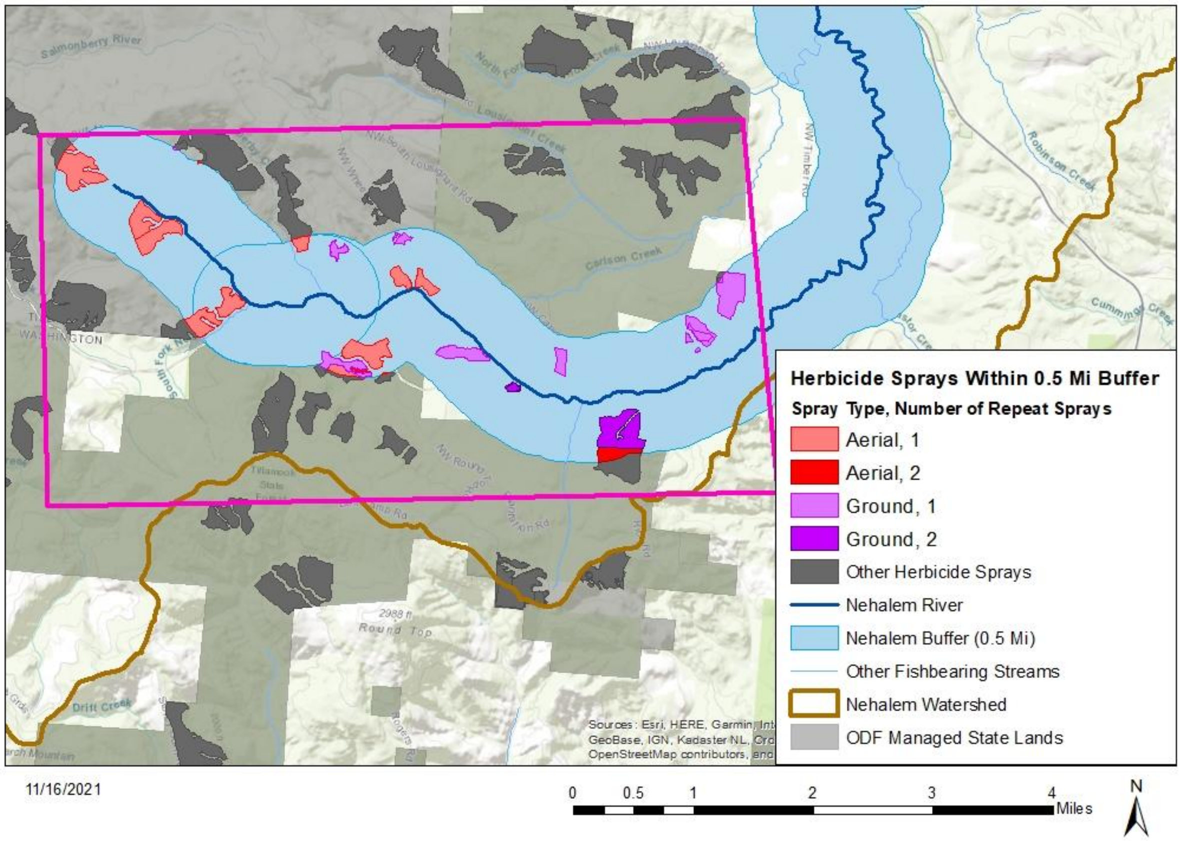
Map 1. The Nehalem Watershed.

Map 1 shows the whole Nehalem River and watershed, which includes portions of the Astoria, Forest Grove, and Tillamook Districts. From 2015 to present, 33 sprays occurred on state forest lands within a 500 foot radius of the Nehalem River. This amounted to 178 acres **total** being sprayed within a 500 foot radius of the river. A total of 82 sprays fell within a 0.5 mile radius of the river, which amounted to approximately 1,600 acres sprayed with pesticides or, counting sites sprayed more than once, an accrual of 1,925 total acres sprayed over time.

The maps below take a deeper look at the “Case Study Areas” outlined in pink.

b. Nehalem Headwaters

2015 - 2021 Herbicide Sprays Within 0.5 Miles of Nehalem River Headwaters



Map 2. Headwaters of the Nehalem.

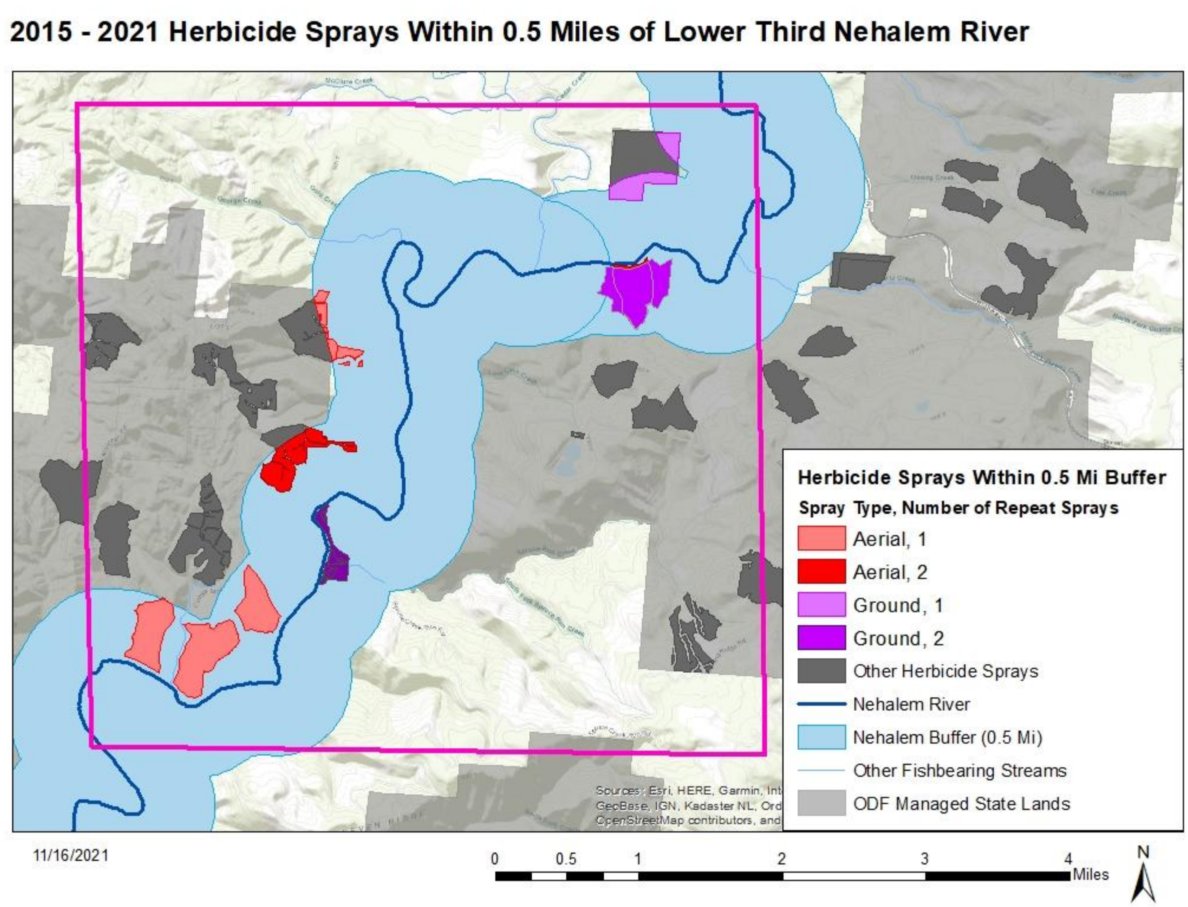
Map 2 shows herbicide applications at the headwaters of the Nehalem River. There were 52 acres sprayed within a 500 foot radius, and many of these were adjacent to perennial streams that form the Nehalem River headwaters.

The blue shading depicts a half mile radius on either side of the headwaters. There were 26 total spray applications (with some repeat sites) in close proximity to the headwaters of the Nehalem River, which is within the Forest Grove District. Ten aerial sprays covered 271 acres within a 0.5 mile radius (not counting repeats). One site was aerially sprayed twice. Sixteen ground sprays covered 208 acres total within a 0.5 mile radius (not counting repeats). One site was ground sprayed twice. This information is outlined in Table 1.

Herbicide Sprays Near Nehalem Headwaters	# of acres sprayed within 500 ft. radius	# of sprays within 0.5 mile radius	# of acres sprayed within 0.5 mile radius	Sites sprayed more than 1 time
Aerial		10	271 (57%)	1
Ground		16	208 (43%)	1
Total	**52**	**26**	**479**	**2**

Table 1. Herbicide sprays near the headwaters of the Nehalem River.

c. Herbicide Sprays Near Lower Third of the Nehalem



Map 3. Lower third of the Nehalem.

Map 3 shows part of the lower third of the Nehalem River, which includes the Astoria District. There were 95 acres sprayed within a 500 foot radius.

The blue shading depicts a half mile radius on either side of the headwaters. There were 18 total spray applications (with some repeat sites) in close proximity to the lower third of the Nehalem River. Ten aerial sprays covered 408 acres within a 0.5 mile radius (not counting repeats). One site was aerially sprayed twice: once in 2015 and once in 2017. Eight ground sprays covered 193 acres total within a 0.5 mile radius (not counting repeats). One site was sprayed twice: one aerial application in 2015 and one ground application in 2017. Another site was sprayed three times, with both ground and aerial applications in 2016, 2018, 2019. This information is outlined in Table 2.

Herbicide Sprays Near Lower Third Nehalem	**# of acres sprayed within 500 ft. radius**	**# of sprays within 0.5 mile radius**	**# of acres sprayed within 0.5 mile radius**	**Sites sprayed more than 1 time**
Aerial		10	408 (68%)	1
Ground		8	193 (32%)	2
Total	**95**	**18**	**601**	**3**

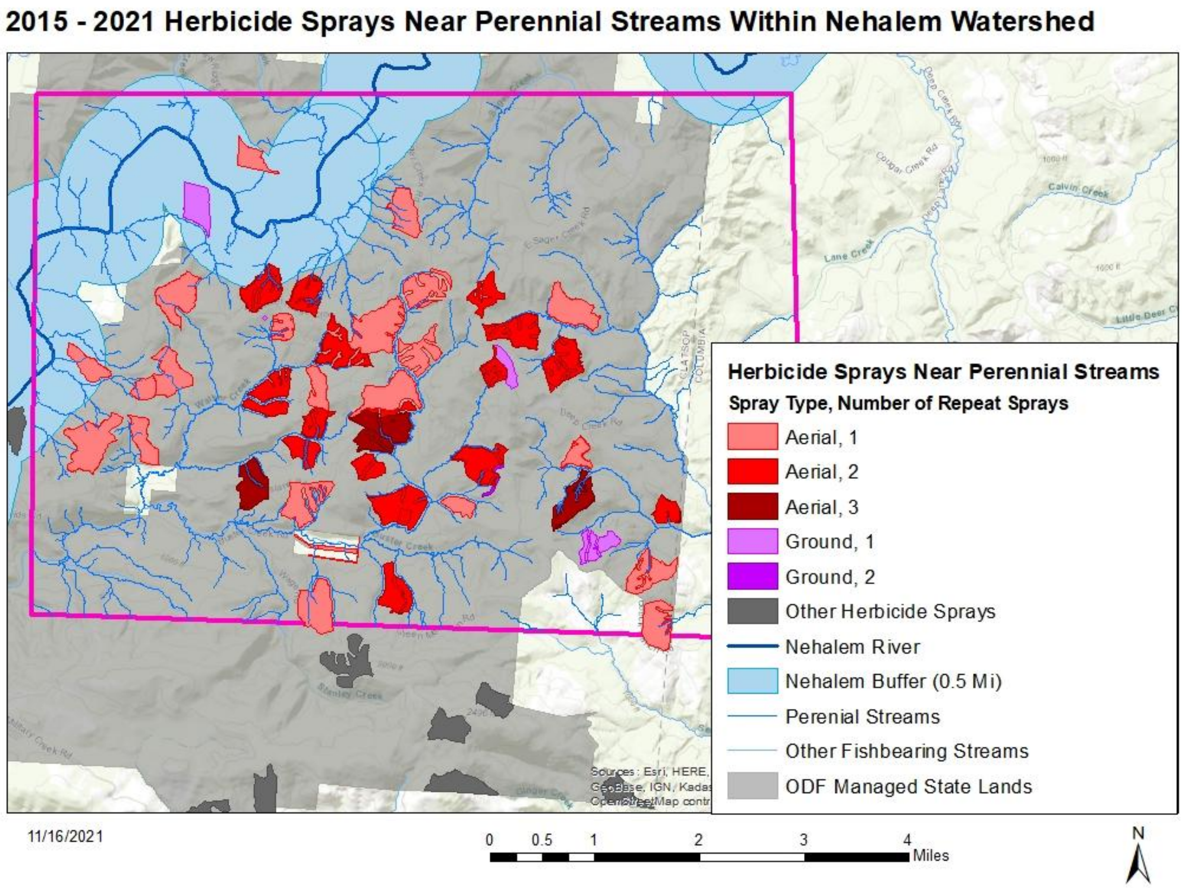
Table 2. Herbicide sprays near the lower third of the Nehalem.

d. Perennials Streams

Map 4 below shows herbicide sprays that occurred near perennial streams within the Nehalem River Watershed. ODF requires a no-spray buffer on perennial streams, so Map 4 accounts for a 100 foot no-spray buffer.

Map 4 shows the large number of sprays that occurred in close proximity or adjacent to perennial streams, the majority of which were aerial sprays. There were 100 aerial sprays near perennial streams over time, covering 2,214 total acres (not counting repeats). Of these aerial sprays, 15 sites were sprayed twice while four sites were sprayed three times. There were 10 ground sprays over time, covering 135 acres near (not counting repeats). This information is outlined in Table 3.

It must be noted that, despite no-spray buffers, chemicals applied may unintentionally enter waterways--especially in the case of aerial applications. A number of factors including weather and site conditions can cause aerially-applied pesticides to drift into unintended areas, including closer to streams.



Map 4. Herbicide sprays near perennial streams.

Herbicide Sprays Near Perennial Streams within the Nehalem River	# of sprays near 100 ft buffer on perennial streams	# of acres sprayed near 100 ft buffer on perennial streams	Sites sprayed more than 1 time
Aerial	15	2,214 (94%)	19
Ground	10	135 (6%)	0
Total	**25**	**2,349**	**19**

Table 3. Herbicide sprays near perennial streams within the Nehalem River.

2. Pesticides and Fish Populations

To build on the case study maps above, this section describes related impacts of pesticides to important fish habitat.

a. Impacts of Pesticides to Fish

As shown by analyzing the FERNS data, herbicide sprays of chemical tank mixes are occurring throughout the length of the Nehalem River. The spray activity starts in the highest reaches of the perennial streams that form the headwaters of the watershed. Both aerial and ground sprays are also made adjacent to the headwaters themselves. Multitudes of sprays over the years, from the headwaters to the outlet, may result in a pattern of cumulative residues in the waters and soils of critical aquatic wildlife habitat.

After application, pesticides can easily enter rivers and streams, due to high mobility in soil, drift and deposition. Once in the streams, they can affect fish including salmon in many different ways. Certain pesticides reduce the olfactory system of juvenile salmon,[1] which they use to sense predators and eventually navigate back to their birth stream as adults. Pesticides can also make it difficult or impossible for juvenile salmon to adapt to saline environments when they travel downstream and enter the ocean. Other impacts include a disruption in swimming and predator avoidance, fin deformities, and smaller size which all make it harder to survive.[2]

In addition to the known effects of single chemicals, tank mixes of pesticides that are used often have not been tested in their combined state so their true toxicity on fish and aquatic organisms remains unknown. Studies have found mixtures lead to synergistic effects and higher rates of unpredicted mortality. Basically, these chemicals combine to create a soup-like mixture of toxins that weaken the immune systems of salmon, disrupt their endocrine system, and increase population mortality rates.

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[1] Tierney KB, Ross PS, Jarrard HE, Delaney KR, Kennedy CJ. "Changes in juvenile coho salmon electro-olfactogram during and after short-term exposure to current-use pesticides." *Environ Toxicol Chem*, vol. 25, no. 10, Oct. 2006, pp. 2809-17. doi: 10.1897/05-629r1.1. PMID: 17022425.

[2] See Baldwin, David H., et al. "A fish of many scales: extrapolating sublethal pesticide exposures to the productivity of wild salmon populations." *Ecological Applications*, vol. 19, no. 8, 2009, pp. 2004-2015; Du Gas, Lindsay, et al. "Effects of Atrazine and Chlorothalonil on the reproductive success, development, and growth of early life stage sockeye salmon (Oncorhynchus nerka)." *Environ Toxicol Chem*, vol. 36, no. 5, 2017, pp. 1354-1364.

b. Fish in the Nehalem

The Nehalem River is the largest "wild fish only" river on the Oregon Coast.[3] It is home to several runs of salmon, including one of the healthiest runs of Oregon Coast coho. Oregon Coast coho are a federally threatened species of salmon[4] that have key spawning habitat in this basin. The table below shows which fish species are present in the Nehalem and the time of year they are present.

Fish Species	Presence in the Nehalem River
Summer Chinook	• Start upriver in July through early August • Juveniles make way downstream slowly in June
Fall Chinook	• September to early November • Juveniles move downstream in March and April
Oregon Coast Coho	• August through September • Juveniles spend one year in freshwater
Chum Salmon	• Spawn during November to early December • Fry emerge and move promptly downstream
Cutthroat Trout	• Mid July through September • Fry spend two years in the streams before migrating downstream in the spring
Winter Steelhead	• December to March • Fry emerge in mid-August and spend two full years in freshwater before going to ocean

Table 4. Fish type and presence in the Nehalem.[5]

[3] Wild Salmon Center, "Oregon's Scenic Nehalem," https://wildsalmoncenter.org/2018/05/21/oregons-scenic-nehalem/.

[4] NOAA Fisheries, "Oregon Coast Coho Salmon," https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/oregon-coast-coho-salmon.

[5] Sources for Table 4: Wild Salmon Center, "Oregon's Scenic Nehalem," https://wildsalmoncenter.org/2018/05/21/oregons-scenic-nehalem/; Oregon Fishing Info, "Nehalem Bay," http://oregonfishinginfo.com/Nehalem%20Bay.html; Oregon Department of Fish and Wildlife, "Salmon and Steelhead Recovery Tracker: Nehalem (Independent Population)," http://www.odfwrecoverytracker.org/explorer/species/Coho/run/default/esu/129/145/; Maser, Joseph. "Nehalem River Watershed Assessment: Fish and Fish Habitat," Portland State University Project, http://web.pdx.edu/~maserj/project/project1/9.htm.

Based on the data we have compiled using the FERNS system, the large majority of the Department's pesticide sprays in the area take place in the summer, so steelhead juveniles will be hit hard because that is when they emerge. Summer Chinook spawn right at the end of the peak spray season, so their egg development may be affected as well. The biggest effects will be on Oregon Coast coho, cutthroat trout, and steelhead, all of which spend one to two years in the Nehalem as juveniles and will thus be exposed to these toxins for longer than other species that migrate downstream immediately, such as chum salmon.

3. Pesticides and Climate Change

Finally, we want to thank the Board for voting to approve the Climate Change and Carbon Plan and emphasize the significance of prioritizing climate mitigation and adaptation in further planning initiatives, including the Western Oregon Forests FMP.

The Pacific Northwest has warmed by about 3 degrees F (or 1.7 degrees C) in the past half-century.[6] Higher temperatures create imbalances in natural systems, causing more outbreaks and damage from pests and invasive weeds. This leads to increased reliance on pesticide use as there are more pests to manage.[7]

However, pesticides contribute to the climate crisis throughout their manufacture, transport and application. When pesticides are made, greenhouse gases including carbon dioxide, methane and nitrous oxide are emitted.[8]

While all communities deserve protected, clean drinking water, pesticide use has put crucial drinking water sources at risk. Further, warming waters may increase pesticide toxicity. As water temperatures rise, the harms from even small amounts of pesticides in waterways worsen for fish and other aquatic life.

Additionally, studies show pesticides kill over 70% of the microbial diversity in soils.[9] Mature and old growth trees, diverse vegetation, and healthy soils are needed to maximize the carbon sequestration potential of our forests.

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[6] Johnson and Cline. "Northwest US faces hottest day of intense heat wave," June 28, 2021. Available at https://apnews.com/article/canada-heat-waves-environment-and-nature-cc9d346d495caf2e245fc9ae923adae1.
[7] Matzrafi M. "Climate change exacerbates pest damage through reduced pesticide efficacy." *Pest Management Science*, vol. 75, no. 1, 2019, pp. 9-13, doi: 10.1002/ps.5121.
[8] Heimpel GE, Yang Y, Hill JD, Ragsdale DW. "Environmental consequences of invasive species: greenhouse gas emissions of insecticide use and the role of biological control in reducing emissions." PLoS ONE, vol. 8, no. 8, 2013, e72293. Available at https://doi.org/10.1371/journal.pone.0072293.
[9] Gunstone, Tari, et al. "Pesticides and Soil Invertebrates: A Hazard Assessment." *Frontiers in Environmental Science*, vol. 9, 2021, p. 122. Available at https://www.frontiersin.org/article/10.3389/fenvs.2021.643847, DOI=10.3389/fenvs.2021.643847.

Finally, as pollinator populations are declining due to climate change, pesticide use causes additional stress. Recent research indicates high bee abundance and diversity in PNW forests.[10] However, pesticide use can degrade pollinator habitat, particularly for ground nesting native bees, and exposure to heavily-used glyphosate can harm the development of a pollinator's gut microbiome, lowering lifespans and decreasing their ability to withstand pathogens.[11]

While numerous goals included in the draft FMP address these concerns, we advocate for the inclusion of a specific chemical spray goal. We greatly appreciate Chair Kelly recognizing this request and expressing support for this revision during the November 3rd meeting.

Overall, it is crucial that ODF draft strategies to support resilient, climate-adapted forests that can withstand disturbances and changing conditions. We look forward to continuing to work with ODF staff as the process continues and ask that the Board please support a strong FMP that prioritizes ecologically-sound and just forest management that supports the health of our forested ecosystems and communities.

Thus, we ask that the Board consider the data we have compiled and ultimately call for a moratorium on aerial herbicide sprays and initiate an evaluation of the full range of impacts of herbicide sprays, particularly aerial herbicide applications, on state-managed forest lands on drinking water quality, greenhouse gas emissions, essential fish habitat, and community health and wellbeing.

Thank you very much for your consideration of our comments.

Sincerely,

Lisa Arkin, Executive Director, Beyond Toxics
larkin@beyondtoxics.org

Grace Brahler, Oregon Climate Action Plan and Policy Manager, Beyond Toxics
gbrahler@beyondtoxics.org

Emily Cook, Environmental Science Coordinator, Beyond Toxics
ecook@beyondtoxics.org

Jenna Travers, Water Quality Intern, Beyond Toxics
jtravers@beyondtoxics.org

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[10] This is true even in intensively managed forests or forests damaged by wildfire. Christine Buhl, Ph.D., Oregon Department of Forestry Entomologist. Forest Bee Pollinators Handout, 2020. Available at https://www.oregon.gov/odf/Documents/forestbenefits/forest-bee-pollinators.pdf.

[11] Motta, Erick V. S., et al. "Glyphosate Perturbs the Gut Microbiota of Honey Bees." *Proceedings of the National Academy of Sciences of the United States of America*, vol. 115, no. 41, National Academy of Sciences, 2018, pp. 10305–10, https://www.jstor.org/stable/26532174.

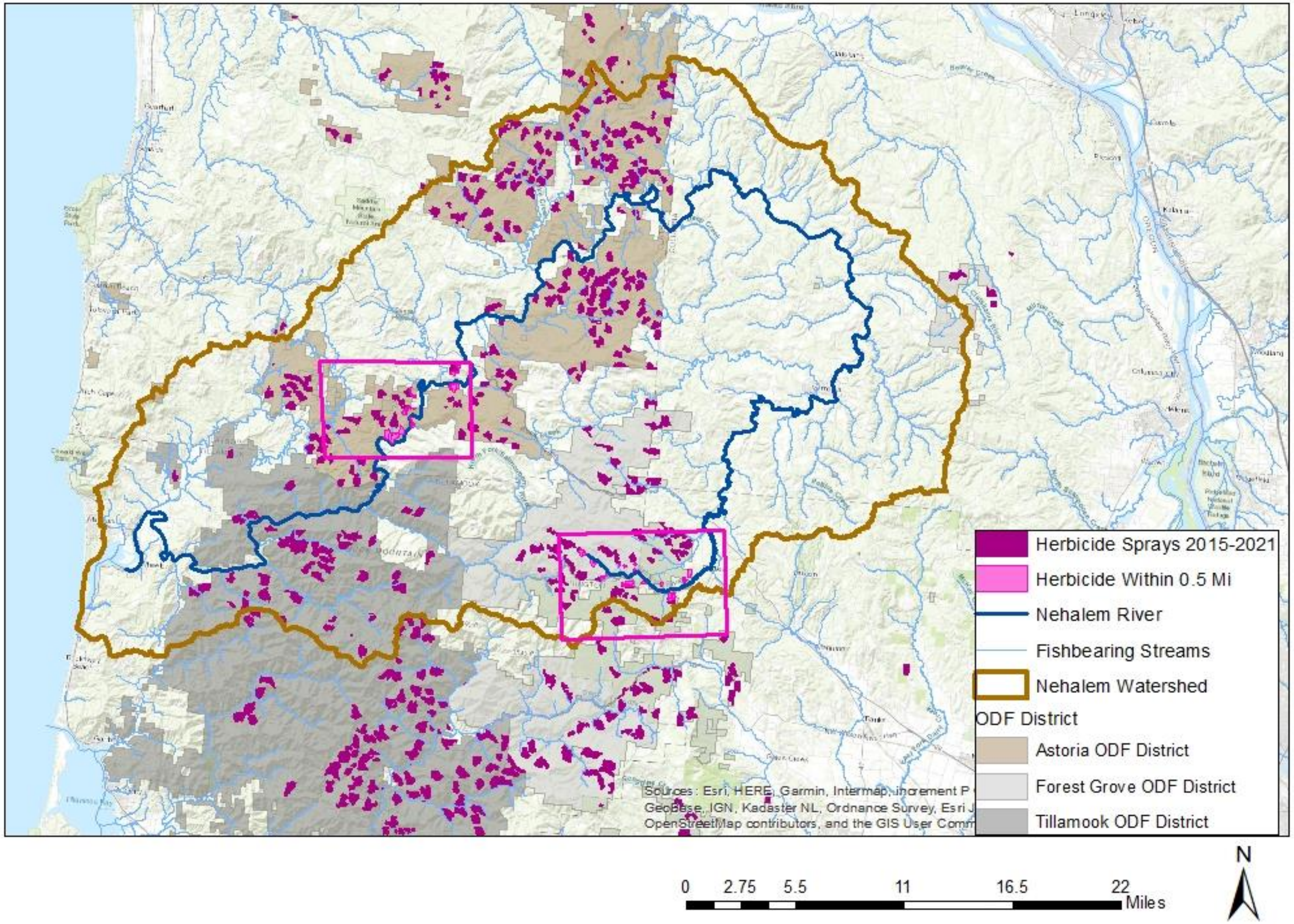
Pesticide Application in State Forests

A case study on the Nehalem Watershed

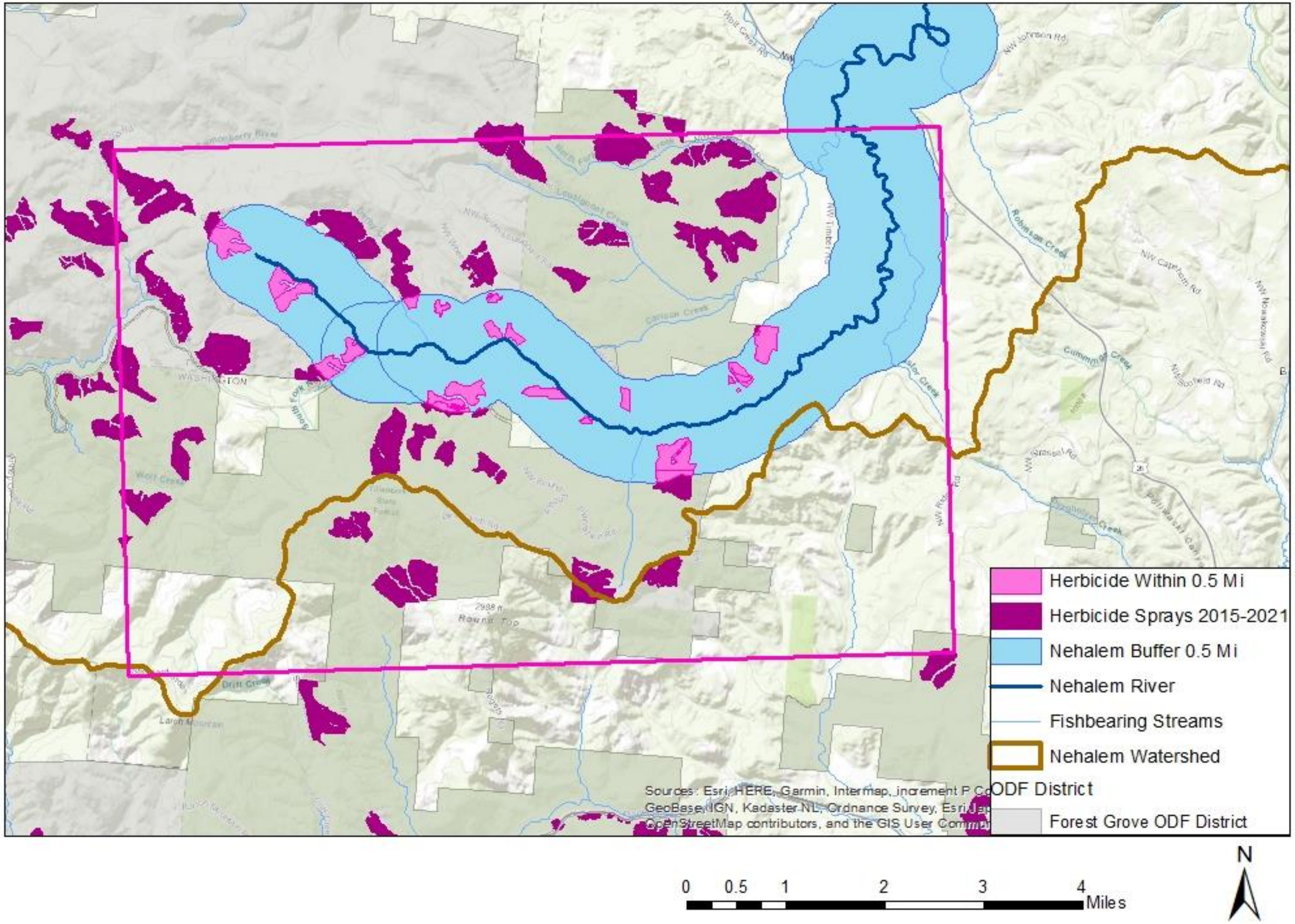
Presented by Beyond Toxics
Board of Forestry Virtual Meeting
November 3, 2021

BEYOND TOXICS

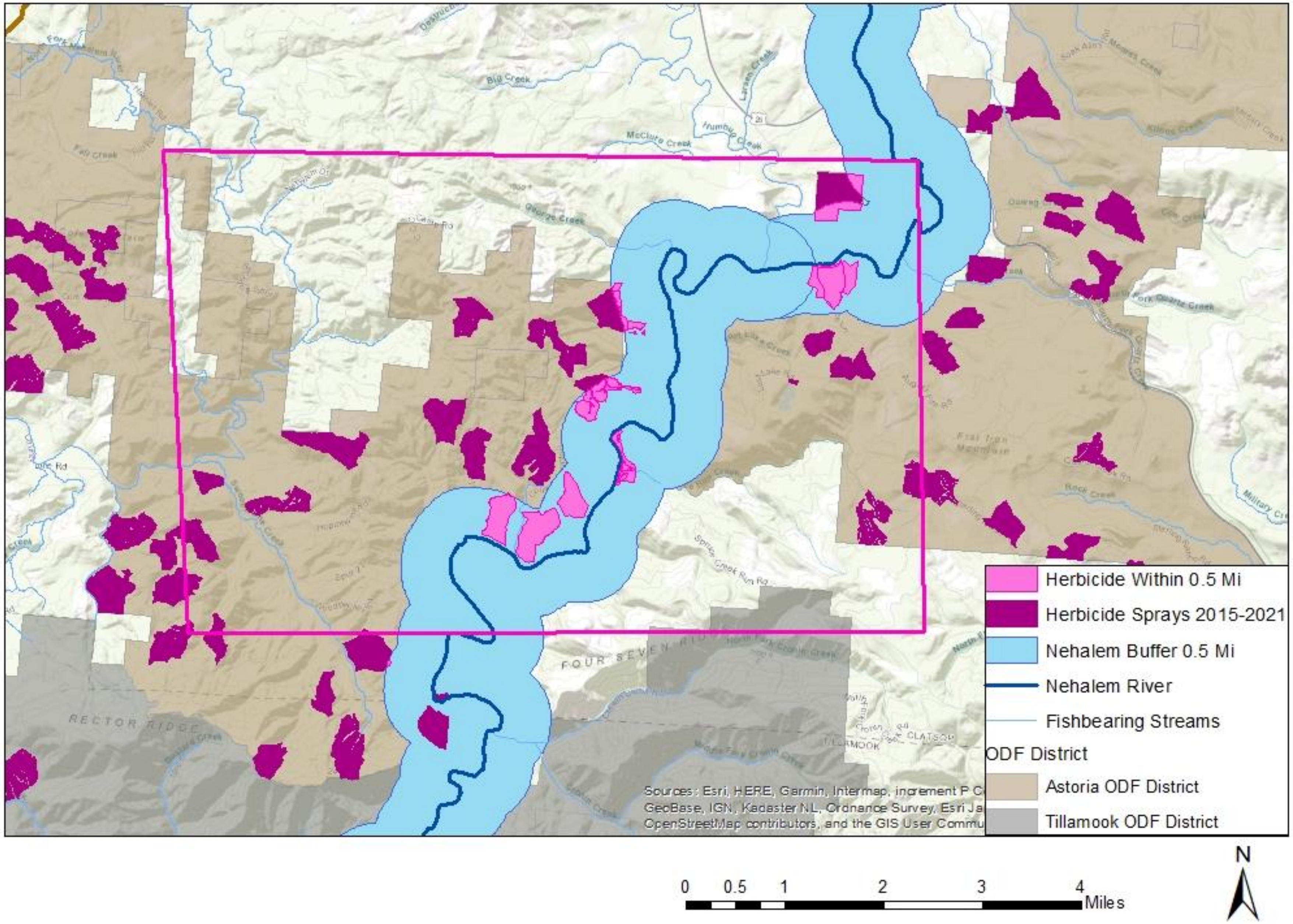
Herbicide Sprays on State Forests Within Nehalem Watershed



Herbicide Sprays Within 0.5 Miles of Nehalem River Headwaters



Herbicide Sprays Within 0.5 Miles of Lower Third Nehalem River



THE OREGON DEPARTMENT OF FORESTRY SLIDE ON ROUTE 30

The Oregon Department of Forestry (ODF) was responsible for hiring the contractor which cut a section of forest, ODF owns, on Route 30, by the Harmony Heights Development. Knowing it had an unstable soil type, underlain by the slide – prone Astoria Formation, they took a Las Vegas risk. The Clatsop County Landslide potential soil maps, containing the areas of Harmony Lane, Macey Drive and Liberty Lane, East of Astoria, off of Route 30 are marked High Risk for Landslides. This highway, is a vital corridor for employment, commerce, medical needs, and emergency services.

The ODF employees must be more thoughtful ; consider County Soil Maps, the Department of Geology and Mining Industries (DOGAMI), ODOT and watershed data. The ODF, are gamblers with our economy, clean water needs, and environment. The ODF contractors could have left a buffer of ten acres in a band on the edge, to hold the soils in place, avoiding the slide. They knew they were cutting in shaky ground. There is evidence near the entrance to Emerald Heights of a contained former slide. We have been having increased rain. Are they paying attention or even care? They work for us the people of Oregon.

These timber companies need to be held to account. I don't know the cost of the hiway clean up on Route 30 in January of this year, but I bet the State lost out on any profit from the cut. The people of Clatsop County, of Oregon and the Oregon Attorney General need to demand the Department of Forestry change their rules for the better health and community responsibility of Oregon's Citizens.

Pamela Mattson McDonald

Written Comments to Oregon Board of Forestry

Greatest Permanent Value

October 23, 2021

Chair Kelly, Acting State Forester Hirsch, and Member of the Board:

Audubon Society of Lincoln City and Salem Audubon Society strongly object to Forest Trust Lands Advisory Committee testimony that presumes to speak for “the counties” as if they represent a monolithic public with a singular point of view and the narrowest possible set of values. Citizens of forest trust land counties hold a wide range of opinions on what constitutes the Greatest Permanent Value of state forest lands. Citizens who support a balanced approach to forest management that recognizes the critical importance of ecosystem services are not being represented in FTLAC testimony. In fact, FTLAC leadership recently demeaned ODF staff work to engage the public in discussions on the draft goals for the proposed Forest Manage Plan. The FTLAC Chair said that gaining public input was inappropriate and that only the opinions and values of the FTLAC should be considered. This is absolutely unacceptable.

FTLAC’s failure to represent their constituencies has been pointed out before and yet never acknowledged by their leadership. We believe the majority of Oregon’s citizens support a broader definition of GPV that reflects our current ecological, social, and economic needs. FTLAC leadership chooses to ignore this instead taking their cues from law firms and consultants who were not elected and who are accountable to no one.

We respectfully ask the Board and State Forester to reject attempts by FTLAC representatives to lock Oregon’s state forests into a definition of Greatest Permanent Value that is grounded in the past, narrowly defined, and justified only through economic self-interests. Oregon Revised Statute 530.050 defines GPV as “healthy, productive, and sustainable forest ecosystems that over time and across the landscape provides a full range of social, economic, and environmental benefits to the people of Oregon. Oregon Administrative Rule 629-035-0020 directs the State Forester to manage for a very specific list of those benefits:

1. Production of forest products that generate revenue
2. Properly functioning aquatic habitats
3. Habitats for native wildlife
4. Productive soil, and clean air and water
5. Protection against floods and erosion
6. Recreation

We support forest management for each and all of these benefits. We are not opposed to production of forest products – they are essential to our current existence. But we take great exception to constant and consistent testimony from timber companies and the FTLAC that timber production must be the only benefit. The statute clearly states that timber production is not exclusive but must be pursued within a broader management context and then again lists a full set of ecosystem services.

The governing OAR is not forever tied to a definition formed decades in the past, but instead anticipates the need to look to the future and specifically requires incorporation of adaptive management that applies new practices as new scientific information becomes available. The Board is directed to review its management in light of current social, economic, scientific, and silvicultural considerations. Again, the emphasis is on using the most up-to-date information to manage for the future benefits to the citizens of Oregon. No one can claim with any credibility that our current conditions argue for business as usual.

We ask that the Oregon Board of Forestry and our State Forester recognize that FTLAC testimony does not if fact represent "the counties" but instead a small group of county officials. We believe these county officials should in turn work harder to more honestly represent the values of all their constituents. We believe policy makers at every level should live up to their respective responsibilities and work together to manage our state lands for the fullest suite of benefits that serve all Oregonians. We look forward to working with you and with ODF staff on the very important work coming in the next few months.

Respectfully submitted by:

Joseph Youren
Audubon Society of Lincoln City
Salem Audubon Society
yourenjoseph@gmail.com
(541) 921 9862

Submitted: Fri 10/29/2021 1:44 PM

Subject: RE: Nov 3 Item 2: Urban and Community Forestry Assistance Program Inbox

Message:
Dear BoF Members,

Regarding the **Urban and Community Forestry Assistance Program** and **Oregon Community Trees.**

I have read the meeting material packet for Item 2 on these programs presented by Kristin Ramstag.

I am sure that Kristin will be presenting other info, and perhaps the following questions will be answered, but in case they aren't, can you please put these questions to Kristin since others cannot ask questions:

1) How much **state** and **federal** dollars has each program received each year over the past 5 years and how much has the Legislature budgeted for next biennium?
2) Approximately how many new trees/forests have actually been planted or maintained with these funds to date?
3) Which cities and communities have received these funds and are they in areas where there are heat islands?
4) Who has the responsibility of tracking and monitoring the number of trees planted and maintained?

I hope one or you will ask these questions. It appears from the materials in the packet that a lot has been done on programming and administration, but have more urban trees/forests been planted or maintained as a result of this funding, or have grants been obtained to do this work? Are there metrics, KPMs on this?The CCCP has cited that the federal government has provided funding for 30 years for urban forestry. How can we find out how and where that money has been spent?

(Please note that there is no contact info provided on the OCT website (no email addresses, phone numbers or board contact info, not even on their donate page.)

Thank you,
Glenn Begis

OREGON FOREST &
INDUSTRIES COUNCIL
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November 17, 2021

Dear Chair Kelly and Board of Forestry Members,

As Chair and on behalf of the Oregon Forests & Industries Council State Lands Committee, I am writing to express significant concerns with the State Forests Metrics Update presented to the Board on November 3, 2021, specifically the carbon storage information. In this update, it was suggested that state forests carbon inventories are decreasing (see Agenda Item 5, Figure 2). This information was incomplete and contradictory to previous representations made by the Oregon Department of Forestry (ODF) regarding Stand Level Inventory (SLI) data and trends. The ODF must present comprehensive and accurate data to the Board, especially on issues as important as climate change and decisions regarding forest management policy and planning.

The SLI, as reported by ODF staff, shows overall growth (and therefore carbon stored) is increasing on harvestable acres. It is beyond belief that ODF could then present information to the Board that somehow shows state forests are emitting more carbon than they sequester. This same presentation shows industrial forests storing carbon on a slight increase. If you plainly consider the fact that private forests are over time harvesting their approximate growth, and have smaller buffers and set asides than public forests, then how could carbon storage be decreasing on state forests? Barring catastrophic wildfire, it is hard to imagine a reality where carbon inventories have been reduced on state forests under its current forest management practices.

Another flaw in this presentation is the absence of a full lifecycle analysis and complete carbon storage on the landscape. Below ground and soil storage, along with dead trees, must be included in any metrics presented. Most importantly, wood products cannot be excluded from carbon storage models. When a stand is harvested, that carbon doesn't just disappear, its stored in the wood products produced from that harvest. It would be irresponsible to not consider the benefits of carbon stored in wood products.

The ODF used SLI to predict outcomes under the current Forest Management Plan (FMP), draft FMP, and draft Habitat Conservation Plan. It is concerning that the State Forest Metrics Update states "…trends estimated from SLI are unreliable…" and that "The Division is currently developing a new inventory system to replace SLI… The new system is in active development and will roll-out over the next year to provide more accurate information on forest growth, change, carbon and other forest biometrics over time."

Presentation of incomplete information has real-world implications. Based on the inaccurate information in this one presentation, the Board's conversation led to suppositions that the state may be harvesting more than it is growing. As you know, any decrease of timber harvest will have a detrimental effect on the communities that have few other realistic opportunities to find family wage jobs or the funds to provide necessary social services. The economic, environmental, and social issues in front of the Board are significant. If we are going to successfully balance the challenges of climate change, with the already difficult balance of greatest permanent value, the data you review needs to be credible.

Before moving forward with any new policies or priorities, ODF needs to develop better data related to inventory and carbon storage. For the sake of public accountability and clarity, we also urge the Board to request an explanation from ODF as to the status of carbon inventories and the inputs used to-date at the next Board meeting. Lastly, we ask that the Board assist ODF in its efforts to provide more accurate information by allowing staff the time and focus needed to complete studies before being asked to present.

Thank you for your consideration.

Steve Zika
Chair, OFIC State Lands Committee
CEO, Hampton Lumber

Cc Jason Minor, FTLAC

Council of Forest Trust Land Counties
1201 Court St. NE / P.O. Box 12729
Salem, Oregon 79309-0729
TEL (503) 585-8351 FAX (503) 373-7876

Board of Forestry Testimony – November 3, 2021

Chair Kelly, members of the Board of Forestry, Interim State Forester Nancy Hirsch, newly appointed State Forester Cal Mukumoto, and ODF Staff: I am David Yamamoto, Tillamook County Commissioner and Chair of the Forest Trust Land Advisory Committee (FTLAC). I'm here today because FTLAC has a statutory responsibility to advise the BOF and the State Forester on matters which affect management of the State Forest Trust Lands (ORS 526.156). Specifically, I'm here to discuss the Draft Forest Management Plan Goals. I want to thank Interim State Forester Nancy Hirsch for her work over the last few months and welcome newly appointed State Forester Cal Mukumoto with whom I look forward to a close and prosperous working relationship.

Summary

The Forest Trust Land Counties have concerns about the Draft Forest Management Plan Goals (Draft Goals) as they are currently written. These concerns are:

- The goals do not reflect ODF's contractual obligation to provide sustainable timber harvest and revenue to the Trust Counties.
- The Draft Goals appear to go beyond the 1997 GPV administrative rule (OAR 629-035-0020).
- The Draft Goals do not recognize the "management focus" in the administrative rule.
- The Forest Management Planning administrative rule (OAR 629-035-0030) requires that forest resource management goals state what "the State Forester intends to achieve." The Draft Goals do not do this.

ODF has a contractual obligation to provide sustainable timber harvest and revenue to the counties

Based in the 1941 Act (Oregon Laws, 1941, Chapter 236) describing Greatest Permanent Value, the primary goal driving management of the state forest trust lands is to provide sustainable timber harvest and revenues to the state, counties, and taxing districts. The jury in the *Linn County* case agreed with the Counties that the State has a contractual obligation to manage these lands first for the generation of revenue. The jury awarded $1.065 billion to the counties, which is currently gaining interest at the State mandated 9% interest rate. This adds $262,000 to the award every day...almost $100M every year.

The Draft Goals appear to go beyond even the 1997 GPV administrative rule

Setting aside for a moment the Counties position that the GPV must be interpreted in relation to the State's duty to fulfill its contract with the Trust Counties, FTLAC has a duty to notify the BOF that it appears that the Draft Goals offered by ODF go beyond the GPV defined even in the 1997 administrative rule. The Draft Goals do not reference timber management to produce revenue as the "**management focus"** of the plan, as required by the 1997 OAR on GPV.

The administrative rule states (OAR 629-035-0020(2):

> *"To secure the greatest permanent value of these lands to the state, the State Forester shall maintain these lands as forest lands and actively manage them in a sound environmental manner to provide sustainable timber harvest and revenues to the state, counties, and local taxing districts. This management focus is not exclusive of other forest resources, but must be pursued within a broader management context that:*
>
> - *Results in a high probability of maintaining and restoring properly functioning aquatic habitats for salmonids, and other native fish and aquatic life;*
> - *Protects, maintains, and enhances native wildlife habitats;*
> - *Protects soil, air, and water; and*
> - *Provides outdoor recreation opportunities*

The Draft Goals include statements that go beyond the specific language in this rule, as shown in Appendix 1 of this written testimony, which were transmitted to you last week by FTLAC. The Trust Counties cannot support goals that change, expand or obfuscate the management focus of the lands.

The Trust Counties acknowledge there may be other laws that affect State Forest Land management in addition to the GPV rule. Strategies, actions or standards that are in conflict with the management focus might be accommodated only to the extent required to meet other laws or rules. If a goal is intended to support implementation of a law or rule, ODF should clearly state what law or rule that is, and be specific as to the requirements of the law or rule.

Before accepting any of the Draft Goals, the BOF should ask ODF to reconcile the language in the Draft Goals with the GPV Administrative Rule.

The Forest Management Planning administrative rule requires that forest resource management goals state what the State Forester intends to achieve

The Forest Management Planning administrative rule (OAR 629-035-0030(2)(c)) states that forest management plans goals "*are statements of what the State Forester intends to achieve for each forest resource within the planning area consistent with OAR 629-035-0020 (Greatest Permanent Value)."*

The Draft Goals do not state what the state forester "intends to achieve." The goals lack definitions of key terms such as "enhance" and "resilient." The goals do not provide a statement of future desired conditions, nor a way to assess whether a goal has been achieved. The BOF, Trust Counties, and stakeholders are left to interpret for themselves what will occur under each Draft Goal.

ODF has explained that managed actions will become clear after it develops the forest management plan strategies. However, the administrative rule states (OAR 629-035-0030(2)(d)):

> "Management strategies, which describe how the State Forester will manage the forest resources in the planning area to achieve the goals articulated in the plan. The strategies shall identify management techniques the State Forester may use to achieve the goals of the plan during the implementation phase of the plan."

The strategies describe only how the State Forester will manage the forest resources, not what the outcomes will be. The outcomes must be clear from the goals alone.

Conclusion

The Draft Goals should be re-written such that they meet the contractual obligation to the Counties and comply with administrative rules. The goals should be consistent with the GPV rule and should clearly state what the State Forester intends to achieve. Until these changes are made, the Trust Counites cannot support the Draft Goals.

Respectfully submitted,

David Yamamoto
Tillamook County Commissioner
Chair, Forest Trust Lands Advisory Committee

Draft goal that is consistent with the GPV rule

Timber Production	Provide sustainable and predictable production of forest products that generate revenues and jobs for benefit of the state, counties, local taxing districts and communities.

Draft goals that expand the definition of GPV beyond the 1997 rule

Forest Carbon	Contribute to Oregon's carbon stores within State Forest lands.	Forest carbon is not mentioned in the OAR.
Climate Change	Lead by example in demonstrating climate-smart forest management that supports climate adaptation, mitigation, and the achievement of forest resource goals.	Climate change is not mentioned in the OAR.
Wildfire	Mitigate the risk of wildland fire effects on forest production, wildlife habitat, landscape function and to support wildfire resilience of local communities.	Wildfire is not mentioned in the OAR. However, minimizing wildfire damage is consistent with the management focus of sustainable timber and revenue generation.
Mining, Agriculture, Administrative Sites and Grazing	Permit mining, agricultural use, administrative sites and grazing when resource use is compatible with other forest resource goals.	Leased resources is not mentioned in the OAR. However, this goal seems consistent with revenue generation.

Draft goals that expand the definition of GPV beyond the 1997 rule

Forest Carbon	Contribute to Oregon's carbon stores within State Forest lands.	Forest carbon is not mentioned in the OAR.
Climate Change	Lead by example in demonstrating climate-smart forest management that supports climate adaptation, mitigation, and the achievement of forest resource goals.	Climate change is not mentioned in the OAR.
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Mining, Agriculture, Administrative Sites and Grazing	Permit mining, agricultural use, administrative sites and grazing when resource use is compatible with other forest resource goals.	Leased resources is not mentioned in the OAR. However, this goal seems consistent with revenue generation.

Draft goals that expand the definition of GPV beyond the 1997 rule

Cultural	**under development – written comments welcome*	Culture is not mentioned in the OAR.
Scenic	Manage forests in ways that value scenery and forested settings that are visually appealing.	Scenic is not mentioned in the OAR.
Recreation, Education, and Interpretation	Provide high-quality forest recreation, interpretation, and education opportunities to create meaningful and enjoyable experiences which foster appreciation and understanding of forests and contribute to community health, forest stewardship, and economic wellbeing.	The OAR states "Provides outdoor recreation opportunities." Additional language in the Draft Goals is not reflected in the OAR.
Recreation, Education, and Interpretation	Manage REI infrastructure and recreational use in an environmentally sustainable manner that seeks to minimize adverse impacts to natural resources and forest ecosystems.	

Draft goals that expand the definition of GPV beyond the 1997 rule

Aquatics & Riparian	Maintain, protect, and restore dynamic, resilient, and functioning aquatic habitats that support the life history needs of a full range of aquatic and riparian-dependent fish and wildlife species.

The OAR states that management results in a high probability of maintaining and restoring properly functioning aquatic habitats for salmonids, and other native fish and aquatic life"

The OAR does not include terms "dynamic" and "resilient", or consideration of riparian-dependent wildlife. The OAR only refers to aquatic life.

Aquatics & Riparian	Maintain and protect forest drinking water sources that provide high quality drinking water for private and public domestic use.

The OAR states "protects soil, air and water." Drinking water source maintenance and protection is not mentioned in the OAR.

Draft goals that expand the definition of GPV beyond the 1997 rule

Soil	Maintain, protect, and enhance soils.	The OAR states "protects soil, air and water." "Maintain" and "enhance" are not mentioned in the OAR.
Forest Health	Ensure healthy, sustainable, and resilient forest ecosystems that over time help achieve environmental, social, and economic goals to benefit all Oregonians.	The OAR states that the management focus for state lands is sustainable timber and revenue production. This goal goes further than the OAR.
Wildlife	Maintain, protect, and enhance functional and resilient systems and landscapes that provide the variety and quality of habitat types and features necessary for long-term persistence of native wildlife species.	The OAR states "protect, maintain, and enhances native wildlife habitats" and does not include other aspects of this Draft Goal.

Draft Goal falls short of the definition of GPV in the 1997 rule

Special Forest Products	Provide opportunities to obtain special forest products.

Forest products are mentioned in the OAR. However, they are included in the context of providing "Sustainable and predictable production of forest products that generate revenues for the benefit of the state, counties, and local taxing districts." Revenue generation is not included in this Draft Goal.

Board of Forestry CFTL Testimony – November 3. 2021

Chair Kelly, members of the Board of Forestry, Staff: I'm John Sweet, Coos County Commissioner and Vice-Chair of CFTLAC.

I'd like to discuss the draft Climate Change and Carbon Plan (CCCP) that ODF has prepared. CFTLAC Chair, David Yamamoto's testimony today will note that the GPV administrative rule (ORS 629-035-0020) does not make any provision for managing state forests as a carbon sink. Rather than repeat those arguments here, I'll focus on the substance of the draft CCCP.

I thank ODF for their rewrite of the CCCP. They have improved the language around substitution in the CCCP, but I note there is more to do. While changes in the CCCP would have ODF encourage the use of wood products, it does not direct ODF to account for substitution effects when considering climate change impacts of harvest or harvest deferrals. The CCCP emphasizes only carbon in the forest and in wood products and not the CO_2 emissions avoided by substituting wood for concrete and steel in buildings.

We have proposed revisions to the draft CCCP. It would take more time than we have today to present these revisions to the Board, so they have been attached to the copy of this presentation that was scanned to ODF last week. I believe each of you has a copy of the material, which includes not only the proposed revisions to the CCCP but also a paper entitled, "Environmental Life-Cycle Assessment and Life-Cycle Cost Analysis of a High-Rise Mass Timber Building ………" and another entitled, " Tracking Carbon From Sequestration in the Forest to Wood Products and Substitution". As one can tell from the titles, they make for fascinating reading.

I'm not a scientist, but I think I can explain in laymen's language the concept suggested by CORRIM and the one we are endorsing. As a tree grows, it takes in CO_2. The carbon component becomes wood fiber creating a carbon sink, and the oxygen is released back into the atmosphere. As a part of a NW forest the tree grows and continues to sequester carbon for years. However, as time goes by the lower limbs on the trees in the forest die and start to rot. The rotting process releases CO_2 into the atmosphere offsetting the amount of CO_2 that is being sequestered by the forest. Ultimately, some trees crowd out others causing them to die and rot. The net rate of CO_2 absorption is again reduced. Somewhere around 120 years of age, the amount of CO_2 being generated by rotting wood equals the amount being absorbed from the atmosphere and converted into wood fiber, and the forest becomes carbon neutral. Ultimately, as the forest continues to age, more wood rots each year than is added, and the forest ends up releasing more CO_2 than it consumes.

If, however, the forest is harvested and replanted prior to the time it becomes carbon neutral, the replanted forest continues to be a carbon sink. And, the wood that is converted into building materials continues to help mitigate climate change in two ways: 1) it continues to sequester carbon in the form of lumber and plywood adding to that sequestered in the new trees replanted and growing in the forest, and 2) as a substitute for concrete and steel, the massive amounts of CO_2 generated in the manufacture of these materials is avoided.

Finding the sweet spot of at which age to harvest to maximize beneficial harvest impact needs to be a part of the conversation. I believe CORRIM suggests somewhere between 40 and 80 years of age. That doesn’t exactly pin down the optimum harvest age, but we need to leave the Department something to do.

I’ll leave you with that. Thank you again for the opportunity to weigh in on the search for a FMP.

sustainability

MDPI

Article

Environmental Life-Cycle Assessment and Life-Cycle Cost Analysis of a High-Rise Mass Timber Building: A Case Study in Pacific Northwestern United States

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Abstract: Global construction industry has a huge influence on world primary energy consumption, spending, and greenhouse gas (GHGs) emissions. To better understand these factors for mass timber construction, this work quantified the life cycle environmental and economic performances of a high-rise mass timber building in U.S. Pacific Northwest region through the use of life-cycle assessment (LCA) and life-cycle cost analysis (LCCA). Using the TRACI impact category method, the cradle-to-grave LCA results showed better environmental performances for the mass timber building relative to conventional concrete building, with 3153 kg CO_2-eq per m^2 floor area compared to 3203 CO_2-eq per m^2 floor area, respectively. Over 90% of GHGs emissions occur at the operational stage with a 60-year study period. The end-of-life recycling of mass timber could provide carbon offset of 364 kg CO_2-eq per m^2 floor that lowers the GHG emissions of the mass timber building to a total 12% lower GHGs emissions than concrete building. The LCCA results showed that mass timber building had total life cycle cost of $3976 per m^2 floor area that was 9.6% higher than concrete building, driven mainly by upfront construction costs related to the mass timber material. Uncertainty analysis of mass timber product pricing provided a pathway for builders to make mass timber buildings cost competitive. The integration of LCA and LCCA on mass timber building study can contribute more information to the decision makers such as building developers and policymakers.

Keywords: LCA; LCCA; mass timber building; environmental impacts; carbon analysis; cross-laminated timber

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1. Introduction

The buildings and buildings construction sectors together account for over one-third of global primary energy consumption and almost 40% of total CO_2 emissions, direct and indirect. Increasing energy demand from buildings and buildings construction is partially driven by surge in global buildings floor area and population [1]. Natural climate solutions have been proposed as one way to mitigate these impacts along with a drive for environmental and economic sustainability [2,3]. The nature of the building construction requires multi-criteria decision-making support and optimization of many aspects including environmental and economic costs [4]. New construction using wood from sustainably-harvest forest is a natural climate solution by both reducing greenhouse gas (GHG) emissions and by storing carbon while providing economic incentives for keeping forests as forest and even afforestation [2,3]. Mass timber construction (MTC), an emerging technology has become an available option to concrete and steel construction which are the primary construction materials for mid- to high-rise nonresidential buildings globally [5,6]. MTC is a category of framing styles using large solid wood panels such as glued, nailed or dowel connected cross laminated timber, known as CLT, NLT and DLT, respectively, and also glue laminated timber (glulam) and mass plywood panels. These are used in walls, floors, columns and roof construction [7,8]. CLT and other mass timber family products exhibit a reduced carbon footprint that are less energy intense relative to concrete and steel [9,10]. Using mass timber allows buildings to be built approximately 20% faster with less noise pollution than a similar project using concrete because of easier material handling and high level of prefabrication at the factory [11]. Well-designed mass timber building may also exhibit better earthquake performance and fire durability [12]. As with any emerging technology, economics drive the adoption of whether it will be accepted as a viable replacement.

All these advantages allow mass timber to replace concrete and steel in selected buildings. CLT was incorporated into the International Building Code (IBC) in 2015 [13], and the following revised 2021 IBC permits mass timber structures up to 18 stories for business and residential buildings [14,15]. Across the United States, 1060 mass timber projects have been evaluated and are in different stages of development and construction [16]. In particular, there has been great interest in mass timber buildings in the Pacific Northwest, due in large part to the cost savings and regional economic benefits associated with local production of the mass timber products. Scouse and others [17] showed the local or regional economic benefits of mass timber over a comparable traditional concrete include direct and indirect jobs and economic growth, when CLT is locally sourced from regional manufacturers. Drivers for increasing MTC include both environmental life-cycle assessment (LCA) and life-cycle cost analysis (LCCA) benefits [18–20]. Linking LCA and LCCA together can greatly contribute to creation of a sustainable built environment [21].

Whole building LCA (WBLCA) is a method to analyze building environmental impacts that can include the raw materials extraction, product manufacture, transport, construction, operation over the building lifetime and end of life impacts [22]. LCA is an important tool for guiding the selection of building materials and operating systems and their specific environmental impacts and has been used by the building sector since 1990s [23]. There are several worldwide LCA studies on mass timber buildings [24–27], and all the results showed mass timber buildings have lower embodied carbon and other environmental impacts than alternative conventional buildings. WBLCA studies of mass timber buildings in the United States are limited [28,29], and some only focused on the cradle-to-site analysis, and the building operations and end of life stages were excluded [10,19]. Nevertheless, there is a consensus that MTC can be an effective means for the mid-term (60–100 years) storage of biogenic carbon [30].

Building LCCA uses a set of financial criteria to evaluate the cost of a building across its entire service life [31]. LCCA is an effective tool to determine the cost effectiveness of different building designs and explore trade-offs between initial costs and long-term cost savings using a discounted accounting approach.

Liang et al. [32] applied this methodology to a hypothetical case study of a high-rise mass timber building compared to a concrete baseline building, and concluded that the total life-cycle cost (TLCC) was dominated by the construction cost, and were also sensitive to variations of study period and discount rate. Several recent studies explored the inclusion of LCA and LCCA on mass timber and other buildings [21,33–35], but more efforts are necessary to fully understand the environmental and economic impacts of U.S. mass timber buildings.

As part of a larger project centered on a pioneering high-rise mass timber building named Framework Kelley and Bergman [36], a first of its kind cradle-to-grave LCA and LCCA of a 12-story mass timber building in U.S. Pacific Northwest was performed. This work aims to investigate the environmental implications and economic contributions of CLT mass timber building. Research from this case study can be used to support developers and owners as they strive to reach environmental and economic goals, as well as help policy makers contribute to the development and management of the future sustainable built environment.

2. Case Study

The case study used in this work was a 12-story mixed-use commercial and residential building designed by LEVER Architecture (Portland, OR, USA) and intended to be built in Portland, OR. As illustrated in Figure 1, CLT and glulam are the main construction materials used in the building assemblies of walls, floors and columns and beams. This mass timber building has total floor area of 8360 m^2, and the dimension is 30.5 m in length, 25.9 m in width and 45.1 m in height.

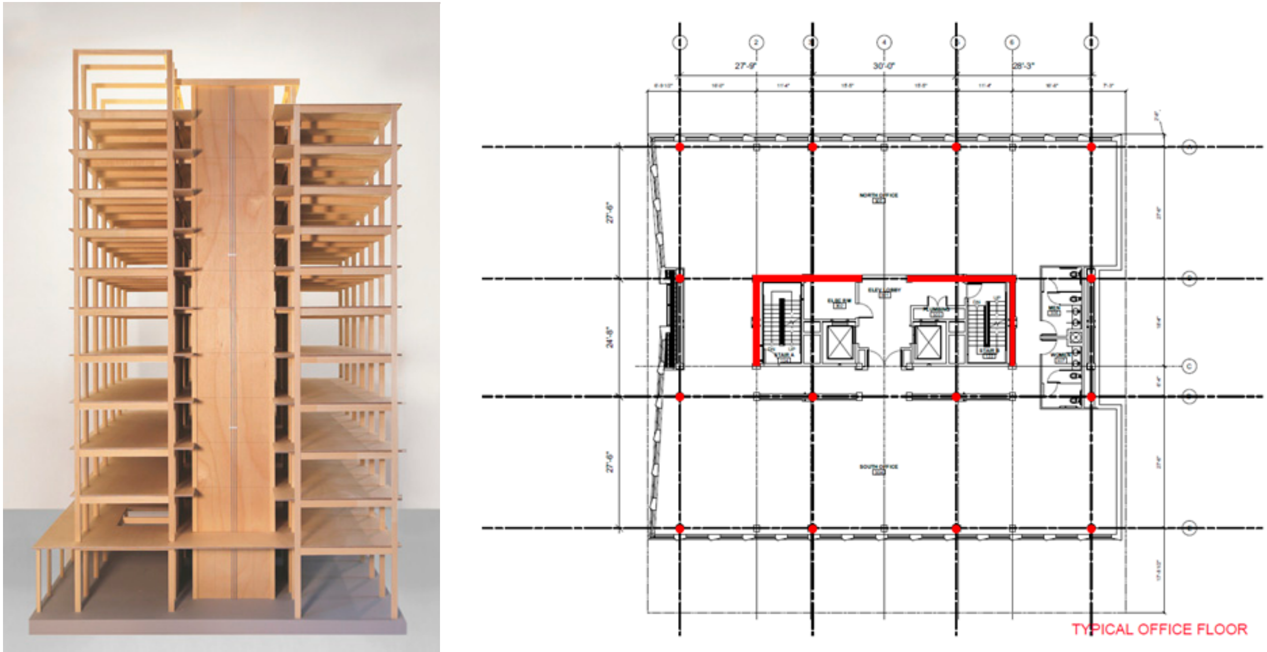

Figure 1. Image model of high-rise mass timber (Framework) building and main office floor plan.

Table 1 provides the bill (list) of material for this mass timber building along with its concrete alternative. The comparable conventional concrete building with same floor area and envelope design was also modeled by LEVER Architecture. Both buildings complied with same Type I-B fire-resistant construction code. This 8360 m^2 mixed-use building used a total of 2339 m^3 of mass timber products, including 1782 m^3 of CLT and 557 m^3 of glulam, that equals to 0.27 m^3 mass timber per m^2 building floor area. Specifically, the walls use 502 m^3 of 7-and 9-ply CLT, the floors use 1279 m^3 of 5-ply CLT and the post beams use 557 m^3 of glulam for columns and beams. Additionally, the mass timber building also consumed 36% more gypsum board, and 16% more structural steel than the concrete alternative. Conversely the mass timber building used 72% less rebar and 58% less concrete than the concrete building. Still about 1104 cubic meters of concrete were used in the mass timber building design for foundation and concrete layer on top of CLT floor for vibration control. Details of material used in each building assembly can be found in previous papers from this study [18,19].

Table 1. Bill of Building materials and data assumptions.

Materials	Unit	Buildings		Transport Distance (km)	Maintenance and Repair		Landfill Rate [2]
		Mass Timber	Concrete		Frequency (year)	Material Use [1] (%)	
1″ Mineral wool	m^2	286	286	172	20	100	1.00
1″ Polystyrene board	m^2	11,773	11,774	1299	20	100	1.00
1/2″ Gypsum board, regular	m^2	4154	3337	172	20	2	1.00
3/8″ Plywood	m^2	3889	3889	320	20	2	0.60
5/8″ Gypsum board, fire-resistant	m^2	72,237	53,042	172	20	2	1.00
60 mil TPO membrane	m^2	352	352	172	1	2	1.00
Acrylic latex paint	L	12,196	6691	642	10	1	1.00
Acrylic adhesive	L	117	117	840	10	1	1.00
Aluminum	kg	31,039	31,051	663	12	12	0.02
CLT	m^3	1782	-	320	-	-	0.30
Coated steel deck	kg	106	106	431	1	3	0.02
Concrete	m^3	1104	2627	24	15	2	0.45
Concrete masonry unit	kg	71,031	70,908	24	15	2	0.45
Glulam	m^3	557	-	320	-	-	0.30
Hollow structural steel	kg	87,324	77,071	431	-	-	0.02
Mortar	kg	94,851	94,561	172	15	2	0.45
Rebar	kg	103,845	376,272	431	15	2	0.30
Silicone sealant	L	578	578	840	10	1	1.00
Steel sheet	kg	10,716	7391	431	1	3	0.02
Steel welded wire mesh	kg	105	105	431	15	2	0.30

[1] Percentage of material used in the M & R. [2] the rate at which material is landfilled after building demolition.

3. Methodology

3.1. Goal, Scope and Functional Unit

The primary goal of this case study, the first of its kind, is to analyze both the LCA and TLCC of a high-rise mass timber building with a comparison to a functionally equivalent concrete building. The LCA and LCCA approaches used in this research were based on EN 15978 [22] and ASTM E917 [31], respectively. For the baseline analysis in this study, both buildings were assumed to be demolished after 60 years' service life. The scope of LCA was a cradle-to-grave analysis of materials effects, operation energy and water use over a 60-year period, where the equivalent aspects of the two buildings such as windows, doors, plumbing, electrical, and heating, ventilation and air conditioning (HVAC) systems were excluded from the analysis. The LCCA covered building construction cost, operation cost, maintenance and repair (M & R) cost, and demolish cost and/or salvage value at the end of study period, while the land acquisition, planning and externalities such as management and insurance were excluded from the analysis. The functional unit for this case study is defined as "1 m^2 of living/working floor area in a mixed-use commercial/residential building in the Pacific Northwestern United States for 60 years".

3.2. System Boundary and Life Cycle Stage

The system boundary defines the life cycle activities to be included in the analysis. Figure 2 illustrates the temporal flow of the building life cycle according to EN 15978 [22]. The building cradle-to-grave LCA includes module A to C minus a few submodules (B1, B5, C1 and C3) and module D (beyond building life cycle). The building LCCA in this case study includes all these modules. Detailed life cycle stages and data assumption were described in the following sections.

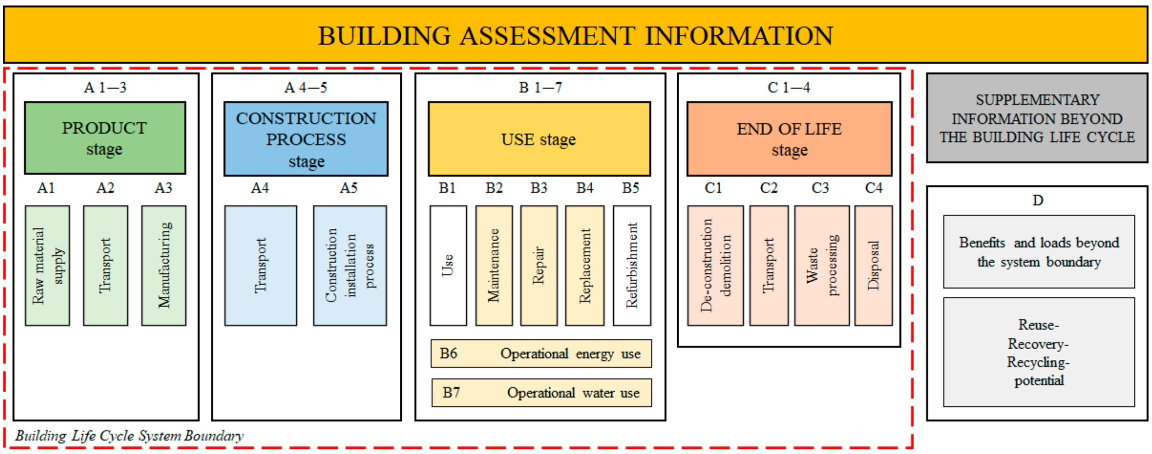

Figure 2. Building life cycle stages and modules.

3.2.1. Product and Construction Stage (Module A)

The product stage (A1–A3) includes raw materials supply (A1, primary resource harvesting and mining), transport (A2, transport up to manufacturing plant gate) and manufacturing (A3, manufacture of raw materials into products). The construction stage (A4–5) includes transport (A4, transport of materials to site) and construction installation process (A5, construction equipment energy use). The A4 transport was based on diesel truck and the estimated transportation distances for the building materials, listed in Table 1. Transportation distances were estimated based on the location of the construction and building materials' suppliers. The A5 equipment energy inputs were estimated from diesel use in Athena Construction Energy Database described by Bowick [37]. The life cycle inventory (LCI) of building materials and energy were sourced from DATASMART (Long Trail Sustainability, Huntington VT, USA) and Athena Impact Estimator (AIE) databases

(Athena Sustainable Materials Institute, Ottawa, ON, Canada) for Pacific Northwest forest resources. The LCI of CLT was provided by the University of Washington [38]. The whole building construction cost was estimated with individual material cost, onsite labor/equipment cost and overhead cost from the RSMeans database [39]. For instance, the estimated construction cost to use 1 m^3 glulam consists of $1440 of material cost, $219 of onsite labor/equipment cost and $260 of overhead. In this study, the cost of glulam in mass timber building was used as a proxy for CLT cost since the CLT industry average cost market data are not currently available. This proxy is on the high end of the CLT price range, which made the whole building LCC result more conservative. With the demands increase and more CLT manufacturers emerge, the price for mass timber products will become competitive within building materials. Scenario and uncertainty analysis were conducted to show the potential cost reduction for CLT as the MTC industry matures.

3.2.2. Operation Stage (Module B)

The M & R stage (B2–B4) includes the production of building materials used for maintaining (B2), repairing (B3) and replacing (B4) building components during operation stage. The material use and M & R frequency assumption were based on literature (Gu and Bergman, 2018) and listed in Table 1. The utility stage (B6–B7) includes the operational energy use (B6, energy production and use) and operation water use (B7, water supply and wastewater treatment) were the same for the two buildings. Table 2 shows the annual utility use and estimated cost for both buildings. The electricity and natural gas consumption were simulated by IES Virtual Environment software (Integrated Environmental Solutions, Glasgow, Scotland, UK), and the water use was estimated based on the plumbing system design. The unit utility prices were obtained from government sources and listed in previous study [19]. The use (B1) and refurbishment (B5) stages were excluded from this case study due to information unavailable for the mass timber buildings.

Table 2. Annual utility estimation for mass timber and concrete buildings.

Utility	Usage	Cost ($)
Electricity (kWh)	738,128	62,372
Natural gas (m^3)	9397	2947
Water (m^3)	8518	84,495

3.2.3. End of Life Stage (Module C)

The end-of-life stage (module C) in LCA study includes transport (C2, transport of building waste from site to disposal facilities, and transport of recyclable materials to recycling facilities) and disposal (C4, landfill of building waste), while the deconstruction/demolish (C1) and waste processing (C3) stages were excluded due to lack of data. The distances of 24 km to landfill site and 100 km to recycle facilities were assumed, and the landfill rates of building materials were listed in Table 1. For the LCCA, all modules were included, and the building demolition cost (including de-construction and dump charges) was estimated using RSMeans database for concrete- and wood-framed buildings.

3.2.4. System Expansion (Module D)

Per EN 15978 [22], module D quantifies the potential environmental and economic benefits from the reuse, recovery and recycling of materials and energy from the building and existing system. These outputs are assumed to substitute for materials or energy production from existing technologies. For example, recycled metals substitute for metal scraps, recycled concrete substitute for aggregate and reclaimed wood products substitute for virgin materials and/or are used for energy production. Specifically, this work assumes 30% of CLT and glulam would be landfilled after building demolishment, where for the rest of un-landfilled mass timber, 75% would be reclaimed to substitute virgin CLT/glulam and remaining 25% un-landfilled (with lower heating value of 20.9 MJ/kg) [40,41] would be combusted in wood boilers, with efficiency of 77%, to replace natural gas, with lower heating value of 37.5 MJ/m^3 STP and efficiency of 80%. For the concrete material, landfill rate was assumed as 45% (Table 1), and the other 55% would be recycled as aggregates. The demolition costs and salvage values were estimated using RSMeans database [39] and assumed the reused CLT/glulam would be sold at a 50% of virgin price. Sensitivity analysis of different mass timber reclaim ratios and resale prices were also evaluated to address the uncertainties of these assumptions.

3.2.5. Carbon Sequestration and Storage

Wood and concrete can sequester and store carbon at different life-cycle stages which varies depending on various assumptions. For wood, after its original service, the reclaimed CLT/glulam were assumed to keep their structural integrity as well as the carbon stored in wood for additional 60 years beyond the building's original lifetime thereby doubling its original useful life. Landfilling wood products release GHGs as the wood decays but also store carbon permanently. Michaels and Skog [42] estimated 1.5% of carbon content in wood products was released to the atmosphere and the following literature by Skog [43] increased the number to 23%. According to the IPCC guidelines, wood carbon decayed in landfill maybe as high as 50–60%. However, according to the US EPA, wood decomposition rates vary from 5–16% [44]. The GHG emissions in this study were calculated through DATASMART database within SimaPro LCA modeling software (PRé Sustainability, Amersfoort, Netherlands) based on US EPA [44], with the landfill gas recovery system included. For concrete, concrete carbonation included carbonation during the 60-year building use phase, carbonation of waste fraction in landfill, and carbonation of recycled concrete waste as aggregate. The module A to C concrete carbonation was calculated based on reference [45] with exposed concrete surface area of 764 and 41,718 m^2 for CLT and concrete buildings, respectively. The concrete carbon dioxide absorption increases dramatically in 10 years after demolishing building and slows down afterwards to approximately 70% of carbonation limit at 100 years [46]. These assumptions were used to estimate carbon sequestration and storage for modules A to D.

3.3. Life Cycle Impact Assessment

The life cycle inventory data of each building stage was quantified, and the impacts were modeled using SimaPro 9.0 software following the ISO 14040 [47] and ISO 14044 [48] environmental management standards. WBLCA analysis followed EN 15978 [22] and ISO 21930 [49]. Global warming (GW), ozone depletion (ODP), smog formation (SFP), acidification potential (AP) and eutrophication potential (EP) were reported using the embedded TRACI 2.1 impact method [50]. The primary energy consumption which included fossil, nuclear and renewable energy were calculated using the cumulative energy demand (CED) v1.10 method.3.1.

3.4. Life Cycle Costing

The LCCA calculation integrates cost data of each building stage following the ASTM E917 [31] standard and method developed previously [32]. Real term discount and escalation rates were incorporated, and interest payments and taxes were excluded from the analysis. All future costs were discounted to the base-year monetary values, called present value. The building's TLCC was calculated by the summation of all present values of construction cost, operation cost, M & R cost, demolish cost and salvage value at the end of 60-year study period. The building service life is the span of time in which a building is in use. The study period appropriate to the LCC analysis may or may not reflect the building's service life span.

4. Results

Table 3 presents the cradle-to-grave LCA and LCCA results of mass timber building and its difference with concrete building. When including the operational stage which was dominant, the mass timber building outperformed the concrete building slightly on most of environmental impacts (0.3–1.6% reduction) except for AP and renewable energy consumption. The AP and renewable energy consumption were mainly derived from the wood products manufacturing processes. In both buildings, operation was the largest contributor to all environmental impacts except for ODP, where the ODP mainly stemmed from the insulation material polystyrene at the M & R stage (module B2–B4). The use of grid electricity and natural gas caused more than 90% of all environmental impacts at the utility stage (module B6). In this initial case study, the building utility included electricity, natural gas and water consumption for 60 years, and assumed both buildings had same utility consumption (Table 2). Excluding the operational utility demands, the environmental impacts of mass timber building over concrete building showed 0.5–40% lower values (e.g., 17% lower GW impact). Details of the comparison excluding the operational energy and water use were published in a previous paper [19]. This is a substantial reduction that can be attributed to the selection of the MTC over concrete construction. As expected for building types, within the product and construction stage (module A) the choice of building material contributes 80–90% of most environmental impacts, followed by material transportation (A4) and on-site construction (A5).

Table 3. Life cycle impacts and costs of 1 m^2 floor area of mass timber building with 60-year study period and difference with alternative concrete building.

Category	Unit	A1–3	A4	A5	B2–4	B6–7	C [1]	D	A–C	% Diff.	A–D	% Diff.
GW	kg CO_2 eq	177	8.53	6.75	52.0	2898	10.3	−364	3153	−1.57	2789	−11.6
ODP	kg CFC−11 eq	1.9E−4	1.5E−8	1.3E−8	5.6E−4	2.1E−4	1.1E−6	−7.9E−7	9.6E−4	−0.33	9.6E−4	−0.38
AP	kg SO_2 eq	0.89	0.05	0.09	0.12	6.83	3.05	−0.15	11	8.89	11	7.63
EP	kg N eq	0.18	0.00	0.01	0.04	21.5	0.04	−0.03	22	−0.81	22	−0.90
SFP	kg O_3 eq	11.4	1.36	2.89	1.28	94.8	1.32	−1.84	113	−0.18	111	−1.40
Fossil	MJ	2019	107	90.9	454	34,277	120	−1820	37,068	−0.34	35,248	−5.08
Nuclear	MJ	196	1.56	1.33	62	6445	2.53	−20.1	6707	−0.71	6687	−0.91
Renewable	MJ	955	0.24	0.21	9.22	8784	0.61	−481	9749	10.1	9269	4.68
Cost	USD ($)	A1–5: 2281			469	1257	C-D: −30		-	-	3976	9.64

[1] Incudes all submodules for life-cycle costs but not C2 and C4 for life-cycle impacts.

Figure 3 shows the relative environmental impacts contribution of material type to material use life-cycle impact assessment results at product and M & R stages (modules A1–A3, B2–B4). For concrete building, concrete (35%), rebar (27%) and insulation (23%) materials were the largest contributors to GW impact, while insulation (28%), wood (22%) and concrete (18%) were the largest contributors to GW impact for mass timber building due to the substitution of concrete and rebar by CLT and glulam as well as the extra gypsum board use. The extra gypsum board was used to meet the building fire code requirements, which required almost all exposed wood surfaces to be covered for a building of this height (ICC 2019; Breneman and Richardson 2019). Similar trends were also found for other environmental impacts except for ODP and renewable energy consumption. As expected, wood was the dominant contributor (97%) to renewable energy consumption in the mass timber building because wood product manufacturing facilities burned wood residue onsite for steam or electricity production for processing.

In contrast to the LCA results, the mass timber building had 9.6% higher TLCC than concrete building. Building construction cost was the largest contributor to the TLCC, accounting 57% and 50% for mass timber and concrete buildings, respectively. As shown in Table 3, the mass timber building had an estimated construction (A1–A5) cost of $2281 per m^2 floor area, which was 26% higher than concrete building. Additionally, the mass timber building had an estimated end of life (or recycled) value of $30 per m^2 floor area versus end-of-life cost of $94 per m^2 floor area for concrete building. It is worth noting that while the mass timber building had higher initial costs, these buildings are also expected to be a ‘premium product’ and command higher rents, and thus be more profitable [51,52].

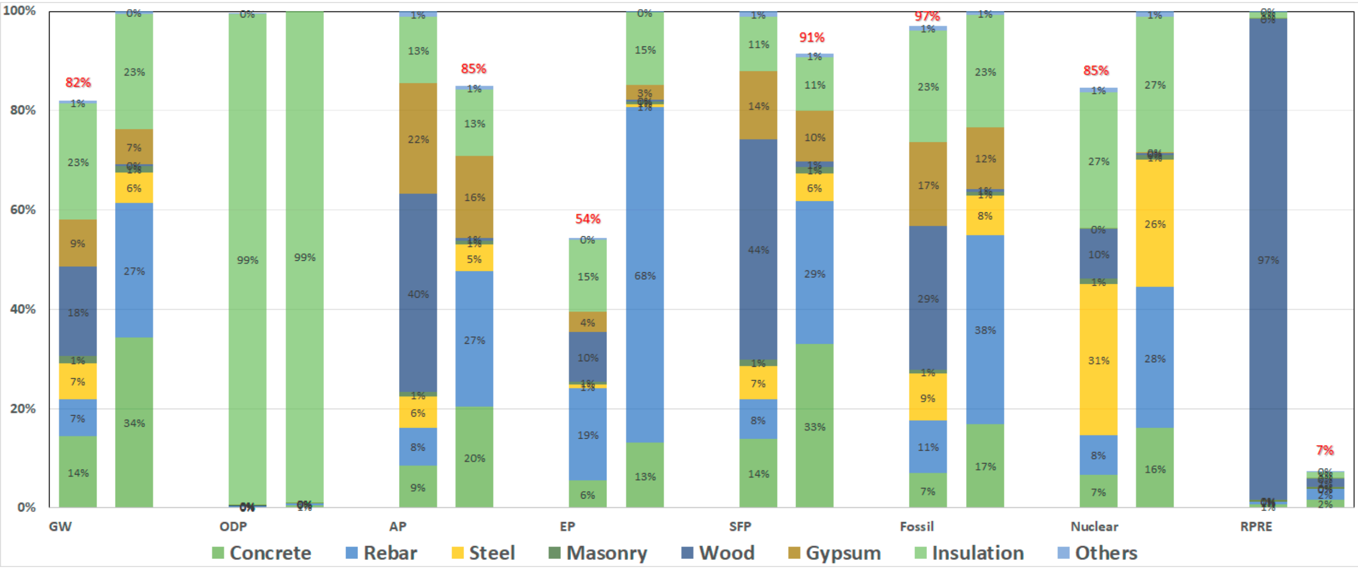

Figure 3. Material type contributions to material use life-cycle impact assessment results for high-rise mass timber (left column) and concrete (right column) buildings.

5. Discussion

5.1. Operational Energy Consumption

Operational energy tends to dominate the overall environmental life-cycle impacts the longer the building lasts. For example, the operational energy frequently has the greatest environmental impacts and accounted for over 90% of building cradle-to-grave GW with study period ranges from 50 to 100 years [37,45]. The consumption of electricity is site-specific, influenced by climate zone, building type and energy efficiency. In this case study, the electricity use during the occupation in buildings were mainly for heating and cooling, vent fans, plug loads and lights. For this analysis, both buildings were designed by LEVER to have the same, superior energy performance. When compared to a standard, typical code-compliance concrete building in Portland area, the mass timber building design in this study could save 70% annual energy use (according to LEVER architects), or 68% reduction in total cradle-to-grave GW. This energy saving is equivalent to avoiding 882 tonnes of fossil CO_2 emission annually. The same effect would occur for a high-performance concrete building over a code-compliant mass timber building. Although the operational energy contributed 90% of cradle-to-grave GW it only contributed 7% of TLCC for both buildings because energy is relatively cheap in the United States. If the more energy-efficient design was incorporated into the mass timber building, this could reduce the TLCC by 4.9% from the typical code-compliance concrete building as shown in the previous study [32]. As buildings continue to improve in operating energy usage, the embodied carbon emissions of the structure will become more prominent.

Although this study was based on the assumption of same operational energy and water use during the building use stage for both buildings, there is still potential that mass timber products will provide better thermal performance to save building's heating/cooling energy in reality since wood has lower thermal conductivity comparing to steel and concrete, so it contributes to energy efficiency with exceptional air tightness and thermal insulation during building service life [53]. A simulation study by Khavari et al. [54] compared a 10-story multi-unit residential building model constructed using CLT versus light-frame metal with same floor plan, and concluded that the CLT envelope has significant improvements for heating energy and for varied energy performance efficiency at different climate zones. Energy-efficiency buildings have long-term environmental and economic benefits [55,56], and it is highly possible that MTC in green building could become part of normal construction and business practices.

5.2. Cross Laminated Timber

The environmental impacts of CLT are mainly from upstream lumber production, electricity consumption during manufacturing, resin use and feedstock transportation. The lumber production and electricity consumption together contributed over 70% of total GW [38]. The wood species and electricity grid composition at various US regions are different, as shown in Table 4, therefore the GW impacts from lumber (47–81 kg CO_2-eq/m^3) and electricity (0.3–0.8 kg CO_2-eq/kWh) varied greatly (DATASMART, 2019) between regions, too. Therefore, CLT produced from different regions have different environmental impacts. In this case study, the GW from lumber was estimated to be 59 kg CO_2-eq/m^3, and thus the CLT in the mass timber building contributed 33 kg CO_2-eq GW per m^2 floor area, or 18% of total GW at product stage (module A1–A3). For module A4, the transport of CLT from manufacturer to building site (320 km via truck) contributed 3.4 kg CO_2-eq GW per m^2 floor area, or 39% of total GW at transport stage.

Table 4. Global warming impacts of lumber and electricity for cross-laminated timber production for different US regions.

Region	Main Wood Species	Lumber GW (kg CO_2-eq/m^3)	Electricity GW (kg CO_2-eq/kWh)
Pacific Northwest	Douglas-fir and western hemlock	57.8	0.51
Northeast	Eastern spruce	46.8	0.31
Southeast	Southern pine	81.4	0.77

Figure 4 shows the comparison results of mass timber building GW impacts caused by CLT material (module A1–A3) and its transportation to site (module A4) under different scenarios (S1 sources from Inland Northwest, S2 sources from BC, Canada; S3 sources from QB, Canada; and S4 sources from Austria, Europe). These additional four scenarios were analyzed and assumed the CLT was sourced from different North American and European manufacturers [24,57,58]. The GW impact of mass timber building CLT at product stage (module A1–A3) varied from 15 to 34 kg CO_2-eq per m^2 floor area under different scenarios, which was largely due to the wood species and regional electricity composition differences as mentioned above. Sensitivity analysis shows that ±50% changes of CLT's embodied carbon emissions, would cause only ±0.5% variation in the total cradle-to-grave GW emissions over the 60 years lifetime of the building. While the GW of mass timber building CLT at transport stage (module A4) varied from 3.4 to 47 kg CO_2-eq per m^2 floor area, and obviously longer CLT transport distances create greater financial and environment costs. It is highly possible that CLT's embodied carbon emissions from its transport will be reduced as more local, technologically advanced production infrastructure is developed.

The use of CLT in mass timber building costs $409 per m^2 floor area (0.21 m^3 of CLT per m^2 floor area), accounting 18% of total building construction cost. It is worth noting that the price range of CLT is relatively wide due to its early adoption status and nature as specialized product in building sector [17]. This current work modeled the LCCA using the glulam prices in RSMeans database [39] as a proxy for CLT, (e.g., $1440 per m^3 of CLT, construction labor/equipment cost of $219 per m^3, and overhead of $260 per m^3), which is on the high end for CLT price. Other work [59] has suggest that the price of CLT could range from $600–750 per m^3, or as high as $1500 per m^3.

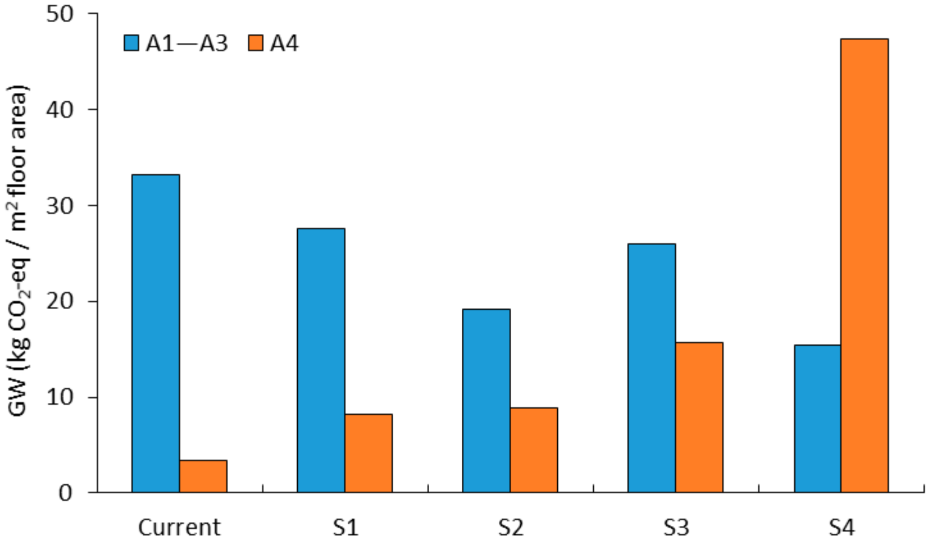

Figure 4. Global warming impact of cross-laminated timber material (module A1–A3) and transportation to construction site (module A4) for mass timber building under different scenarios (S1 sources from Inland Northwest, S2 sources from BC, Canada; S3 sources from QB, Canada; and S4 sources from Austria, Europe).

To evaluate the wide range of potential prices, a Monte Carlo simulation was conducted to test the impacts of combined uncertainties of CLT price (triangular, mode = \$1440 per m^3, min = \$600 per m^3, max = \$1500 per m^3), labor/equipment charge (normal, μ = \$219 per m^3, σ = \$44 per m^3), and overhead (normal, μ = \$260 per m^3, σ = \$52 per m^3) on the overall CLT construction cost. The results are shown in Table 5. The simulated total cost of CLT used in the study's mass timber building was \$354 $\pm$ 2.8 per m^2 floor area (95% confidence interval), and there was a 97.5% likelihood that the total cost of CLT mass timber building would be less than \$427 per m^2 floor area. Additionally, sensitivity analysis result showed that $\pm$50% change in CLT price would affect $\pm$6.7% of mass timber building construction cost and $\pm$2.8% of mass timber building TLCC and would result in a TLCC that is 6.5–12.8% higher for mass timber building relative to the concrete building with same operational energy and water use for 60 years.

Table 5. Monte Carlo simulation results of total cost of cross-laminated timber use in mass timber building.

Total Cost of CLT Use	Value (\$ Per m^2 Floor Area)
95% confidence interval	354 $\pm$ 2.8
Standard deviation	45
97.5th percentile	427
Coefficient of variation	13%

Building life span has a significant impact on the TLCC. In this study, both buildings were assumed to be demolished after 60 years. A survey of building longevity conducted by Athena Sustainable Materials Institute (Ottawa, Ontario, Canada) found that more than 65% of demolished wood buildings were older than 75 years, while 60–80% of concrete and steel buildings were demolished at less than 50 years old. Architects from Lever Architecture believe the mass timber buildings are more likely to survive for more than 100 years (personal communication). Using projected building longevity of 100 and 75 years for mass timber and concrete buildings, respectively, under the same study period of 60 years, the mass timber building would have 2.5% lower TLCC than the functionally equivalent concrete building.

5.3. End of Life Management and Carbon Analysis

After buildings are demolished, some materials can be recycled to substitute for new materials required for construction of the next building, and in the case of wood products burned for energy to avoid fossil fuel consumption. The environmental and economic consequences of these end-of-life decisions can be significant at the building level and could represent up to 50% of the building total life cycle impacts [60]. In this work, the mass timber building stored 364 kg CO_2-eq per m^2 floor area due to the recycling of the mass timber in module D. In contrast, recycling at the end of life for the concrete building only stored 46 kg CO_2-eq per m^2 floor area, which mainly derived from concrete carbonation. Therefore, including module D for carbon credit, the mass timber building had a total GW of 2789 kg CO_2-eq per m^2 floor area that is 12% lower than concrete building (3157 kg CO_2-eq per m^2 floor area).

In landfills, solid wood decomposes very slowly, but nevertheless releases biogenic methane while sequestering the majority of carbon. In this work, the base case assumption was that 30% of the CLT was landfilled and 70% were recycled and reused. If this landfill rate was increased to 100%, the total carbon credit at module D would be reduced from 364 kg CO_2-eq per m^2 floor area to 287 kg CO_2-eq per m^2 floor area. While this the carbon credit is still large, landfill should be avoided, and recycle and reuse should be the first principle in waste management.

This research further assumed that 52.5% of building mass timber (75% of the 70% non-landfilled) could be reclaimed for reuse in MTC, and the remaining 17.5% of building mass timber (25% of the 70% non-landfilled) would be combusted in boiler to substitute natural gas for heat and electricity. This assumption could be conservative when considering the nature of mass timber as building structural components. Studies from USDA Forest Products Laboratory (Madison, WI, USA) found reclaimed glulam after 75 years' building life had showed no degradation in structural integrity and exhibited good mechanical performance [61,62]. In the case of CLT, the reuse rate is less likely to be related to the strength of wood, but more likely driven by the match of the specific dimension of the CLT coming out of service. To evaluate this issue, different mass timber reuse ratios for the CLT between 0 to 100% were applied. This range in the reclaim ratio led to a variation of 9–12% lower total GW (module A–D) for the mass timber building relative to the concrete building. Sensitivity analysis result shows that ±25% changes in mass timber reuse rate would affect ±9% of carbon credit at module D, or ±1% of total GW for module A–D. Carbon impact of each source at different mass timber reuse rates were calculated and illustrated in Figure 5. The absolute values of fossil and biogenic carbon dioxide emission as well as natural gas substitution decreased, and wood carbon storage increased with the increase of mass timber reclaim/reuse rate. Biogenic carbon dioxide emissions are considered carbon neutral from the climate change prospective based off the IPCC's 100-year timeline, however some debates exist on global warming carbon accounting with biogenic and fossil carbon dioxide [63]. The total carbon dioxide (including the biogenic carbon) emission of mass timber building decreased with the increase of mass timber reuse rate except for the scenario where all the non-landfilled mass timber was combusted for energy. Combusting all mass timber at end of life generated 2% higher total carbon dioxide emission, while in other scenarios the mass timber building had 1–8% lower total carbon dioxide emission than the concrete building (Figure 5).

The reclaimed mass timber has financial value. It was assumed that the reclaimed mass timber could be re-sold as 50% of its virgin price, and under such assumption, the end-of-life salvage value of mass timber building was approximately \$123 per m^2 floor area, accounting 3% of TLCC. As expected, the salvage value was impacted by both the value and volume of recovered mass timber, and there were large uncertainties in these assumptions. To better understand these effects, different reclaiming rates (25–100%) and resale prices (25–100% of the original price) were evaluated and shown in Figure 6. Without considering the end-of-life costs, the TLCC costs of the mass timber building was about 13% higher than the concrete building. With considering the end of life where 25% of the mass timber was recovered and valued at 25% of its original value, the TLCC costs for the mass timber building were about 12% higher than the concrete building. When assuming the best-hope scenario for the reclaiming rate of 100% and the original value being maintained, the mass timber building's TLCC would be only 4.8% higher than the concrete building. Although this assumption maybe considered unrealistic from the current view, it implies, anyhow, that the mass timber buildings ought to be designed and then deconstructed/demolished with outmost care to maintain the value of the CLT and glulam.

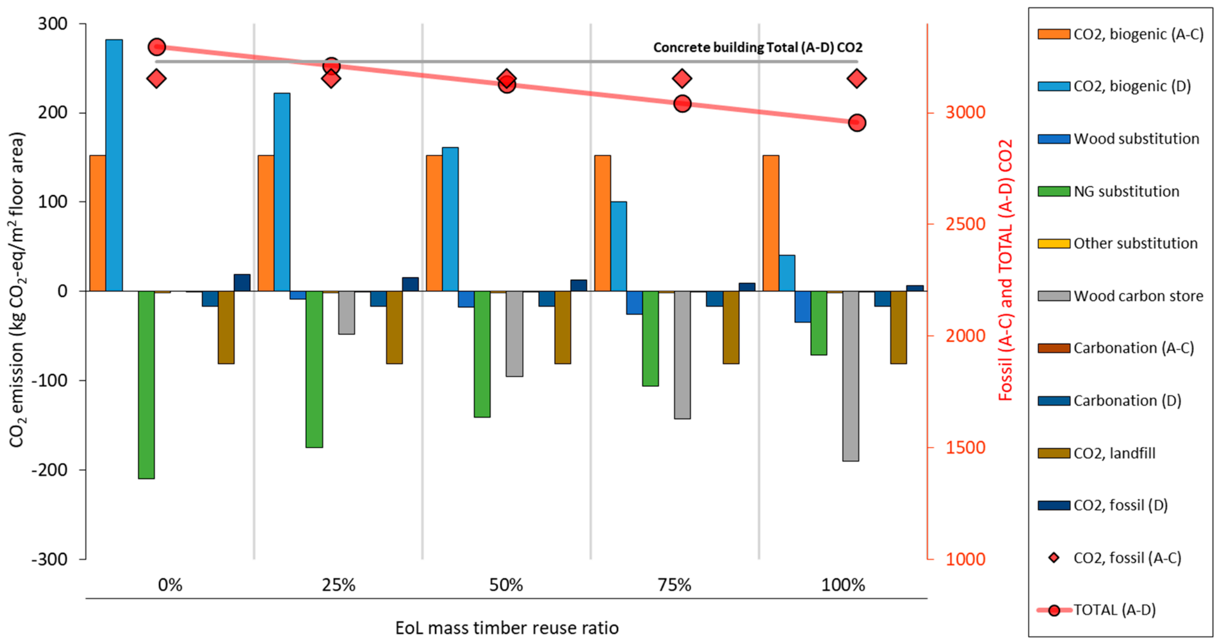

Figure 5. Full carbon accounting of mass timber building at different end-of-life mass timber reuse rates with respect to a functionally equivalent concrete building.

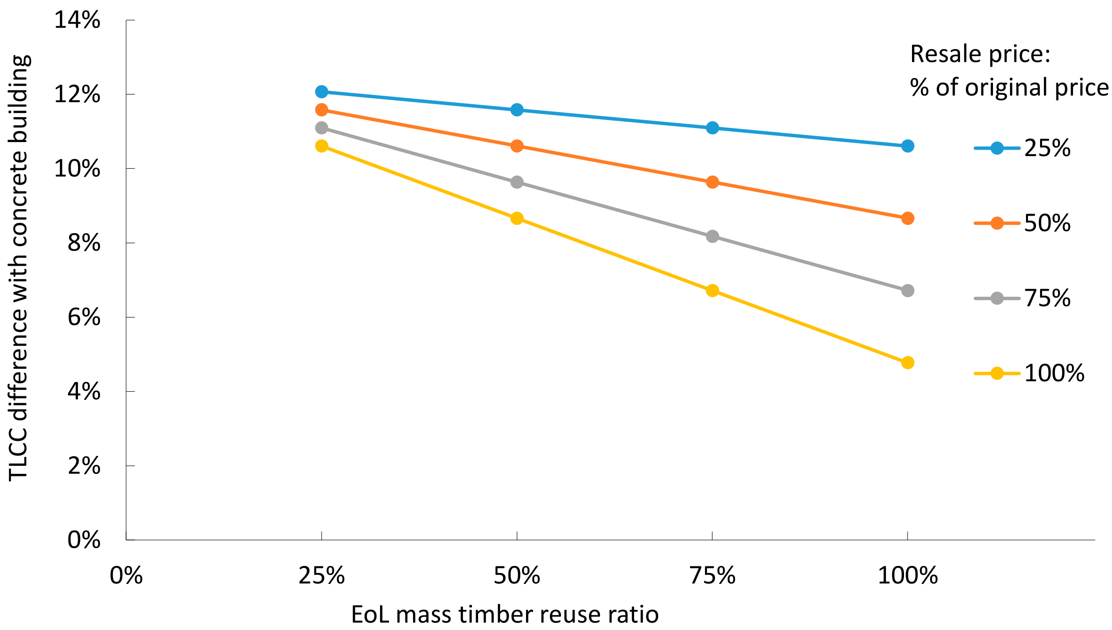

Figure 6. Total life cycle cost difference between mass timber and concrete buildings at different mass timber reuse rates and salvage prices.

6. Conclusions

A high-rise mass timber building in Pacific Northwest was assessed using LCA and LCCA approaches to evaluate the life-cycle environmental and economic performances and compared these results to a concrete building of same design. Operating over 60 years, the cradle-to-grave (module A–C) LCA results show the mass timber building had better performance in respect to GW (1.6% lower) and other environmental impacts than concrete building. As expected, the operating energy dominated the buildings' GHG emissions, accounting for over 90% of the emissions from the mass timber building. Simply comparing the GW impacts of the materials, the mass timber building had 17% lower emissions. These greater carbon benefits in the materials of construction, will have enlarged benefits when the timing of the emissions is considered [64,65]. The GW advantages of mass timber building become more significant when considering the end-of-life management activities tracked in module D (potential benefits beyond building life) are included, which highlights the need for architects and designers to consider deconstruction instead of demolishing at end of life and potential mass timber reuse in the original building design phase. The mass timber building had 9.6% higher TLCC than concrete building for a 60-year service life analysis. The cost was mainly driven by front end construction cost, especially mass timber cost, which is a relatively unknown parameter. Uncertainty analysis showed that the building's service life span and a design that allowed for recycling of the mass timber could significantly lower the TLCC of mass timber building.

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CORRIM: Phase I Final Report

Module N

TRACKING CARBON FROM SEQUESTRATION IN THE FOREST TO WOOD PRODUCTS AND SUBSTITUTION

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EXECUTIVE SUMMARY

Forest management's role in carbon cycling is often viewed as one of expanding the terrestrial pool in forested ecosystems, and many conclude that the removal of timber for storage in product form does not lead to reductions in atmospheric concentrations of carbon dioxide. This study tests the conclusion by analyzing the forest's role in carbon cycling using an accounting system that tracks carbon from sequestration to substitution in forest product end-use markets. Various models are used to convert carbon into comparable units during its forest stage through to its product pool stage. The amount of carbon embodied in wood and competing products in end-use markets are taken from a life cycle inventory and analysis study on housing construction. The study concludes that forest management leads to a significant reduction in atmospheric carbon by displacing more fossil fuel intensive products in housing construction. However, forest management's role in global warming can be recognized only if this displacement is included in carbon accounts. The result has important policy implications since any incentive to manage forest lands more intensively would likely increase the share of lands positively contributing to a reduction of carbon dioxide in the atmosphere, a position that is not supported by the Kyoto Protocol which only recognizes terrestrial pools of carbon.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

Many studies conclude that forest management for timber products will lead to lower forest carbon stocks, and hence more emissions of carbon dioxide and higher carbon concentrations in the atmosphere. Cooper (1983) was among the first to demonstrate that converting a forest region of fully stocked mature stands into managed stands decreases the forest carbon stock by about two thirds. Harmon et al. (1990) used simulations to illustrate the reduction and subsequent time path of forest carbon when an old growth forest is converted to younger plantations. These early studies limited their analysis to an examination of only forest carbon. Dewar (1990) introduced forest product carbon. He showed that longer timber rotations sequester more carbon if products decay less quickly than the harvest rotation. While the Dewar (1990) study considered carbon storage in both forests and its timber products, his study did not consider embodied forest products carbon as a substitute for fossil fuel.

Energy embodied in wood products has been recognized to be an important carbon pool (Koch 1991). Yet there has been little or no analysis that tracks the movement of carbon from forest to forest products end uses accounting for embodied energy and their carbon emission implications. A notable exception is the work by Schlamadinger and Marland (1996). They analyze 4 mechanisms by which net flux of carbon to the atmosphere may be influenced through forest management. Glover et al. (2002) presents a life cycle assessment of wood versus concrete and steel in house construction concluding that houses built primarily of wood require lesser amounts of energy in their manufacture, construction and use. The present study analyzes the movement of carbon. It creates a carbon account for three stages of forests and forest products to determine whether forest management leads to more carbon emission to the atmosphere and higher carbon concentrations there. It differs from the recent life cycle assessment by Glover et al. (2002) in that the carbon account considers the forest stock, the product stock and the product market implications of carbon emissions from fossil fuel use.

The findings of this study are important in two respects. First, the study shows that management of forests can positively contribute to reduced carbon concentrations in the atmosphere. Second the study indicates that international protocols to reduce the threat of climatic change, such as the Kyoto Protocol, limit the recognition of forestry activities since such protocols do not explicitly consider the positive contributions of forest management and wood use, but rather view forest management activities as a leakage issue.

This report is organized as follows. The carbon debate and the relevance of this debate to forest management as a mitigation option are summarized in the following section. In section 3 the study approach is outlined. Model assumptions are presented in Section 4. In sections 5 and 6 the results of the analysis and related discussion are presented. The final section of the report examines the question of whether forest management leads to more carbon emissions to the atmosphere.

2.0 THE CARBON DEBATE

The most recent IPCC report (IPCC 2001) concluded that global change is occurring. The report also recommended that a life cycle analysis is needed to describe the fate of stored carbon in industrial applications, including the conversion efficiency from tree growth into wood products. However, debate leading to the Kyoto Protocol ignored stored carbon in industrial wood products as forestry options were developed. Product carbon is not recognized as a valid carbon credit, nor is the substitution effect associated with greater production of wood products from more intensive forest management.

There are three options for mitigating the rate of carbon emissions to the atmosphere associated with forests. They are 1) increasing standing carbon in vegetation, 2) increasing product carbon storage and 3) substituting for fossil fuel use in economic activity. The Kyoto Protocol recognizes only changes in vegetation carbon as legitimate carbon sequestration. A forest landowner cannot claim credit for any reduction in carbon emissions associated with forest management that leads to less steel or concrete use in the housing market for example. Hence many of the forestry-based options that have been analyzed have been limited to preservation and afforestation projects.

In this study we examine mitigation options available through forestry and forest products use in the economy. We show that, while actions on the part of a forest landowner to intensify his or her forestry practices may lead to less carbon stored in the forests, it creates positive carbon leakage through greater use of wood products in the market place. The term leakage is used since most of the impact of intensive management on carbon pools occurs outside of the forest management project boundary. The leakage is positive since it reduces emission to the atmosphere. The effect of producing and using more wood products reduces consumption of more fossil fuel intensive products in home construction. The proper boundary condition for carbon and wood flows extends beyond the perimeter of the forest area whenever wood is harvested for products.

3.0 STUDY APPROACH

The study approaches the problem of evaluating the forest mitigation option by creating an accounting method that tracks carbon from forest to product end use. We follow the approach suggested by Sampson and Sedjo (1997). The method accounts for biomass carbon, product carbon and fossil fuel substitution carbon. The sum of the three components is defined as total carbon and is measured on a per hectare basis. Comparison of the total carbon accounts across alternative management and no management scenarios are made to assess how a forest management mitigation option influences carbon sequestration and emissions. We pay particular attention to how rotation age and management intensity influence the movement of carbon in all three accounts.

The study utilizes several models that track carbon stocks and emissions from reforestation to forest product use. Models at the forest level are combined with models that describe product use and their associated emissions at the product end-use level. We discuss the models and their use in the sections that follow. But first we describe the carbon pools that are relevant to our study. This literature review becomes our basis for calibrating the carbon model.

3.1 CARBON MOVEMENT AT THE FOREST LEVEL

Forest ecosystems have essentially three carbon pools: living biomass, detritus, and soils. Forests represent a huge storage of carbon since they hold about 80 % of the carbon fixed in the living biota. Much interest and effort has been put into their study due to the fact that much of it can be directly altered by human activity. Different studies present a dichotomy on aboveground biomass dynamics, with some suggesting that aboveground components can be a net sink (Delcourt and Harris 1980, Oliver at al. 1990), or a net source (Houghton et al. 1983, Harmon et al. 1990) of carbon.

In the development of a forest, the foliage, litter fall, net wood production, and nutrient accumulation in above ground tree components usually reach a plateau as trees mature during the stem exclusion stage (Tadaki 1966, Gessel and Turner 1976, Oliver 1981, Sprugel 1985). This pattern, for example, characterizes Douglas-fir (Turner and Long 1975) and directly impacts the development of biomass through time in the various components.

The distribution of standing forest biomass in representative stands in the Pacific Northwest region has been previously estimated (Grier and Logan 1977, Keyes 1979, Edmonds 1980, Vogt et al. 1980, Cooper 1983, Keyes and Grier 1981, Santantonio and Herman 1985, Vogt et al. 1986, Edmonds 1987). Total biomass and forest carbon will depend on stand conditions such as age, density, and species composition. However, biomass distribution in coniferous stands of forests of the Pacific Northwest is very similar and is roughly as follows: 65-75% in the stem and bark, 15-20 % in coarse roots, and 5-10 % in the crown (branches and foliage). Biomass in stem and bark on a 40 year old Douglas-fir stand on a high productivity site was about 76 % (Cooper 1983; this proportion was determined to be about 73 % in a low productivity site planted with Douglas-fir (Keyes and Grier 1981). Similar values have been established for old growth Douglas-fir in western Oregon (Grier and Logan 1977).

Soils are believed to be the largest pool of carbon. Soils contain almost twice as much carbon as the aboveground vegetation and the atmosphere combined (Brady 1996). The live biomass, which includes above and below ground pools is composed of coarse roots, understory vegetation and canopy, captures carbon dioxide while releasing oxygen, and also respires, releasing part of the carbon dioxide previously absorbed. Detritus, the debris from dead plants and animals, is a source of storage as well as a source of food for life forms releasing carbon. Detritus forms soils, and soils regulate the carbon cycle through processes of decomposition and the accumulation of organic matter.

The effects of forest management on carbon soil storage are not as clear nor as well understood as our knowledge of carbon in living biomass and detritus. Estimated carbon storage in belowground components is known and has been measured (Brady 1996), but knowledge is lacking as to how harvesting and forest management affect soil carbon.

Soil carbon has been found to be strongly dependent on stand composition and climate (Schlesinger 1977). Organic carbon in the root zone accounts for approximately two-thirds of the carbon in terrestrial ecosystems worldwide (Post et al. 1982). Such carbon is less responsive to harvest than the litter fraction because of its long residence time. Post et al. (1982) estimated a soil carbon turnover rate of 0.00083 per year, although faster turnover rates have also been shown: 0.013 per year (Gardner and Mankin 1981) and 0.025 per year (Schlesinger 1977).

Harvesting can have a significant positive or negative effect on forest floor biomass, mostly based on how much slash is left behind after the harvest operation (Johnson 1992). The majority of studies however, have shown little or no change, with less than 10 % increase or decrease after harvest (Fernandez et al. 1989, Johnson et al. 1991, Aztet et al. 1989, Huntington and Ryan 1990, Alba and Perla 1990, Raich 1983). Exceptions are found in tropical areas. Several researchers suggest a much lower rate of carbon loss following harvest than the commonly held assumption of soil carbon losses of 30-40% (Musselman and Fox 1991).

Fire, be it prescribed or a wild fire, reduces carbon and the overall forest floor biomass. The effect on biomass depends on the intensity of the burn. In the Pacific Northwest, a study found significant losses of forest floor biomass and nitrogen (40%) after a wildfire (Grier 1975). Another study, where a broadcast burning was prescribed, found a decrease in soil carbon of 20 to30 percent, with an equal or higher level of soil carbon almost two years after the prescription (Macadam 1987).

Carbon within soil can be increased with fertilization through its effect on primary productivity. Nitrogen fixation and fertilization may increase soil carbon from 3% to 100% depending on the site and the species mix composition (Binkley 1983, Binkley et al. 1982).

3.2 CARBON MOVEMENT IN PRODUCTS

Harmon et al. (1990) argued that the conversion of old-growth forests to younger forests under current conditions has added and will continue to add carbon to the atmosphere, even when considering long-term products such as lumber. Oliver et al. (1990) found similar results at the forest ecosystem level, but pointed out that the conversion of old growth to managed stands is negligible when compared to the addition of carbon by the burning of fossil fuels. Both studies recognized carbon movement in products as a potentially important consideration but did not give it an adequate deliberation.

Forests store carbon as they accumulate biomass, but forests are also sources of commercial timber and wood fiber products. In most carbon accounting budgets, forest harvesting is usually considered to cause a net release of carbon from the terrestrial biosphere to the atmosphere (Houghton et al. 1983, Harmon et al. 1990). There are at least two implications of drawing the boundary on carbon movements at the edge of the forest. One, no credit is received for the carbon stored in the product pool. Second, and perhaps more importantly, the product pool represents a pool of embodied energy that has been used in its manufacture. This pool of products enters the marketplace and competes with other products that also have embodied energy used in their manufacture. The substitution of fossil fuel-based energy and products by wood biomass can further decrease the emissions of carbon to the atmosphere (Schlamadinger and Marland 1996, Kohlmaier et al. 1998).

4.0 MODELING ASSUMPTIONS

The carbon account is created using a suite of models that can be customized to different site conditions. We use conditions for the west Cascades area of the Pacific Northwest region. Tree list inventory data combined with growth and yield model simulations and the Landscape Management System (LMS) (Oliver et al. 1992) are used to simulate inventory conditions through time and create the forest account. Multipliers based on the literature review then take various biomass components and convert them into carbon on a per unit basis. The forest module calculates the carbon pools accounting for changes in growth, mortality and decomposition of various carbon pools. Products are exported from the forest module to the product module, which then calculates carbon pools in products and manufacturing centers. Each module is described in more detail below.

Use of the forest biomass module requires that a tree list be entered into the LMS, which tracks tree and stand development through time including diameter information. The diameter is used to estimate various biomass components using Ghotz (1982). Biomass is converted into carbon using Birdsey (1992, 1996). Forest components include the canopy, the stem, roots, litter and snags. The module also considers their decay. Canopy biomass is composed of foliage and branches and is 5% to 10% of the total biomass. Stems, composed of the tree trunk and bark, were assumed to make up 65% to 70% of the total biomass. Coarse roots were assumed at 20% to 25% of total biomass and carbon in litter was assumed to be 10% of foliage and branches (Spies and Franklin 1988, Edmonds 1979, Grier and Logan 1977). Assumptions as to the volume in snags were based on mortality predicted by a growth model, adjusted for the density of snag class and is less than 0.5% of total biomass (Canary et al. 1996). Carbon decomposition is modeled following Aber and Melillo (1991).

$$X_t = X_0(1 - k^* t)$$

Where X_t is the biomass at time t, X_0 is the initial biomass, k is a species specific constant describing the biomass loss per year and t is time in years. $k = 0.16$ for litter, 0.5 for snags and coarse roots (Turner et al. 1995, Harmon and Sexton 1996, Canary et al. 2000). More complex nonlinear decay models could easily be incorporated but are not likely to alter any conclusions.

The products module is based on data produced by the Consortium for Research on Renewable Industrial Materials (CORRIM) (Bowyer et al. 2004). The module tracks carbon pools associated with production of forest products from the forest through to end use in the housing sector. Products that are exported from the forest as commercial volume are first converted into biomass and then into carbon using species dependent density factors (Birdsey 1992, 1996). We use the results of sawmill studies (Bowyer et al. 2004) to distribute the commercial volume into long- and short-term products. Roughly fifty percent of the forest carbon in a harvest is exported to lumber, a long-term product. The remaining 50% of carbon is exported to wood chips, sawdust, bark, and shavings, all short-term products or hog fuel used for the production of energy. Short-term products are assumed to decay at 10% per year (Harmon et al. 1996, Winjum et al. 1996). Hog fuel is decomposed in the production of energy. Long term products are assumed to decompose at the end of the useful life of a house, which was set at 80 years, within the range estimated by Bowyer et al. (2004; Module L). Harvested timber volumes per acre are converted into product volumes, then to mass expressed in pounds per thousand board feet. Mass is then converted to carbon units considering moisture content.

Energy consumption and air emissions associated with the manufacture of products used in the housing sector are used to analyze carbon flows associated with alternative building techniques with different materials. Bowyer et al. (2004) provides an analysis of home construction in two markets with competing materials. The study utilizes a life-cycle inventory produced by CORRIM (2004) to quantify the carbon emissions and convert them to a per hectare basis to be compatible with the forest carbon account.

Bowyer et al. (2004) provides data for a 45 year rotation harvest producing the wood products for one typical wood house in the Minneapolis market. If no wood were harvested, the use of non-wood products would have to increase to support the same housing market. Substituting 4.9 metric tons of steel and additional insulation for 5.3 metric tons of wood in the steel versus wood frame construction tradeoff emits 9.8 metric tons of CO_2, based on CORRIM results. In other words, foregoing the 134 metric tons of wood products that would be produced in a 45 year rotational PNW harvest, is equivalent to emitting 266 metric tons of carbon dioxide per hectare (72.5 tons carbon) by steel frame substitution. Similarly, substituting 2000 concrete blocks, additional mortar and rebar for 1.5 metric tons of wood in the concrete versus wood-frame construction emits 7.7 additional metric tons of CO_2. So foregoing the PNW harvest is equivalent to emitting 701 metric tons of carbon dioxide per hectare (191 metric tons of carbon) by concrete frame substitution. When a harvest occurs, the carbon contained in products is moved from the forest to product account with a corresponding reduction in emissions from substitute products by the above amounts and referred to as avoided emissions. The carbon in co-products is assumed to be short lived and decomposes rapidly (10% per year).

We utilize scenario analysis to quantify the effects of rotation age on carbon accounts. The four scenarios involve 45, 80 and 120-year rotation and a no-harvest scenario. The no-harvest scenario is not equivalent to earlier natural stands since it includes initial stocking and no disturbances but offers some insight for an afforestation-without-harvest scenario.

The study creates a carbon account for each scenario. The account is composed of the carbon in forest stocks, product stocks and the emissions associated with their manufacture and use in construction. We also consider biomass as potential energy in our analysis for co-products that could be used as biofuel. The forest stock includes canopy, tree stems, snags, litter, live roots, dead roots and, when harvesting occurs, emissions of carbon. The product stock includes product carbon (both short and long lived). It includes the transporting and manufacturing emissions associated with the production of the long-lived products that are used in housing construction. The transporting and manufacturing emissions associated with non-biofuel co-products are not tracked so as to be consistent with the assumption that their use would carry their own burden. We illustrate the option of using most low-valued co-products as biofuel, thereby transferring their burdens to the completed long-lived products. The embodied energy account includes emissions associated with the use of substitute long-lived products in the housing market.

5.0 RESULTS

The results are described in four phases. The first phase consists of analyzing the change in carbon over time associated with the forest stock. The study result is consistent with previous results found in Franklin et al. 1997, Burschel et al. 1993, Houghton et al. 1983, Harmon et al. 1990, Oliver et al. 1990, Cooper 1983, Dewar 1991, and Schlamadinger and Marland 1996. Extending the rotation age increases the store of carbon associated with the forest pool. The second phase consists of analyzing the change in carbon over time as carbon is exported from the forests as products. The result suggests again that extending the rotation age increases the store of carbon in forest and product pools as the decomposition of co-products is effectively delayed. The third phase analyzes substitution and the change in emissions associated with the use of substitute products in the housing market. The result indicates that shorter rotations contribute to less carbon emissions since the impact of reducing the use of fossil fuel-intensive, non-wood products more than offsets the effect of the reduced carbon stored in the forest. The fourth phase studies the impact of more intensive management on carbon pools. The result indicates that greater management intensity contributes to less carbon emissions, and is generally more effective in reducing emissions than long rotations especially when economic costs are considered.

5.1. CARBON IN FOREST STOCKS

Figure 5.1 illustrates the change in forest carbon stocks over time under 4 alternative management scenarios. Carbon in metric tons per hectare increases as the forest grows, declines sharply as harvests take place, and responds with renewed growth under all scenarios except with the no action scenario. Under the no action scenario, carbon increases for several hundred years assuming no major disturbance. The assumption of initial stocking followed by no disturbances is not representative of old forests under natural conditions, so it should be interpreted with caution. The no-action scenario demonstrates a hypothetical upper bound to forest growth as an afforestation scenario. Empirical yields for existing old forests in the Northwest contain only slightly more carbon than the 120 year rotation as a consequence of uneven stocking and disturbances, whereas this hypothetical upper bound suggests much more carbon.

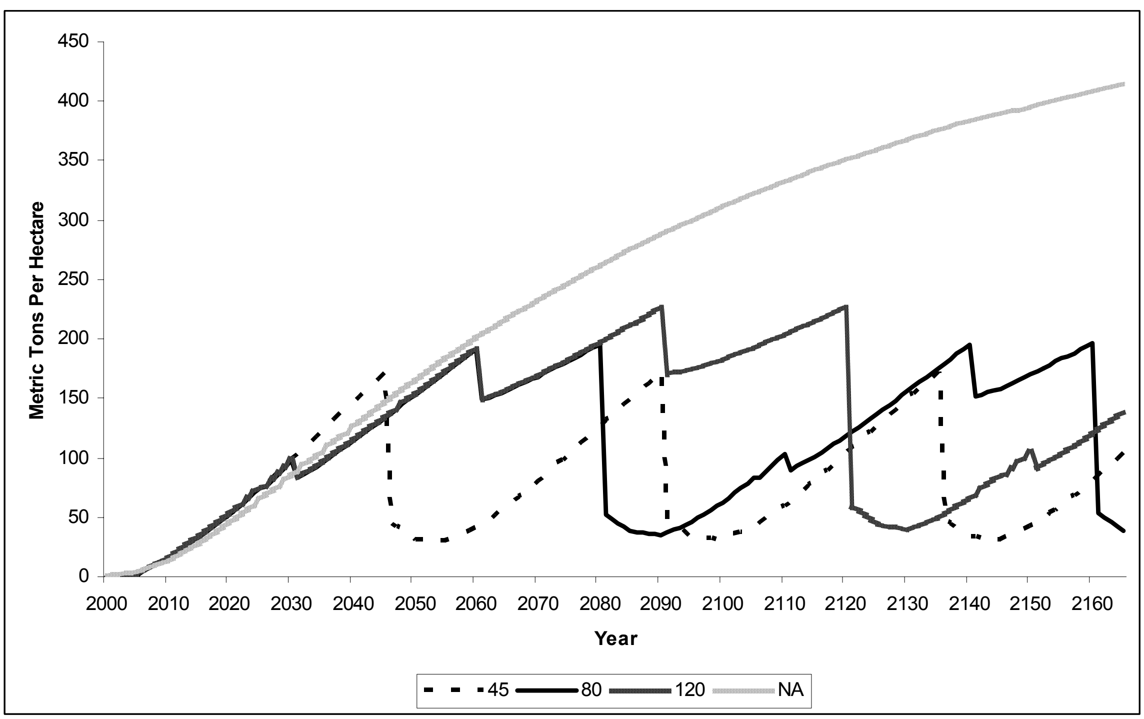

Figure 5.1. Carbon in forest pools for different rotations.

The area under each curve is the cumulative carbon and one can observe that over time, the most carbon is accumulated under the no action scenario, followed by the 120 year rotation scenario, then the 80 year rotation scenario and finally the 45 year rotation scenario. Figure 5.2 shows the sub-accounts leading up to the cumulative carbon pools for the 80 year rotation including two thinning treatments demonstrating that carbon in the stem of the tree is most important, with some offsetting influences over time from decaying litter and roots. For any given repeated treatment scenario forest carbon ultimately reaches a long term steady-state condition. Even the no management scenario will ultimately succumb to disturbances, and so long as the next cycle is similar to the prior cycles, a long-term, steady state condition will be reached.

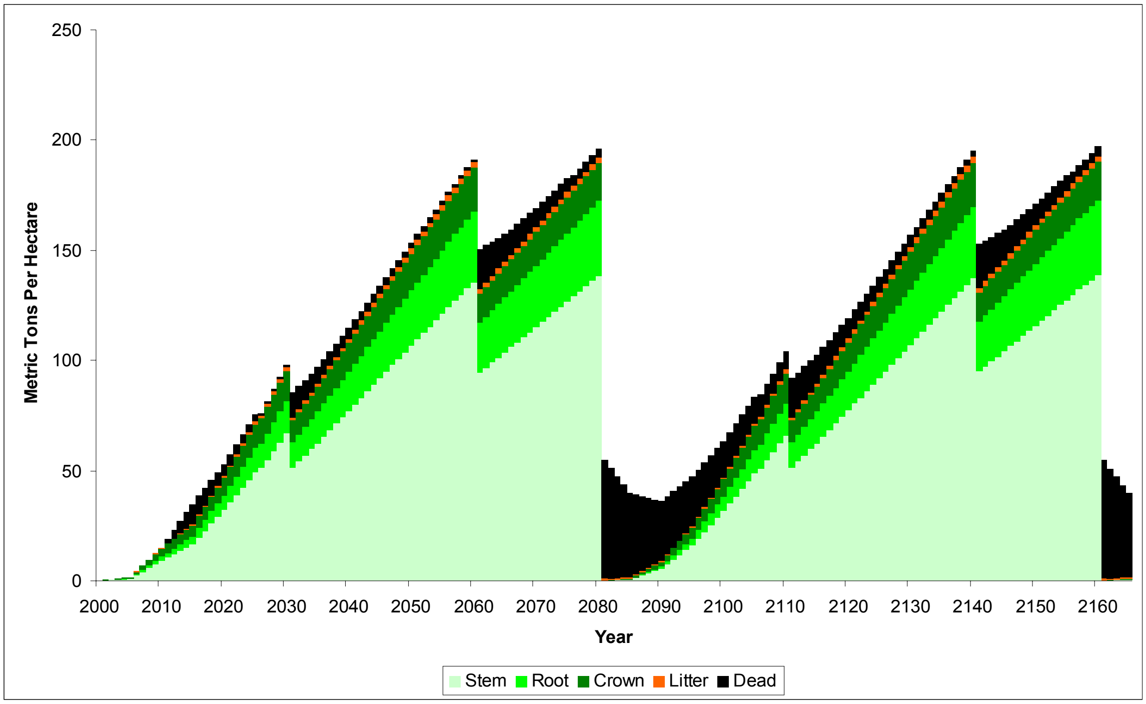

Figure 5.2. Carbon in the forest pools for an 80 year rotation.

5.2. EXPORT OF CARBON IN FOREST PRODUCT

The fate of harvested carbon needs to be accounted for however. As forest carbon is exported into products, product carbon pools develop. Figure 5.3 summarizes the carbon in product pools for the 80 year rotation. It shows that product pools more than offset harvesting and manufacture emissions. There is no carbon associated with products under the no-action scenario since this scenario does not export products. For the longer rotation scenarios the product pools develop much later in time than for the short rotation scenarios. The carbon in short-lived products is assumed to decompose completely during the rotation period contributing no long-term increase to the products carbon pool over time.

Alternatively, any portion of these short-lived products can be used for energy production which would reduce purchased energy needs. The effect of such a decision is that the energy produced and the carbon emissions saved by substituting for fossil fuels becomes a permanent carbon pool instead of a short-lived product that is rapidly decomposing. A longer-term pool than even wood products in buildings which eventually decompose is created under such an energy substitution scenario. But in the very short term, there is a loss in the short-lived products pools as the efficiency of the conversion of wood to energy is lower than gas fired boilers (or coal). The net impact is a small displacement of fossil fuel derived carbon in the short term, but accumulating with each harvest. The decomposition of the long-term products is assumed to take place at the end of an 80 year useful life of the house which could more correctly be modeled as a distribution with some houses removed earlier and others later with no material change on long-term comparisons.

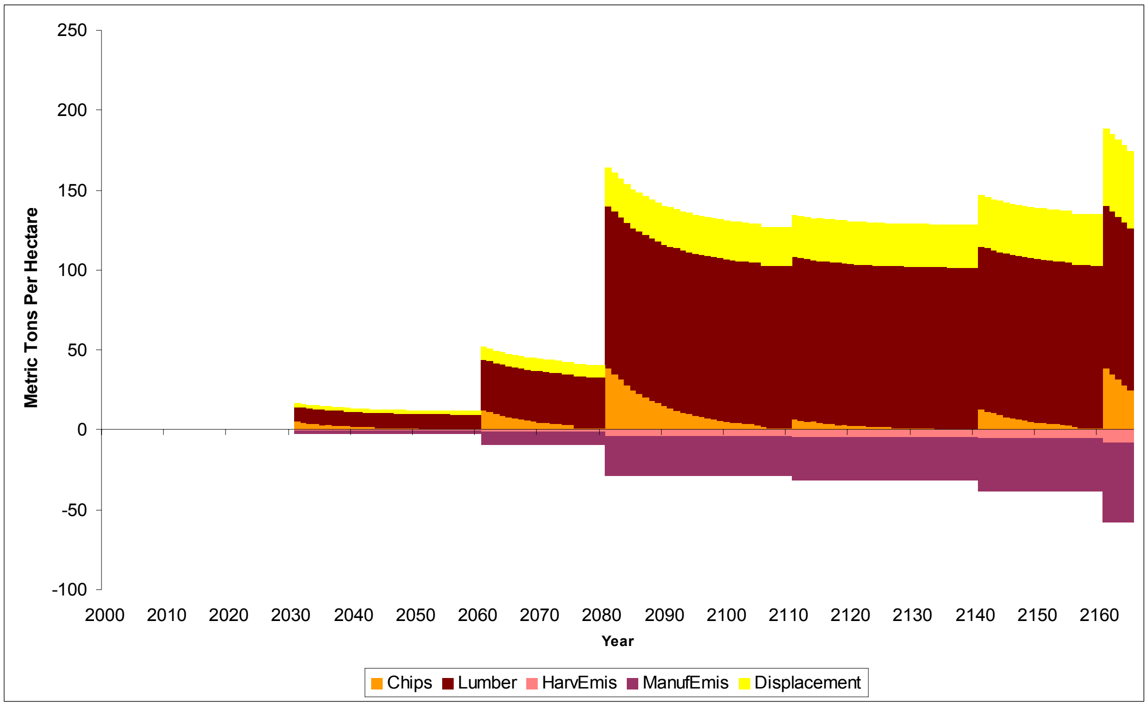

Figure 5.3. Carbon in the products pools for an 80 year rotation.

Figure 5.4 combines the forest and product pools over time for the four scenarios. As in Figure 5.1, the no-action scenario contains the most carbon (area under the curve). The 45-year rotation contains the least carbon. Unlike forest carbon which reaches a long term steady state, there is an upward trend in the carbon stored in products as the decomposition is slower than the rate products are produced. The figure includes the impact of using the non-structural co-products other than chips for energy rather than other short lived products, boosting the long-term storage somewhat consistent with mills that produce most of their own energy needs from wood biomass. For the 45 year rotation this displacement for the carbon from purchased energy increases from 13% of the net product pool over the first 80 years to 19% over the first 120 years, and 29% over 165 years demonstrating the accumulative nature of displacement.

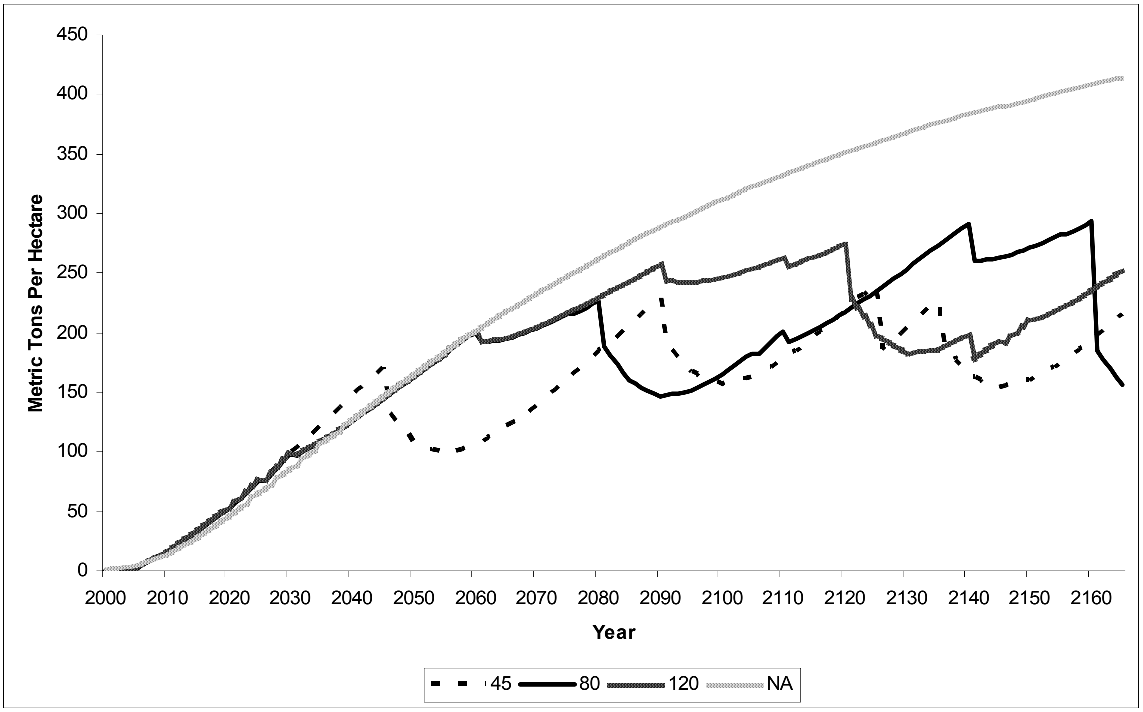

Figure 5.4. Carbon in forest and products pools in metric tons per hectare.

5.3. SUBSTITUTION EFFECTS

Wood enters the marketplace and competes with alternative materials in end uses such as housing. Without wood products, less wood houses would be built and more concrete or steel-framed houses would be constructed. The energy burden each product carries has implications for carbon emissions. Figure 5.5 summarizes the carbon pools for the 80 year rotation including the carbon resulting from displacing cement-framed houses as wood products are produced. The increasing trend in carbon pools is substantially greater with the substitution of wood for cement, the second most prevalent framing material in the residential housing market.

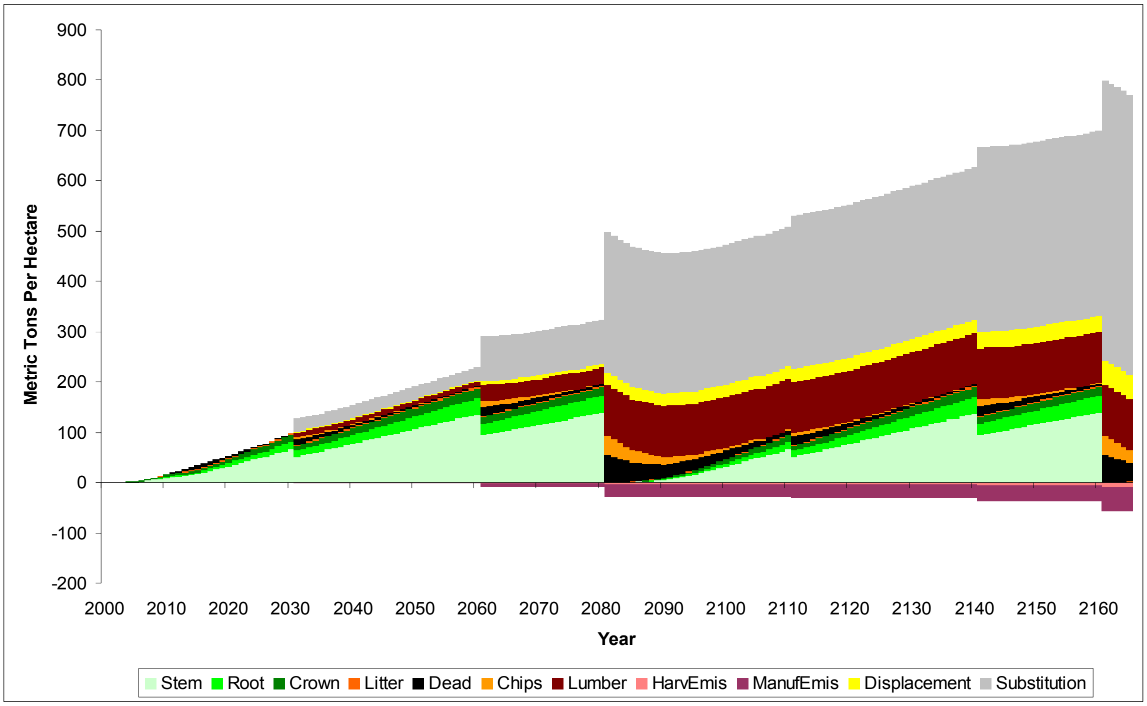

Figure 5.5. **Carbon in the forest and product pools with concrete substitution for the 80 year rotation.**

Table 5.1 summarizes the carbon account averages for intervals of 0-45, 0-80, 0-120 and 0-165 for each of the rotation scenarios and product pools (forest, products, displacement and substitution). Figure 5.6 summarizes these impacts for each rotation and time interval. Unlike the previous charts which show carbon increasing with longer rotations the figure indicates an inverse relationship between rotation age and sequestered carbon with the least amount of carbon stored with the no action alternative. When the fossil fuel burdens in substitute products are included, the shorter rotations gain the benefit of this displacement sooner. While it may be true that over the very long term, the increased volume coming from longer rotations will eventually overtake the early shortfall in products the time frame for this crossover would appear to be in the hundreds of years and beyond any interval of interest for policy.

Table 5.1. Average annual carbon for all rotations at specified intervals in metric tons per hectare.

	averages			
	0-45	0-80	0-120	0-165
45 year rotation BASE				
NET FOREST	70.60	67.30	71.25	74.45
NET PRODUCTS	0.00	24.74	45.38	50.72
NET FOREST & PRODUCTS	70.59	92.03	116.63	126.96
NET FOREST, PROD, DISPLAC.	70.59	95.56	125.46	142.20
NET FOR, PROD, DISPLAC, SUBST.	70.59	165.69	266.18	360.28
80 year rotation				
NET FOREST	60.46	106.90	94.45	110.50
NET PRODUCTS	3.63	11.22	36.92	46.96
NET FOREST & PRODUCTS	64.10	118.12	131.37	157.46
NET FOREST, PROD, DISPLAC.	64.24	119.58	138.27	169.75
NET FOR, PROD, DISPLAC, SUBST.	72.63	150.76	253.16	348.81
120 year rotation				
NET FOREST	60.46	106.95	137.38	121.30
NET PRODUCTS	3.63	11.32	21.08	41.39
NET FOREST & PRODUCTS	64.10	118.27	158.85	163.66
NET FOREST, PROD, DISPLAC.	64.24	119.69	163.14	174.12
NET FOR, PROD, DISPLAC, SUBST.	72.63	150.87	232.20	330.64
No Action				
NET FOREST	60.17	124.03	185.53	238.55
NET PRODUCTS	0.00	0.00	0.00	0.00
NET FOREST & PRODUCTS	60.17	124.03	185.53	238.55
NET FOREST, PROD, DISPLAC.	60.17	124.03	185.53	238.55
NET FOR, PROD, DISPLAC, SUBST.	60.17	124.03	185.53	238.55

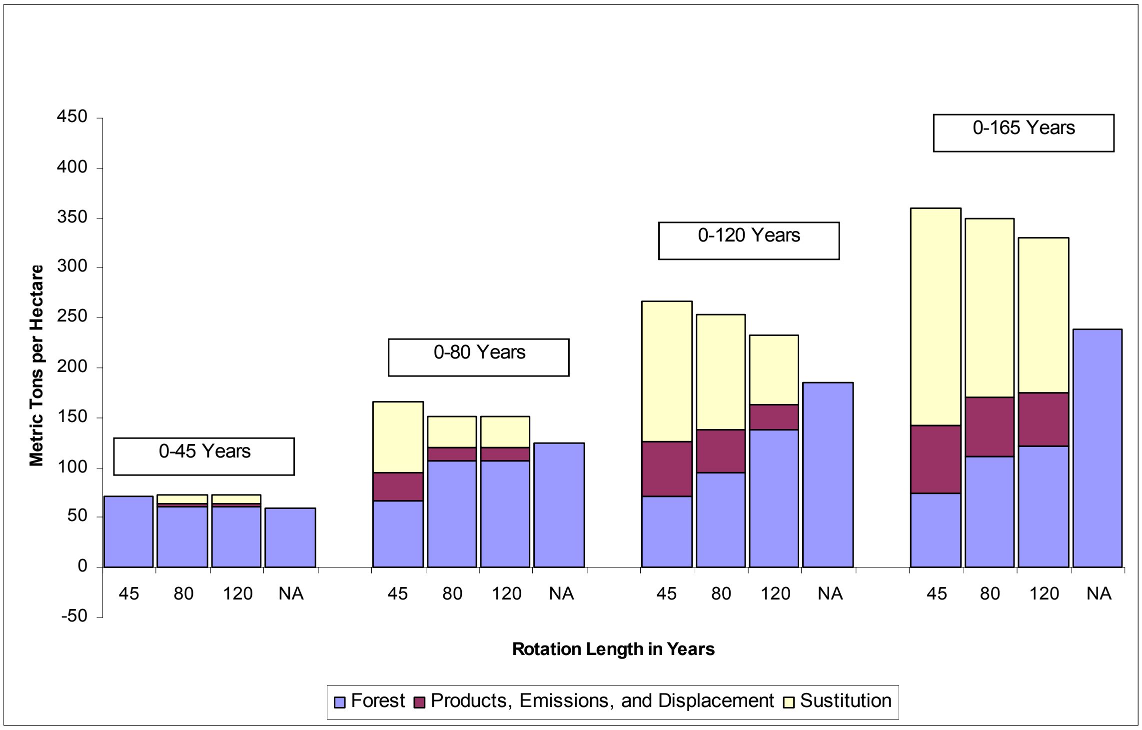

Figure 5.6. **Average annual carbon in forest, product and concrete substitution pools for different rotations and specified intervals.**

5.4 MANAGEMENT INTENSITY

Since the results indicate that forest management leads to more forest products, and that by displacing fossil-fuel intensive products in an end-use market such as housing construction it reduces atmospheric carbon, we explore the implications of intensively managing the forest. The objective of greater forest management is to increase commercial volumes that can be harvested and measure their contribution to the carbon in the products pool. Many acres of industrial forestland are not intensively managed but could be with a small incentive, so such a scenario is relevant to current forest management policies.

The result (Table 5.2 and Figure 5.7) indicates that an increase in management intensity leads to greater carbon pools when we consider the market substitution effects. Under the 45-year rotation age and under greater management intensity, net carbon increases from 72 metric tons per hectare to 89 metric tons per hectare, a 24% increase over the 45 year interval. Net carbon reaches 410 metric tons per hectare over 165 years with intensive management compared to 365 tons, a 12% increase compared to the base case. Extending the rotation just a few years, i.e. 55 years in the illustrated scenario, under intensive management allows the release of increased growth on fewer trees to catch up with the volume removed from the forest. It results in another 2% increase in carbon. But this increase in carbon comes at a substantially greater economic cost and hence would not likely be a cost-effective management option.

Table 5.2. Average annual carbon for all management intensities at specified intervals in metric tons per hectare.

	averages			
	0-45	0-80	0-120	0-165
45 year rotation BASE				
NET FOREST	70.60	67.30	71.25	74.45
NET PRODUCTS	0.00	24.74	45.38	50.72
NET FOREST & PRODUCTS	70.59	92.03	116.63	126.96
NET FOREST, PROD, DISPLAC.	70.59	95.56	125.46	142.20
NET FOR, PROD, DISPLAC, SUBST.	70.59	165.69	266.18	360.28
45 year rotation High				
NET FOREST	69.47	68.33	71.95	74.47
NET PRODUCTS	5.07	30.36	51.10	56.68
NET FOREST & PRODUCTS	74.53	98.69	123.60	133.14
NET FOREST, PROD, DISPLAC.	74.81	103.24	134.34	151.14
NET FOR, PROD, DISPLAC, SUBST.	86.93	190.53	300.61	404.98
55 year rotation				
NET FOREST	69.71	77.49	89.77	96.05
NET PRODUCTS	5.25	29.88	50.09	54.46
NET FOREST & PRODUCTS	74.96	107.36	139.86	152.27
NET FOREST, PROD, DISPLAC.	75.16	111.00	149.30	169.56
NET FOR, PROD, DISPLAC, SUBST.	87.28	192.57	305.61	411.52
No Action				
NET FOREST	62.06	125.73	186.90	239.61
NET PRODUCTS	0.00	0.00	0.00	0.00
NET FOREST & PRODUCTS	62.06	125.73	186.90	239.61
NET FOREST, PROD, DISPLAC.	62.06	125.73	186.90	239.61
NET FOR, PROD, DISPLAC, SUBST.	62.06	125.73	186.90	239.61

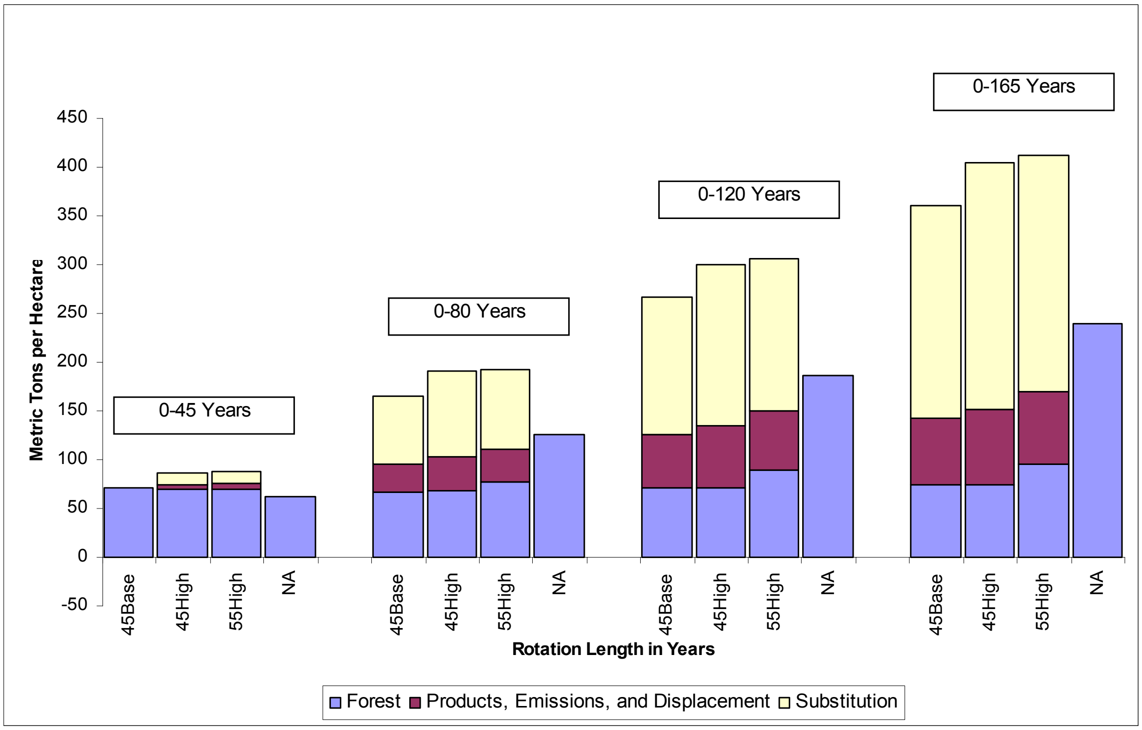

Figure 5.7. Average annual carbon in forest, product and concrete substitution pools for different management intensities for specified intervals.

5.5 ECONOMIC TRADEOFFS

The economic cost of long rotations (Stand Expectation Value (i.e. bare land value) at 5% real discount rate) is high as is shown in Figure 5.8. The economic cost of intensive management is sensitive to treatment costs and market returns and may even be positive (as shown for 45 High) unless the treatment extends the rotation length significantly. Our scenarios show a $503 loss for extending the rotation to 55 years producing an insignificant carbon increase in the short term and only 6.5 metric tons over 165 years. This is equivalent to a production cost of $77 per ton of carbon sequestered. However, many land mangers have not taken the risk of the increased investment associated with intensive management over a 45 year rotation so it may take very little in additional compensation from carbon credits to gain 17 metric tons of carbon/hectare in the short term and 45 metric tons over 165 years. The investment could contribute roughly 30 to 80 million tons of additional carbon on private lands for Washington State alone.

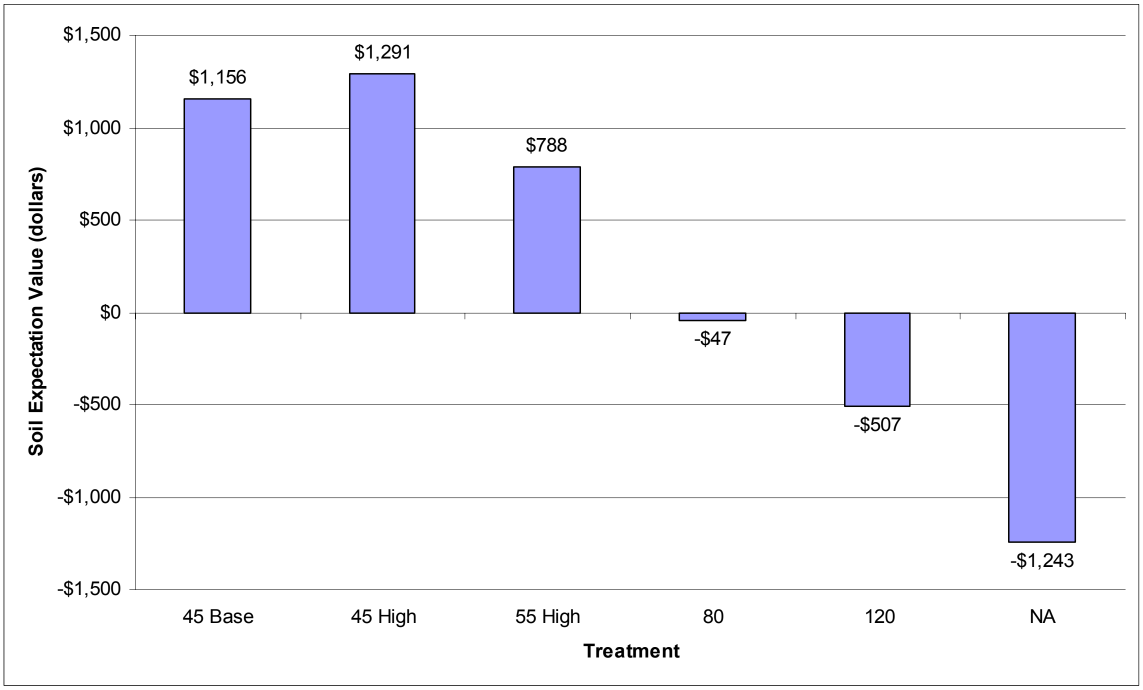

Figure 5.8. Soil Expectation Value for each rotation length and management intensity.

6.0 DISCUSSION

The paper constructs an accounting scheme that considers carbon from forests to end-use markets of forest and competing products. The accounting scheme combines three phases of a forest-based mitigation option of potential climate change where forests may play a role. The carbon phases are the forest pool, the product pool and the product substitution pool. This last pool includes the energy-use and carbon-emission implications of competing products.

The result indicates that a shorter rotation age does not lead to greater carbon emissions into the atmosphere. Short rotations produce more wood products sooner thereby reducing fossil fuel-intensive substitutes earlier in time. Forests managed under short rotations sequester less carbon than forests managed over longer rotations, but avoid and displace emissions associated with production and use of energy-intensive, competing products. Avoided emissions generally exceed any reductions in sequestration in the forest. The net result is that more carbon is sequestered in the forest and wood products under short rotations when the embodied energy pool is included.

This result also holds with more intensive forest management. Greater management activity in forestry leads to more products and greater amounts of carbon sequestered in the combined forest, forest products and displaced energy pools.

The result depends upon the kind of substitution that takes place in the market. While the market for residential houses is dominated by wood frame housing, followed by concrete, steel-framed housing has gained a 2% share in recent years. Figure 6.1 demonstrates that the impact of substitution between wood and steel frame produces less carbon in the substitution pool than concrete, but still demonstrates the benefits of using wood.

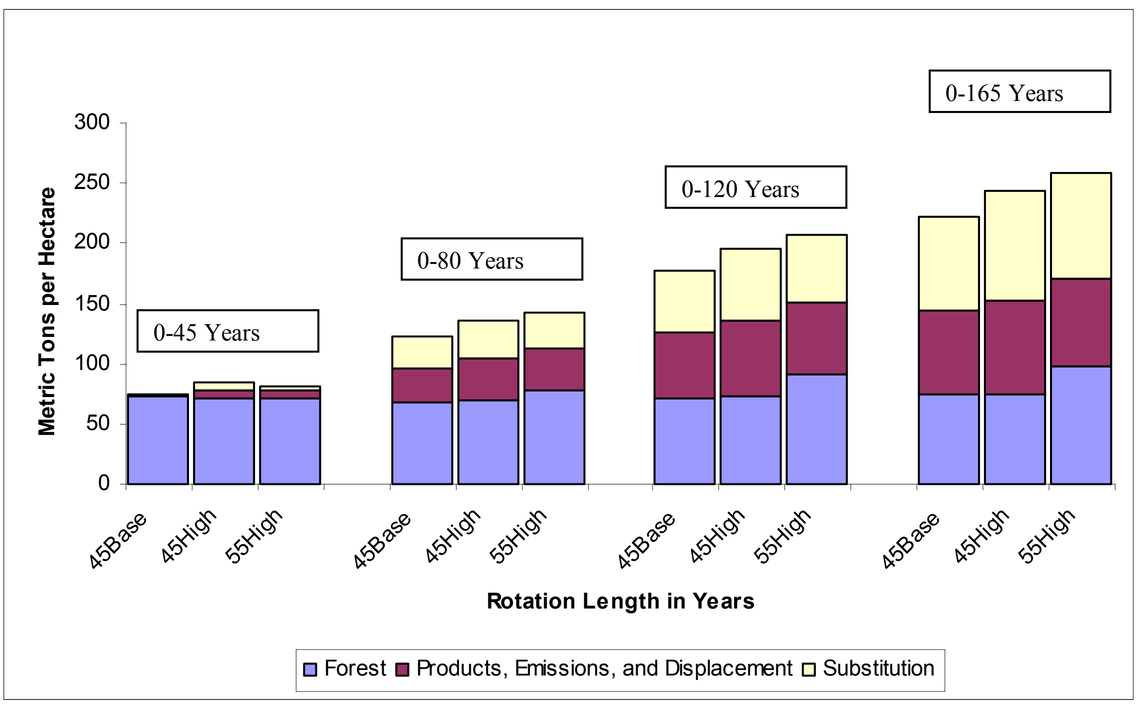

Figure 6.1. Average annual carbon in forest, product and steel substitution pools for different management intensities for specified intervals.

A major implication of the study is that forest management contributes in a positive fashion to mitigating potential climate change. Yet this positive contribution is not explicitly recognized in the Kyoto Protocol. The Kyoto Protocol only recognizes the reduction in forest carbon, and does not consider any other contribution to carbon sequestration that products exported from the forest may contribute. It is through market substitution that forest management leads to a net decrease in atmospheric carbon. While less carbon may be stored in the forest (average forest carbon over time is lower for shorter rotations) more carbon is exported from the forest and conserved in products, and less fossil fuels are utilized by economic sectors such as the housing sector. Leaving out the carbon stored in wood products and the impact of non-wood substitute products may be counterproductive to carbon policy objectives.

The implications of recognition for forest management's positive role in sequestering carbon is important since it could be used as an incentive to more actively manage many acres of forestlands. Increasing the productivity of these lands through greater investments in forest management could lead to significant gains in reducing atmospheric carbon.

The CORRIM report of which this is a part (Bowyer et. al 2004) develops life cycle inventory measures of carbon in support of housing. Live cycle analysis does not consider time and hence infers steady state results. This module demonstrates that when the focus is changed to looking at the implications for managing a fixed unit of land over time, carbon pools are not static but increasing so long as the products are serving long-term product markets. This analysis does however assume that the energy used by the housing occupants or the users of short lived products are burdens for those users and not the forest management system. The CORRIM report does consider the energy used in housing as a part of an integrated analysis.

7.0 CONCLUSION

The study analyzes carbon from sequestration in a forest to substitution of fossil fuels emissions from construction materials. When carbon stocks account only for forest sequestration, the longer the rotation the greater the amount of carbon removed from the atmosphere. Even if we are to consider the export of carbon from the forest into product markets, and even if the rate of exported carbon is greater than the rate of tree growth, conversion inefficiencies and eventual decay limits the amount of carbon removed by forests from the atmosphere. Only when product substitution is considered in the analysis do we find that forestry can lead to a significant reduction in atmospheric carbon by displacing more fossil fuel-intensive products. The current structure of the Kyoto Protocol does not recognize this contribution. Only through credit of the positive leakage from forest management projects into products can intensive forestry produce reduced atmospheric carbon within the Kyoto Protocol framework. Recognizing only the carbon stored in forests incorrectly subsidizes doing nothing or lengthening rotations which are counterproductive to the buildup of carbon in the product market pools. Even a small incentive for more intensive management would likely increase the share of lands so managed producing a substantial increase in carbon pools.

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Effective Uses of Forest-Derived Products to Reduce Carbon Emissions[1]

Bruce Lippke[2], Maureen Puettmann[3], Elaine Oneil[4]

Introduction

This updated research on the uses of forest-derived products summarizes the impacts of forests, forest products, and biofuels on carbon mitigation based on 22 years of research by CORRIM (The Consortium for Research on Renewable Industrial Materials (www.corrim.org)). CORRIM is comprised of 22 university and research associations. Since 1998, CORRIM has developed a data base from primary surveys of representative industries that manage forests and produce wood products, and secondary data of representative forest inventory from the USFS Forest Inventory and Analysis (FIA) program.

The data characterizes the environmental performance of wood from cradle-to-grave. It is based on life cycle inventories of all energy and material inputs and outputs for every stage of processing from forest regeneration, through harvest, processing, transportation, construction, building use, and final disposal. CORRIM has completed a plethora of reports and publications documenting the research. They show the fundamental differences in greenhouse gas (GHG) impacts when using wood and wood derivatives relative to using fossil fuel and materials with high fossil fuel inputs. The research analysis includes evaluations of the net carbon stores in forests and wood products, as well as the substitution of wood products for equivalent non-renewable products. Results consistently show beneficial displacement of fossil carbon emissions when a wood product is used over an alternative. These data have served as the primary information base for many other authors and publications including Malmsheimer et al. (1). They reference the IPPC's Fourth Assessment Report concluding; "In the long term, a sustainable forest management strategy, aimed at maintaining or increasing forest carbon stocks, while providing an annual sustained yield of timber, fiber, or energy from the forest, will generate the largest sustained mitigation benefit (1)."

This technical note provides updated data reflecting changes in technology and regulations over the past 20 years at wood product manufacturing facilities. It provides an integrated perspective of current progress and opportunities to reduce carbon emissions. It is focused on sustainable wood production of jointly produced products and biofuels, including impacts from the competition for feedstocks and the functional substitution of different products and uses. The findings reflect the complexities of tracking carbon. Since every living thing and manufacturing process alters the carbon footprint, every impact depends on a long list of other impacts. Specific measures for each product and process can be compared, including using the same feedstocks for a variety of products each with a different carbon impact. Results illustrate higher and better uses for a given feedstock. However, given the vast number of alternative scenarios, more often than not, any baseline set of comparisons will overlook many options leading to significant "unintended consequences". ***We provide a suite of examples which demonstrate the opportunities for improvement and aid us to better understand the many uses of wood and their associated impacts.***

[1] ACKNOWLEDGEMENT - This material is based upon work supported by the Department of Energy's Office of Energy Efficiency and Renewable Energy under the Bioenergy Technologies Office, Award Number EE0002992, project title, "Carbon Cycling, Environmental & Rural Economic Impacts of Collecting & Processing Specific Woody Feedstocks in Biofuels

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1. Technology changes and regulations have altered energy needs and processing emissions

Figure 1 shows a 5-60% increase in energy used between 2000 and 2012 for the production of a range of wood products. Changes are driven by three elements: 1) a more consistent metric for calculating total energy use from LCI data (2); 2) the LCI methodology has shifted from a manual calculation of energy resources to using an international standard impact method; and 3) the industry reported an increased use in emission control devices (ECDs) in 2012 relative to 2000 (3). The wood industry has faced more stringent emission standards for controlling hazardous air pollutants (HAPs). These standards drove an increase in the use of ECDs industry wide for engineered wood products (plywood, glulam, LVL, I-Joist). The ECDs require fossil-based energy sources (4). There are two exceptions: oriented strandboard manufacturing in the US Southeast, which included ECDs in the earliest survey (5) now shows a reduction in energy use, and Pacific Northwest (PNW) lumber does not show a significant change in energy use between the survey years.

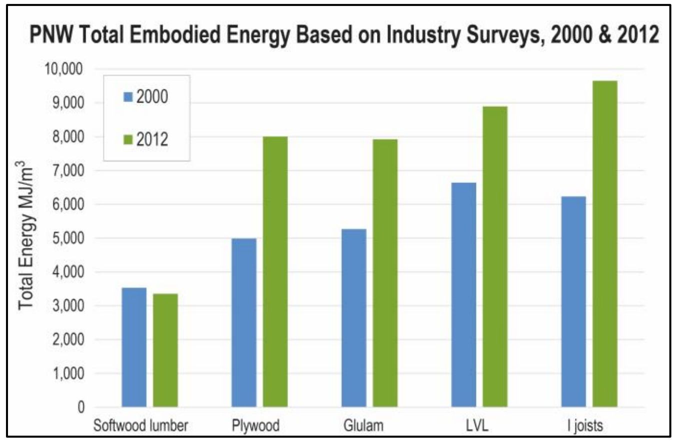

Figure 1. Comparison of cradle to gate total energy use by product for the PNW production region for survey data collected in 2000 and 2017.

Another significant change between 2000 and 2012 has been the substitution of fossil fuels with wood residues (biofuel) for heat energy. This results in a significant decrease in fossil carbon emissions for drying and panel pressing processes. However, this carbon benefit is overshadowed by the increased fossil energy used for ECDs. As a result of the increase in use of biofuel from earlier studies, global warming potential (GWP) impacts for lumber production decreased by 54 kg CO_2/m^3, increasing the net carbon stored in wood products by about 5% (6). Carbon emissions for wood production remain low compared to the amount of carbon stored in the wood product. ***Any diversion of biofuel feedstock from use for onsite energy will only increase production emissions and reduce efficient use of the wood residues. Long term composite panel products displace and store more carbon than is released during production.***

2. Every stage of processing is critical to understand opportunities to reduce emissions and climate change.

Growing Trees Stores Carbon in the Forest: The essential first step for wood to displace fossil fuels and increase carbon stored in products.

USFS forest inventory data (Figure 2) shows that naturally regenerated forests reach their maximum carrying capacity at about 80 years in the PNW with an average of 184 t C/ha. Managed forests reach 81% of that potential at 50 years with an average of 150 t C/ha (7). Without management carbon sequestration is slower and uncertain (7). Large trees may continue to grow larger by crowding out adjacent trees but eventually, due to natural aging and disturbances such as windstorms, fire, and disease, the unmanaged forest is likely to emit carbon rather than store more carbon. ***Preserving forests provides a one-time increase in carbon stores, not a sustainable increase.***

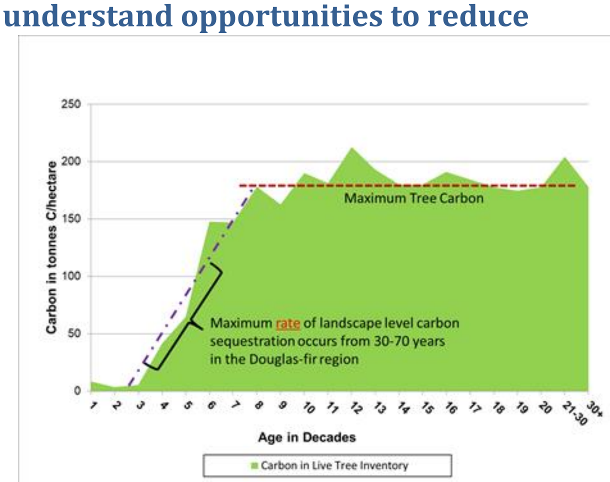

Figure 2. USFS Western Washington carbon inventory by age.

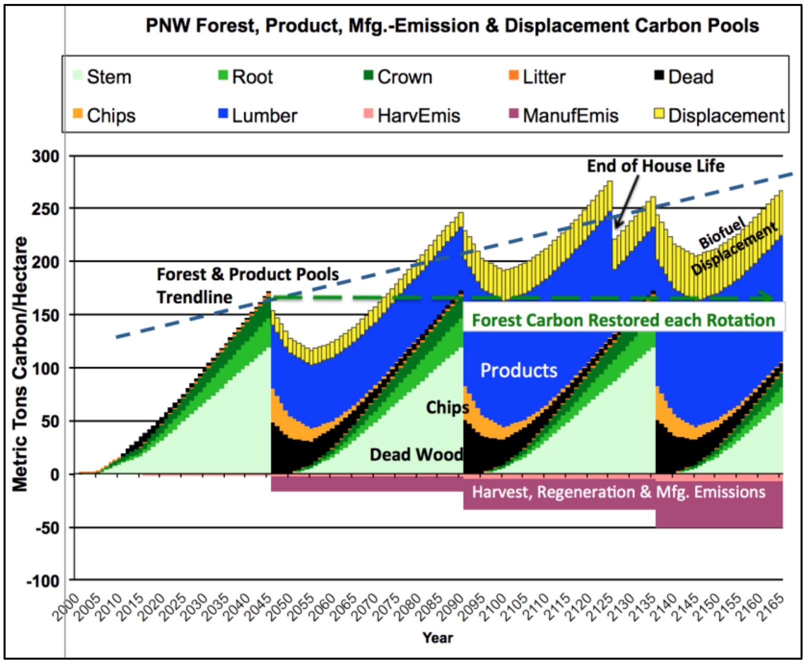

Figure 3. Forest and wood-product carbon pools are substantially larger than processing emissions.

Harvesting and replanting transfers carbon from the forest to products. Continued investment in managed forests stabilizes forest carbon. Forest growth provides the essential beginning of life cycle carbon storage accounting. For managed forests (Figure 3) forest carbon remains below a maximum (light green Stem and darker green Crown and Root), and harvests transfer roughly half the carbon to wood products (blue), and biofuel (yellow) on a sustained basis. Forest regrowth offsets the removals while keeping the average carbon across the whole forest stable. Carbon stored in wood-products and used as biofuel for heat energy displaces emissions from fossil fuel. Intensively managing forests leads to increases in: yield, carbon stores, and the feedstock supply for many products and uses. ***Forests must be sustainably managed to sustain wood-supply for future uses.***

Sustainably managed forests accumulate removals to displace and store carbon year after year. Sustainable wood products manufacturing transfers carbon stored in the forest to the wood products, and their end uses, resulting in a sustainable increase in carbon stores year after year. Additional gains occur from the displacement of fossil intensive products and recycling the wood after first use. Short lived products (orange) (Figure 3) are used and decompose within the rotation. The forest residuals (black) (Figure 3) are left behind to decompose or are piled and burned during site preparation and replanting. In most cases it is too costly to remove these residuals due to the relatively low cost of natural gas (NG). Sustainable management acts like a pump that transfers forest carbon to other uses and storage pools. Products can remain in service beyond the first rotation but are shown for tutorial purposes to be burned at end of life (80 years) with no energy recovery. There is substantial variation in the end of product life age, which would smooth the transition shown. The processing energy for wood-products harvesting (pink) (Figure 3) and manufacturing (magenta) is shown as a carbon emission (below zero). These emissions are partially offset by biofuel use (yellow above) resulting in a sustainable total net carbon trend above 1-ton C/Ha/year exclusive of product substitution for fossil intensive products or end of life recycling.

Some Products can store more carbon and displace more fossil emissions than others. Adding together the carbon stored in wood products and the avoided fossil carbon emissions from substituting wood for non-wood products provides an estimate of the total carbon reduction to the atmosphere (Table 1). A PNW wood wall stud stores a net 16.7 kg CO_2/m^2 (carbon stored minus production emissions) and can displace 18 kg from steel studs for a total carbon stored plus displaced of 34.7 kg CO_2/m^2 (Table 1). Wood wall studs that displace concrete blocks, which uses more energy

Table 1 PNW net wood carbon stored & non-wood fossil carbon displaced (emission) for wall and floor components

WALL COMPONENT: Wood stud displacing a steel stud or concrete block kg CO_2/m^2		
Wood stud:	**Steel stud:**	**Total kg CO_2 reduced**
Stores net 16.7	Emits 18.0	34.7
Wood stud:	**Concrete block:**	**Total kg CO_2 reduced**
Stores net 16.7	Emits 27.5	44.2
FLOOR COMPONENT: Wood based joist displacing a steel joist kg CO_2/m^2		
Dimension joist:	**Steel joist:**	**Total kg CO_2 reduced**
Stores net 30.0	Emits 42.3	72.3
Wood I-Joist[a]	**Steel joist:**	**Total kg CO_2 reduced**
Stores net 14.7	Emits 42.3	57.0

[a] *Does not include the 30% reduction in forest area needed for wood I-joist.*

in production, results in 44.2 kg reduction in CO_2/m^2 of wall. Floors require greater stiffness and strength than walls so the carbon impacts are different. A dimension floor joist displacing a steel joist results in 72.3 kg in CO_2/m^2, or over twice as much reduction as derived from the wall stud. Since Engineered Wood Products (EWP) such as wood I-Joists use much less wood than dimension joists, the carbon stored is cut almost in half thus reducing the total CO_2 benefit to 57 kg/m^2. However, forest resource efficiency is increased because fewer acres are needed for fiber production for I-joists as compared to dimension lumber.

Wall assemblies often include plywood sheathing for both wood and steel studs. In this case, the change in CO_2 reflects only the additional connecting hardware as CO_2 in the sheathing is common to both wood and steel assemblies (Table 2). However, when the wood wall assembly replaces a concrete block wall plus a gypsum cover, the carbon benefit in the wood wall is increased. In the PNW the concrete block has higher emissions due to seismic strength standards. Displacement varies by as much as 300% depending on the alternate material. ***The range of opportunities to displace and store CO_2 is large depending upon the design of assemblies and the products used.***

Table 2 PNW net wood carbon stored & non-wood fossil carbon displaced (emission) for wall and floor assemblies.

WALL ASSEMBLIES	Total kg CO_2 reduced
Wood stud + plywood displacing Steel stud + plywood	34.7
Wood stud + plywood displacing Concrete block + gypsum	105.6
FLOOR ASSEMBLIES	**Total kg CO_2 reduced**
Dimension joist + plywood displacing Steel joist + plywood	70.9
Wood I-Joist + plywood displacing Steel Joist + plywood	50.6
[a] *Does not include the 30% reduction in forest area needed for wood I-joist.*	

Using woody biomass for fuel displaces CO_2 emissions from fossil fuels but does not retain any carbon in storage. The fossil carbon displaced per unit of carbon in the wood used becomes a basic efficiency measure of carbon displaced (the output), per unit of carbon used (the input). The most efficient biofuel option is the historic baseline for drying lumber of 56% mill residuals and 44% NG mix resulting in 0.72 CO_2 displaced per CO_2 in the wood used (Figure 4). This value is boosted by low impact in handling and transportation of the residues when compared to the many alternatives to produce heat and power at wood production facilities. The range of efficiencies in using wood residues to displace fossil emissions runs from 0.21 when pellets are made from open market purchases that use fossil fuels for drying, to 0.64 when pellets are made from flooring residual waste, to 0.4 when residuals are gasified to produce ethanol that displaces liquid fuels for transportation, like gasoline (Figure 4).

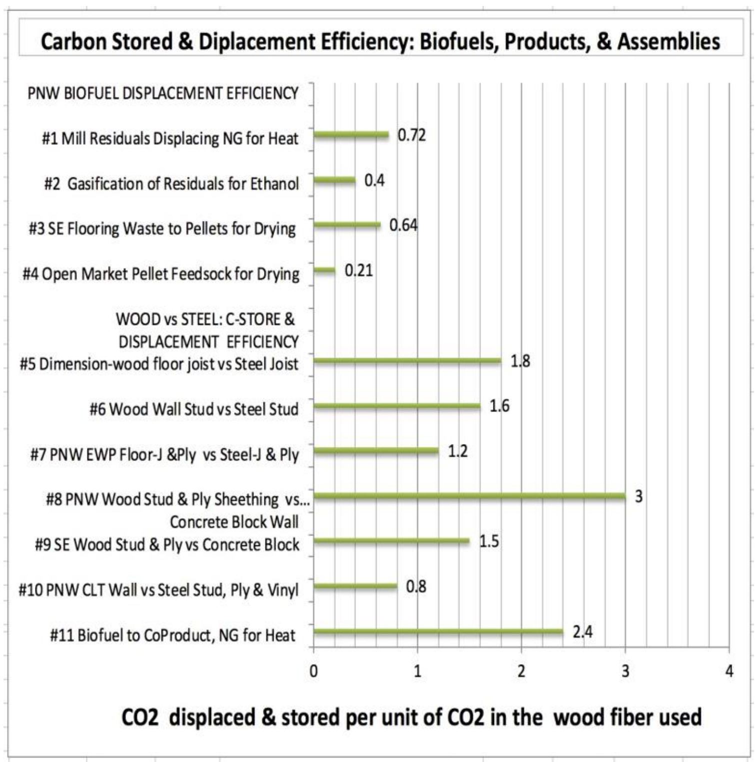

Figure 4. Carbon emission reductions per unit of carbon in the wood used for a range of biofuel and wood uses.

When wood product components are produced with biofuels, the efficiency increases to well over 100%. Figure 4 shows output over input ratios of 1.8 (180%) for floor joists, 1.6 for wall studs, and as high as 3.0 when wood wall assemblies displace concrete block under PNW seismic code standards. In the SE this same wall assembly achieves a 1.5 displacement with no seismic code standard. Using cross laminated timber (CLT) as a wall assembly to displace wood residential walls only produces an efficiency of 0.8. The relatively low value arises because CLT uses so much more wood. The real opportunity for CLT is in high rise buildings where it displaces more concrete and steel and can potentially be reused repeatedly. When wood residues are used as a feedstock for wood composite panels, the efficiency can be as high as 2.4 as compared to 0.4 for transport fuels like ethanol. This is a 600% improvement in efficiency of use (Figure 4).

Recycling demolition wood (recovery and reuse, reprocess, burn to displace NG, or landfill). At the end of its first useful life wood may be recovered and recycled into products or used as a biofuel or even disposed in a landfill. If landfilled, the gas from decomposition is either captured or flared to eliminate methane, a potent greenhouse gas. The gas that is captured and used for energy is a direct substitution for fossil fuel (8). Lippke and Puettmann (8) provide many more simulations of end of life impacts compared to a base case using 56% biofuel and 44% NG for drying wood at manufacturing facilities. Reusing wood material in buildings could potentially increase the trend growth of carbon stores and displacement by as much as 72% if no reprocessing is required (8). When reprocessing is required there is still a potential 44% increase in carbon mitigation (8). If the material could only be recovered for heat energy the additional carbon mitigation benefit is estimated at 19%.

Using updated LCI data and a base simulation that uses 50% more biofuel resulted in a 3.06 t C/ha/year (metric tons carbon per hectare per year) carbon stored and displaced trend (Figure 5). Using a

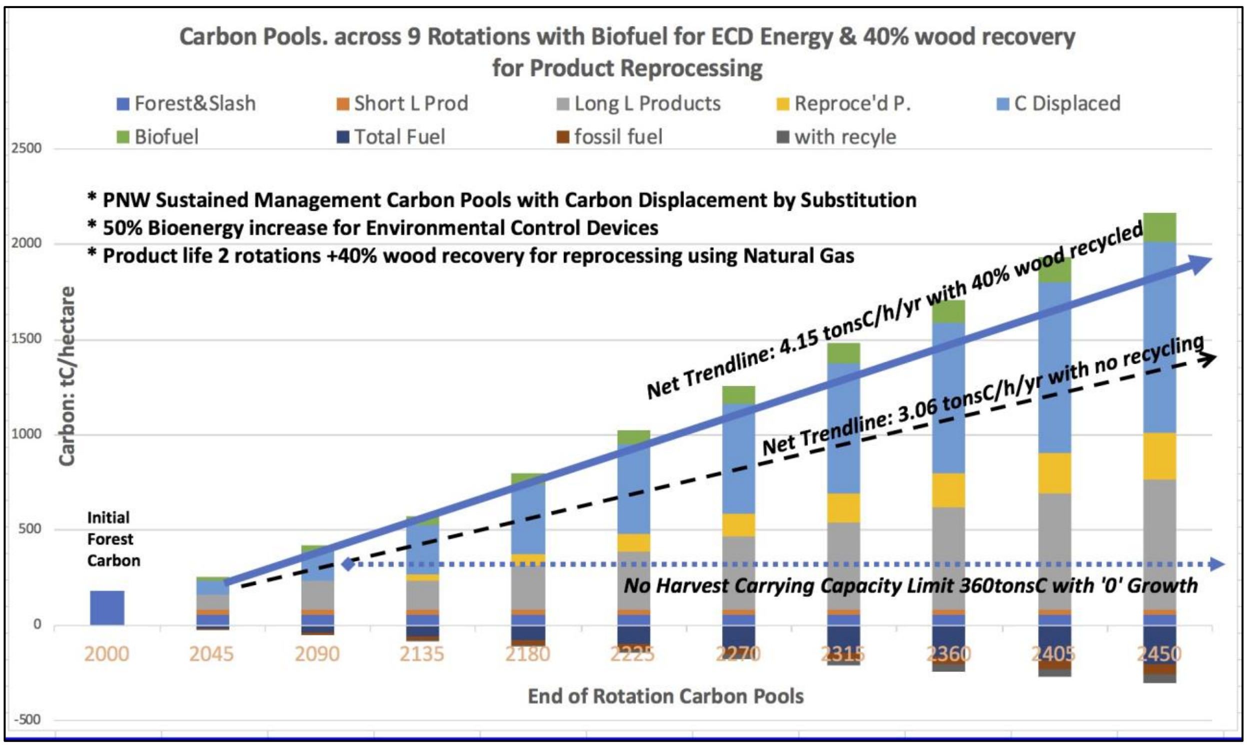

Figure 5. Growth in carbon pools with updated LCI data and 40 % recovery of demolition wood for reprocessing using natural gas

plausible demolition wood recovery scenario of 40% for reprocessed products, even including the NG needed for the incremental processing energy, increased the carbon stored and displaced trendline to 4.15 tons C/ha/yr. This results in a 36% sustained growth trend increase for 40% wood recovery compared to a no wood recovery option.

3. Opportunities for Improvement: Recognize and Avoid Unintended Consequences

The research data suggests that there are many opportunities to substantially improve carbon displacement and storage. Examples above are but a few of them. Policies made using only a few selected benchmark comparisons are likely to ignore many potentially better options and therefore will result in unintended consequences. A classic example is diverting co-product feedstock to biofuel for heat or energy. Avoiding unintended consequences is critical for effective reduction in carbon emissions, investments, and policies. A few policy examples may be the best learning tool for avoiding unintended consequences.

Subsidies to produce cellulosic ethanol - Production subsidies raise the price that ethanol producers can pay for their feedstock. This allows them to bid the feedstock away from other wood producers like wood composite panels that displace far more carbon emissions than the subsidized ethanol producers. The problem of subsidizing one producer and ignoring the unintended consequences to other producers affects many so-called carbon mitigation policies. More often than not the incentives that have been tried result from perceived impacts rather than based upon measured comparisons. At present, there are no subsidies directed at the high end of the displacement possibilities that would result in more efficient use of wood to displace fossil intensive products. To the contrary, "green" building standards such as LEED have given preference to imported recycled steel over locally produced wood products just because it was recycled, not because it shows efficient GHG displacement.

The renewable fuel standard (RFS) - Utilities are forced to gain access to renewable feedstock and pay higher prices that bid it away from better uses. At the same time the RFS fragments the biofuel supply base which makes it more difficult to invest in scale-facilities that can more efficiently reduce carbon emissions. The lack of clear priorities for how forests and forest products might be best utilized to mitigate climate change creates market uncertainty, which discourages investment (9). This contributes to an infrastructure barrier that has stalled the expanded use of biofuels even though it is mandated by federal laws such as the Energy Independence and Security Act of 2007 (10). Renewable fuel standards do not address the need for a cost on fossil emissions consistent with the objective of reducing them. They also ignore the reality that emissions will increase with lower costs for fossil fuels and especially when they are subsidized.

Any subsidy directed at low valued uses of a feedstock is likely to be counterproductive - If the subsidy is aimed at the producers that actually reduce emissions the most, like wood I-joists displacing steel I-joists, there is at least a much lower chance that the increased use of the feedstock will actually be taken away from some producer doing a better job at carbon mitigation.

Nearly every manufacturing process alters carbon with potential cascading effects - While we can compare product A with product B, and can show that B looks better than A using life cycle assessment for both alternatives, it can just as easily be counterproductive once you learn the impact of A vs. C or D or X, especially for competing feedstocks. It is literally impossible to certify that B is better than A without knowing how B impacts all other alternatives. Cap and Trade or carbon offsets are not defensible in spite of their great political support because they ignore so many alternative uses that are likely to result in better displacement of fossil carbon emissions.

The high European fossil fuel taxes have resulted in transporting pellets from the US to Europe. This helps Europe reach their carbon mitigation objectives but is it efficient? The sale of US pellets to the European market demonstrates how markets respond to a cost on emissions. Accounting protocols dictate that imported pellets result in a net reduction of carbon emissions for the importing country. However, the high tax on fossil fuel in Europe takes away the opportunity for producer nations, like the USA, that could have reduced emissions more efficiently with an equal tax. Pellets do provide manufacturing flexibility relative to other low-grade biofuels. Plant size can be adjusted from small to large to match the current raw material availability as well as investor capital. Plants can be readily expanded as desired and investment-to-production output is low. As a contrast, new composite wood product facilities require both large capital investments and dedicated raw material supplies. In addition, they can only utilize a subset of milling residues while both log and mill residues (dirty or clean) can be utilized for various grades of pellets. Trading sulfur emissions among a small number of emitters may have been effective in reducing sulfur emissions but the sources of carbon emissions are well beyond the same degree of accountability.

The greatest unintended consequence probably derives from the subsidies to fossil fuel production and consumption resulting in a price advantage for their use - Skovgaard and van Asselt (11) provide a review of the complexities of fossil subsidies and their implications for climate change mitigation. In scaling the impact of subsidies, their review included the International Energy Agency's estimated impact on consumption to be $300 billion. For comparison the International Monetary Fund's (IMF) estimated impact was $5.3 trillion using a price-gap approach that includes both producer and consumer impacts. Either estimate is large enough to suggest a significant disadvantage for non-fossil fuel alternatives. Subsidies favoring fossil fuels can be hidden even though critical, such as the military protection required to keep the shipping lanes for fossil fuels open.

An efficient inducement for less fossil carbon emissions would be to levy a pollution fee on their use - An efficient inducement to reduce emissions must increase the cost of the emission proportional to the volume of the carbon emitted and be passed through the market affecting every transaction. Economists suggest a carbon tax as the best way to improve carbon mitigation. They do however call attention to the fact that such a tax becomes an increased cost drag on the economy. That drag on income can be neutralized by rebating the tax revenues to the consumers and producers impacted, i.e. a tax offset resulting in no change in total income but a reduction in income to fossil intensive producers/consumers. In effect, a tax with offsetting rebates is not a tax but rather a pollution fee and rebate. Its goal is to change consumer buying behavior but not their income. Since the tax and rebate system will not be global, at least initially, the devil is in the detail on how to prevent a "Carbon Negative Producer" from losing market share at the border. It would be counterproductive if the tax system reduces the production from "Carbon Negative Producers" such as wood manufacturers. The details require that the tax rebate to users must be larger than any tax increase on carbon negative producers that purchase some fossil fuels for their production (all do). The market then determines the best feedstock uses to avoid the high cost of fossil emissions. For regionally specific carbon emission fees, second order subsidies or partial exemptions can be used to offset the loss in product competitiveness at the regional border for carbon negative producers. Using rebates from tax revenues to consumers and producers has been successfully tested in British Columbia. They have avoided reducing economic growth from the tax, given the rebate to consumers thus maintaining income, and reduced fossil emissions (12).

One possible way to support the increased use of biofuel to all producers is to reduce the cost of collecting the currently unused feedstock available to all producers - Providing a tax credit for collecting forest residuals and demolition wastes rather than subsidizing a specific producer can avoid the subsidy being used to steal the feedstock from other more carbon efficient producers. Even tax credits for growing forests increases the supply for all users while market prices efficiently allocate feedstock without bias to different uses.

Economists suggested estimating the social cost of emissions to be used as a criterion for evaluating regulations - EPA provided estimates of the social cost of carbon emissions (13). While their estimate excluded many costs, their estimated values exceeded the cost of collecting forest residuals and other wastes suitable for biofuel. However, no cost on carbon emissions has been introduced as a response to EPA's estimated loss in value from fossil carbon emissions.

4. Summary and Conclusions

Using fossil fuels and fossil fuel derived products generates a one-way flow of emissions to the atmosphere which contributes to climate change. Using wood derived from solar energy results in a two-way flow of emissions to (and from) the atmosphere. From a carbon perspective, preserving forests instead of sustainably harvesting forest carbon to displace fossil fuels and fossil intensive products wastes the opportunity to substantially improve carbon mitigation outcomes.

The best uses of wood provide an advanced "carbon negative technology" with high leverage to displace fossil emissions. That leverage is not matched by solar cells that neither store carbon nor displace fossil intensive building products. There may be new and better opportunities to replace wood-based biofuel on the horizon such as algae. Dovetail Partners Inc (14) in their review of 2nd and 3rd generation biofuels noted in their 'Bottom Line': "For the near-to mid-term, at least, algae-derived biofuels are unlikely to pose competitive risks to the emerging second-generation cellulose-based biofuels industry". Replacing wood products carbon-negative technology in structural uses by still undeveloped carbon recapture technology appears to be even further out in time. But leveraging the structural strength of wood fiber to displace carbon intensive building materials is a near term, implementable solution.

Some policies subsidize improving the efficiency of using fossil fuels. At best this only reduces the rate of increase of emissions that are a forcing element driving climate change. Subsidies are also directed at the lowest efficiency uses of wood rather than the highest efficiency uses that displace fossil emissions and store wood in products. Trading carbon credits between producers that need to reduce their emissions by buying from those that are carbon negative producers will often simply redirect the feedstock away from more efficient uses, including those that have not yet been analyzed. Using wood residues in composite wood panels is far more efficient at reducing carbon emissions than using them to substitute for fossil energy. More effort is required to better understand the best uses of wood for carbon mitigation and how to avoid unintended consequences. Market solutions are an efficient way to raise the cost of carbon emissions which will provide a comparative advantage for carbon negative technologies.

There are regional and rural opportunities to increase economic activity while reducing carbon emissions and increasing efficiency. Some regional opportunities that better use wood resources are enormous and can provide substantial rural economic benefits. Some states are putting a priority on regional opportunities to reduce emissions and contribute more to rural economies by greatly increasing their understanding of better practices and implementing them. Ironically science is not the limiting factor. Understanding how to better use the science to avoid unintended consequences requires educational outreach customized to each region's opportunities in order to gain the support of the public, investors, and policy makers.

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Chair Kelly, Acting State Forester Hirsch and members of the Board,

For the record, my name is Rex Storm, and I am the Executive Vice President at Associated Oregon Loggers.

AOL has been engaged with the Department during their HCP and FMP development and have been willing to focus discussion on conservation and wildlife thus far. We believe it is now time to turn attention to the other parts of Greatest Permanent Value.

AOL represents over 800 small family forest businesses of which a portion help to achieve GPV on state lands. The Department must look to the ways in which the FMP can grow jobs and increase community health, especially rural communities that rely on the sustainable flow of timber from state lands.

The industry and rural communities have been willing to give a little for the wildlife and conservation conversations, so now it is time to hear from them and see what balance we can strike where ecological needs give up a little for rural communities and jobs (social and economic needs).

We must ensure that the flow of timber from state lands is high enough that we do not continue to simply add fuel to fuel beds by removing only a small portion of growth.

We must ensure that the FMP is also paying for itself. It is this Board's responsibility to work with the Department to ensure that the budget is balanced and the sale of products is covering costs.

AOL believes the conversation must shift in this direction to ensure that the overall discussion is balanced between all three legs of the stool. We have focused almost exclusively on the ecological leg and now need to shift to the social and economic legs.

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AOL is more than willing to work with the Board and the Department in good faith to strike this balance.

Thank you for the opportunity to testify and I am available for any questions.

November 03, 2021

By electronic submission to: Oregon Board of Forestry
boardofforestry@oregon.gov

Re: Testimony on Nov. 3 Board Agenda Item: State Forest Management Planning

Dear Chair Kelly and Members of the Board of Forestry:

The Wild Salmon Center appreciates the Board's and Oregon Department of Forestry's (ODF) ongoing state forest management planning work and the related agenda item at your November 3 meeting. We wish to provide our perspective on the ongoing status of this work and future needs relevant to the Board's engagement. First, however, thank you for adopting a first-ever Climate Change and Carbon Plan for Oregon's forests. While a vision document that will be both iterative in response to ongoing science and feedback as well as translated into more substance through ongoing ODF planning efforts like the Forest Management Plan for state forests, this Plan and the Board's unanimous vote represent needed leadership on the existential issue of our time: climate change response.

Oregon's state forests play an important role in achieving many public values, and for this reason, the Board and State Forester are statutorily directed to manage these public lands *"so as to secure the **greatest permanent value** of such lands to the state."* This direction has existed since 1941. What should be of keen interest to and further explored by the Board is the history of how today's system of state forests came about, the context for and complete language of Greatest Permanent Value (GPV) legal direction, and current attempts to misconstrue GPV. This is a matter of significant importance because an accurate understanding of history and of GPV is fundamental to the Board's future decision-making on the draft Western Oregon Habitat Conservation Plan (HCP), a revised Forest Management Plan (FMP), as well as implementation of other plans on state forests (e.g., Climate Change and Carbon Plan).

We believe the following points are very relevant to a full and accurate understanding of GPV and the future of state-forest decision-making. They are in summary form, and we believe you should dig deeper.

- **Context:** The original statute setting forth the GPV mandate passed during the hardship era of the Great Depression (1941). Most of what are state forest lands in Western Oregon today (especially the big three ODF districts of Astoria, Tillamook, and Forest Grove) were then in private ownership and had been subjected to cut-and-run timber company practices and/or the initial Tillamook Burn. Tax foreclosures ensued, and counties who did not want the liability or responsibility of holding these lands deeded many of them to the state.

- **ODF took over a highly impacted landscape** on many of today's state forests and has put significant work into the transformation of these lands into the forests of today. It is **not** the case that ODF received a cost-free deed to immaculate habitat or robust harvestable timber that counties were clamoring to manage for themselves. ODF essentially undertook a public works project to develop forest conditions capable of sustaining timber harvest as well as broader public values. And, it has advanced this work based on revenue support of just 36-cents on every dollar of logs cut on these lands, while sending 64% of those dollars back to the counties where the trees were located. This insufficient business model has compelled many public values to be under-served and under-represented on the land base of today.

- **Deeds speak to more than timber:** Language in the deeds for lands transferred to the state recognize that ODF would manage them for values far beyond just timber production, including water quality, recreation, and watershed health. Even as far back as the 1940's, a broader view was intended for these lands than just timber production and revenues to local governments.

- **The 1941 statute has been amended several times since its passage** (11 times between 1953-2015). To ignore these amendments and hold onto a 1941 structure alone is akin to saying the law is static and future amendments by duly elected legislatures don't matter. There is no principle in law or policy to support this. The current relevant statutory direction is ***ORS 530.050*** (State Forests: Management of Lands Acquired).

- **Certain provisions of the 1941 statute have remained north star constants**. First, the statute has always used the term GPV in reference to "the state", meaning securing GPV for the people of Oregon as a whole, not a group of counties, nor one particular interest or sector. Second, in speaking to the Board and State Forester's powers, the statute has always enumerated various ways GPV **may be** secured (e.g., 1941 statute: "to that end is empowered and authorized: …"; today's statute: "to that end may: …"). This is a permissive construction and allows the Board to set the approach to achieving GPV within it. Importantly, the law's enumerated ways in which GPV may be achieved have always included but also gone beyond the harvest and sale of timber.

- **Other provisions of the 1941 statute have changed or been added** to today's governing law (*ORS 530.050*). Provisions in today's statute speak more explicitly to broader values and direction than existed in 1941. Some have enhanced the direction for forest products as this sector has evolved in Oregon since 1941, and others have enhanced the recognition of broader values. Today's statute clearly states the following are authorized approaches to securing GPV:[1]
    - *"Permit the use of the lands for other purposes, **including but not limited to** forage and browse for domestic livestock, fish and wildlife environment, landscape effect, protection against floods and erosion, recreation, and protection of water supplies when, in the opinion of the board, the use is not detrimental to the best interest of the state."*
    - *"Establish a forestry carbon offset program …"*
    - *"Do all things and make all rules, not inconsistent with law, necessary or convenient for the **management, protection, utilization and conservation** of the lands."*

[1] See ORS 530.050, subsections (5), (12), (13) *(emphasis added by WSC for purposes of this testimony).*

The above values and balanced view of GPV are largely contained and affirmed in the still-applicable GPV Rule adopted by the Board in 1997: ***OAR 629-035-0020***. At the time of rule adoption, the FTLAC counties supported it. Today, however, a flip-flop in this position has emerged based on dollar-motivations and a policy view (supported by a county litigation strategy) that GPV prioritizes timber harvest over all other public values, and ODF should thus promote more harvest and less of other values.

We call attention to the above context, history, and legal direction especially in light of a recent legally styled GPV presentation made by county elected officials to their colleagues as well as Board members and ODF staff at the October 08, 2021 meeting of the Forest Trust Land Advisory Committee (FTLAC). This presentation, which was re-asserted during FTLAC's testimony at your board meeting today, selectively reads the 1941 statute, omits reference to older and current statutory or deed provisions supporting broader values, and misconstrues history.

We would agree that, yes, there is a special relationship between the FTLAC counties and the State based on the history of state forest lands. And yes, the history and law support an expectation of management for some level of sustained timber production. But it is far from the truth (much less an accurate read of GPV, relevant statutes and rules) to say that state forest management must fall in line with a view of GPV that renders all other public values subservient to the production of timber. Yet, this unbalanced view is precisely what FTLAC county officials continue to advocate: that ODF should only pursue other public values tied to state forests (e.g., drinking water, recreation, conservation, carbon sequestration, soil health or social justice) to the extent they do not undermine timber harvest.

We ask that you reject this false GPV interpretation. It is not a viable foundation for collaboration or policy advancement. And please don't simply take our word for it. We request that you dig deeper into understanding the history, context and law as you continue to hear GPV input from FTLAC or others like Wild Salmon Center. Further, we request that the Board understand the Oregon Department of Justice's view of GPV and its obligations, and that the Board play a role in ensuring counties and the broader public are similarly informed. All county commissioners and the public at large should be made aware of how the State's top legal department views this important term, rather than letting a highly selectively read and misconstrued opinion stand in the public record of a public governing body such as FTLAC.

Needs related to FMP Goals:

ODF has released draft Forest Management Plan (FMP) Goals covering a range of values, resources, and interests connected to state forest management. Doing so is certainly consistent with an understanding that securing GPV on state public forest lands means thinking about more than just timber harvest and revenue. The draft Goals are numerous, and we are open to possible ways to consolidate them especially if it can help distill meaningful and measurable goal statements. But overall, we appreciate that ODF appears to be viewing forest management planning through a balanced and accurate GPV lens. ODF's October 2021 FMP Draft Goals and Feedback Summary document reflects some revisions based on input to date, and it appears much still remains for consideration based on Board and other feedback.

Commented [1]: https://www.oregon.gov/odf/board/Documents/fmp-hcp/20211012-FMP-draft-goals.pdf

We appreciate the revision of the first "Aquatics and Riparian" goal to reflect the role state forests play in advancing healthy water quantity / stream flows (not just water quality). While ODF does not manage water resources or water rights, it does manage forests. Habitat protections, types of forestry (prescriptions, clearcut size, etc.) as well as forest rotation ages meaningfully influence stream flow and water storage. The second "Aquatics and Riparian" goal speaks directly to drinking water, and we also appreciate the reflection of water quantity considerations here. That said, labeling this goal explicitly as "Drinking Water" rather than "Aquatics and Riparian" would likely help with FMP goal clarity, transparency, and support by the public.

This water quantity and streamflow connection is significantly tied to the context of carbon storage and climate resilience, including carbon stored in trees and soil as well as water stored above and below ground. As a positive, the revised goal for "Soils" explicitly recognizes the role of soil in carbon storage (which is also important in the context of water storage, flood and wildfire resilience) and proposes to increase that role. As part of the next step implementation of the Climate Change and Carbon Plan for Oregon, the Board and ODF should further recognize and build upon this connection between water and streamflow with climate and carbon objectives.

In order to better reflect today's Oregon and securing GPV for the public, in addition to the above input, we believe the following goals should be further revised or moved from parking lot to actual:

Climate and Carbon: While we believe the reality of climate change is and should be a broader lens for viewing attainment of GPV and all its outputs, the FMP should continue to contain both a goal related to "Climate Change Resilience" (we suggest adding the latter word) as well as "Forest Carbon". These goals are important nexus points for implementing the Climate Change and Carbon Plan on state forest lands, and they rightly distinguish between climate-related carbon sequestration on the one hand and management tied to climate-related resilience on the other (e.g., to flooding, drought, wildfire, etc.). Related to this, the current revised goal language for "Forest Carbon" continues to lead with "Contribute to …". This is not a meaningful verb. State forests (or derived wood products) will always contribute to carbon storage. A goal statement should reflect whether the desire for forest carbon is to increase it over the status quo on state forests, achieve net positive carbon sequestration, and/or at what level.

Wildlife: The FMP process is broader than the HCP effort. State Forest lands play an important role not just in the "persistence" (current framing of the FMP goal) of Oregon's native wildlife, but also in the recovery of species that have dwindled from healthy levels. Recovery is not just a federal Endangered Species Act issue; it is an objective of Oregon-grown efforts like the Oregon Conservation Strategy, the Oregon Plan for Salmon and Watersheds, and state laws governing fish and wildlife. As covered later in this testimony, state forest lands are often the primary place on the landscape where such opportunities are likely to be provided, and it is important for ODF to view state forests not just as places for persistence but for recovery.

We note that the current ODF Draft Goals and Feedback Summary document flags that a "larger conversation on restoration" is needed (see, e.g., p.4--"Suggested revision based on feedback" note tied to the "Plants" goal; p.11--"New Goals" including Forest Restoration). We agree this larger conversation is needed, including amongst the Board, and suggest that it also include habitat / species recovery not just forest restoration.

Additional Goals: The current FMP Draft Goals and Feedback Summary document includes "Other Goal Suggestions" (p.11), which are currently in a parking lot for further consideration, and some of which we believe the Board should encourage ODF to bring into the main body of the draft Goals document.

- **"Chemical Spray"**--we believe this goal is worth advancing, perhaps especially in the context of or in coordination with the goals for "Drinking Water" as well as "Plants" (advancement of biologically significant early seral habitat).

- **"Social Justice"**--we support this goal, including its recognition of communities of color as well as rural communities. We believe this is a timely stand-alone goal that should be moved from the parking lot and into the revised FMP, and that other potential goals in the document could be integrated into it (including those currently titled "Community Wellbeing", "Rural Communities", and "Collaboration and Coordination"). We encourage the Board and ODF to engage the state's Environmental Justice Task Force, Sustainability Commission, as well as the environmental equity committee of the Racial Justice Council in further vetting and engagement around this goal, along with the several tribal governments whose people have used today's state forest lands for millennia. There are meaningful strategies beyond the status quo that the Board and ODF could undertake related to such a goal (or consolidated goals). This includes a potentially new governance structure for how ODF and the Board relate to the various affected interests and communities linked to state forest management. This could not only improve accountability and collaboration but also efficiency, if done well. We would welcome further conversations with the Board and ODF on such a concept.

HCP broader relevance:

The proposed draft Western Oregon Habitat Conservation Plan (HCP) that ODF has submitted into the ongoing federal review process is specifically related to species listed (or that may become listed) under the Endangered Species Act (ESA). The FMP context, on the other hand, is relevant to addressing issues well beyond the ESA. It speaks to and should cover broader values and aspects of GPV than just ESA species, their habitat, and federal permits that allow impacts tied to advancing state land timber harvest.

The ESA-context for the HCP planning effort is certainly relevant to compliance with relevant laws, and in turn GPV. It is also highly relevant to the values of fish and wildlife, habitat conservation, timber and revenue production, recreation, and ODF management costs, all of which are also highly relevant to GPV and the FMP. We are encouraged to hear ODF intends to directly incorporate HCP-related conservation measures and actions into the FMP's conservation-related strategies and rules. That said, we wish to point out the broader relevance of the HCP in the larger landscape context of Oregon's ecosystems, communities, and economies.

Advancement of a state forest HCP (and related ESA-take / impact permit) is helpful to those who care about fish and wildlife, habitat, water quality and quantity, recreation, economic diversity and certainty for timber production **<u>not just on state forest lands but across the broader landscape</u>**. As the attached map indicates (see Attachment 1), much of Western Oregon's state forest lands are surrounded by vast private forest lands. This is especially true in the North Coast, where little other public forest lands exist.

When agencies charged assuring ESA legal compliance evaluate timber harvest or other potential impacts to listed species, they look at the population status of these species. This is affected by landscape-wide actors and actions shaping habitat both on and outside of state forest lands, including on private lands. The proposed state forest HCP would provide designated blocks of acreage for conservation management (Habitat Conservation Areas) that in turn would allow federal ESA agencies to draw conclusions about species persistence and future viability. These conclusions are shaped by the landscape-level view of where (i.e., on whose land ownerships) the habitat central to ensuring viability will be provided (vs. where it will not). These conclusions have legal consequences that permit timber harvest (and an incidental level of species impacts) to occur in compliance with the ESA on state forests, **and** this also enables relative timber harvest dominance (and relative paucity of habitat provision for certain species) to continue on adjacent private lands because this is the assumed current and future landscape context under which the agencies drew their ESA conclusions.

On state public forest lands--and for the N. Coast in particular--it is appropriate to provide large blocks of conservation habitat given the surrounding ownership context (i.e., the habitat cannot be expected to occur elsewhere) (see Attachment 1). This not only makes sense for conservation planning (and related legal compliance) but it also helps provide a more solid footing for harvest-oriented private forest owners and operators because it allows relative clarity and certainty on the landscape as to where ESA species habitat needs will be focused (and where it will not). While the recent Private Forest Accord is a remarkable collaborative agreement between conservation and private forest sector interests with meaningful outcomes especially in the aquatic realm, it will not change the landscape realities with respect the location of significant industrial private forest ownership surrounding state public lands, the dominance of shorter-rotation clearcut forestry practices on those lands, and the relative habitat opportunities and needs on state forest lands.

To be clear, Wild Salmon Center supports collaboration and is certainly open to collaborative solutions related to the proposed HCP and revised FMP. That said, collaborative outcomes require the existence of multiple willing actors. And, with respect to something as fundamental as GPV, if the actors can't agree on what direction is true north versus due south, it is very difficult to take a trip together. Thank you for your consideration of this testimony. We look forward to further discussions with the Board and ODF.

Sincerely,

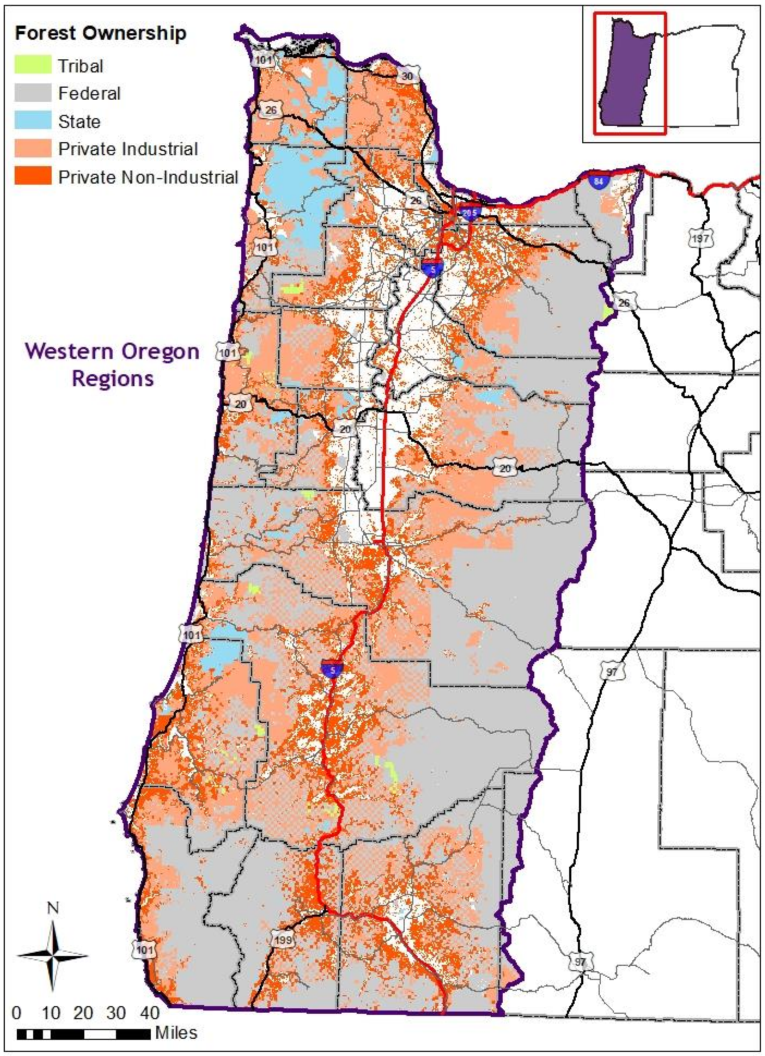
Brett Brownscombe

c:

Nancy Hirsh, Acting State Forester
Cal Mukamoto, incoming State Forester
Liz Dent, State Forest Division Chief
Mike Wilson, State Forest Deputy Division Chief
Sarah Lathrop, Operations / FMP Project Lead

<u>Attachment 1:</u> Western Oregon forested lands—by ownership

***NOTE:** This map appears as Figure 1 at p.3 in the Board's packet / materials for Agenda Item #3 (Annual Forest Practices Monitoring Update) at the Nov. 3, 2021 Board of Forestry meeting



Associated Oregon Loggers, Inc.

PO Box 12339 • Salem, Oregon 97309-0339 • (503) 364-1330 • Fax (503) 364-0836

Good afternoon, Chair Kelly, Acting State Forester Hirsch and members of the Board,

For the record, my name is Rex Storm, and I am the Executive Vice President at Associated Oregon Loggers. We appreciate the work done by ODF on climate change thus far and acknowledge the vast work load.

As we have testified before, getting the CCCP correct is paramount because climate change is of critical concern but also because ODF needs to ensure downstream effects to communities and wood supply are mitigated.

As you will hear in our testimony later on the Forest Management Plan, goals around Climate Change and forests must be focused on achieving NET sequestration. AOL believes the focus in the current version of the CCCP fails to focus on this type of calculation by concentrating on forest carbon stocks rather than all carbon pools and fluxes. The lack of research included in the CCCP on biogenic carbon emissions from wildfire, pertinent research on how working forests can help to reduce emissions during wildfire, wholistic life-cycle-analyses, nor adequate information on substitution being the biggest gain and benefit that the forest sector has to reduce carbon emissions.

This Board has the opportunity to be on the cutting edge of innovation by prompting wood products and breaking barriers in the use of mass timber while increasing jobs in working forests because research shows that this is where the major gains exist for our sector.

Beyond innovative uses of wood, we all recognize that wildfires continue to jeopardize forest carbon permanence. Above all, climate-smart forestry must focus on creation of landscape resiliency on all lands in the state and on long-lived storage of carbon in durable wood products.

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ODF and the Board will be engaging in the creation of the 20-Year Strategic Plan as signed off on by the governor and ODF with the US Forest Service in the MOU on Shared Stewardship and outlined in the recommendations of the Governor's Council on Wildfire Response. We need to treat at least 5.6 million acres over the next 20 years to address our wildfire reality and reduce fire behavior when wildfires do occur.

According to Joe Restaino, Senior Environmental Scientist with CalFire, who helps run the California Climate Change Investment Program and researches the interplay of fire mitigation and climate dynamics, he says, the mitigated wildfire emissions that result when forest thinning and prescribed fire are used on a landscape, are key in increasing net climate change benefits from forestlands.

We must ensure the CCCP does not get in the way of actions needed to address wildfire in the collaborative 20-Year Strategic Plan nor the forthcoming Forestry Program for Oregon. The Board shouldn't arbitrarily tie the state's hands to achieve the goals of either of these documents with prescriptive language before the state has data necessary to make fully formed changes.

With that, I thank you and am available for any questions on AOL's comments on the CCCP.

Oregon Board of Forestry
Oregon Department of Forestry
2600 State Street
Salem, Oregon 97310

submitted via email: *boardofforestry@oregon.gov* 30 October, 2021

Dear Chair Kelly and Members of the Board,

The twenty-three undersigned organizations urge the Board of Forestry to adopt the Climate Change and Carbon Plan, which is decision item #8 in the November 3, 2021 Board of Forestry meeting.

The climate crisis is upon us and management of Oregon's forests plays a pivotal role in determining the extent to which our communities and ecosystems will be disrupted. Oregon's forests have the ability to be either excellent allies in drawing down and storing atmospheric carbon, or to release large amounts of stored carbon into the atmosphere. They can mitigate the worst impacts of climate change by providing refugia for climate-stressed species, producing clear, cold water, and creating recreation opportunities for the many Oregonians who depend on forests for their wellbeing, or they could be managed solely for the near, short-term profit in ways that continue to externalize negative costs to the climate, environment, and public.

By adopting the Climate Change & Carbon Plan (CCCP), the Board of Forestry will support much needed changes toward ensuring managing of Oregon's forests provides a full range of social, economic and environmental benefits to the people of Oregon and that the cross-sector impacts of climate change on all of these values are addressed rather than neglected. This plan rightly recognizes that, with respect to the state's public forest lands, responsible climate action is not just consistent with achieving greatest permanent value to the people of Oregon, but fundamental to it. And as to Oregon's forested landscape as a whole, the Plan represents a crucial first step in Oregon becoming a leader in climate-smart forestry, and creating a model for how to best use forests as a critical natural climate solution.

We strongly support the CCCP's recommendations to:

- Ensure forest policies will be shaped through the lens of social justice and equity;
- Identify and protect climate refugia;
- Use the Oregon Global Warming Commission's Natural and Working Lands goals to guide the Department;
- Revise the Oregon Forest Practices Act to better prioritize climate change and carbon storage;
- Incentivize the adoption of climate-smart forestry practices on private lands;
- Incorporate climate change response into the Forest Management Plan (FMP) process for state forest lands, including through:
    - Extending harvest rotations;
    - Identifying areas that have high carbon storage potential and establishing priorities for these areas that include long-term carbon storage; and
    - Establishing an Internal Carbon Pricing Process and using this to inform future forest management planning and decisions.
- Restore ecological function when addressing the need to manage forests for increased wildfire severity and develop a prescribed fire program within the Department;
- Work with landowners and managers, large and small, to create resilient landscapes;

- Account for forestry related carbon impacts, including the emissions of all proposed actions;
- Ensure climate change is a foundational consideration in all agency planning processes.

However, we note that protecting mature and old growth forests – the best known way to increase carbon storage and climate resiliency – was not explicitly included in the CCCP. We believe that this omission weakens the plan, and we urge the Board of Forestry to enact rules to protect older trees and forests, in particular in state forests where the Board has the greatest authority.

Also, in the face of extended drought and longer fire seasons, wildfire risk is increasing across Oregon. Thinning and prescribed fire are insufficient tools for addressing the threat of wildfire, and we encourage the Board to direct ODF to consolidate resources and focus suppression and risk reduction efforts on fires that pose a direct threat to communities, and prioritize fuels reduction efforts near at-risk communities. Further Board actions that incorporate these suggestions, and others previously submitted by the undersigned, will improve land management so that Oregon forests can better mitigate the climate crisis.

Indeed, the same strategies that lead to more stored forest carbon and climate-resilient ecosystems can also promote vibrant and prosperous rural communities across our state. Longer logging rotations, larger riparian buffers, increased green tree retention, and conserving mature and old growth forests will improve stream flows and ensure abundant, clean drinking water as well as reduce wildfire impacts, while allowing for a sustainable supply of high quality timber, outdoor recreation and wildlife habitat.

The CCCP acknowledges that there are many barriers – cultural, economic & political – to shift management of Oregon's forests in a climate-smart direction. We encourage the Board and ODF to describe these as challenges rather than barriers to emphasize they can be addressed and clarify that ODF can take actions to mitigate and adapt to the climate crisis now/under the current regulatory framework.

The undersigned organizations are committed to working with the Board and Oregon Department of Forestry to address these challenges and transform management of Oregon's forests into outcomes that support vibrant, climate resilient ecosystems and the public values they provide for all Oregonians.

Brenna Bell
350PDX
Forest Climate Manager

Darlene Chirman
Great Old Broads for Wilderness
Cascade Volcanoes Chapter
Volunteer Team Leader

Joseph Youren
Audubon Society of Lincoln City
Vice President

Debby Garman
350.org Washington County
Team Lead

Joseph Vaile
KS Wild
Climate Director

Dominick DellSalla,PhD.
Wild Heritage, project of the
Earth Island Institute
Chief Scientist

Noah Greenwald
Center for Biological Diversity
Endangered Species Director

David Harrison
Salem Audubon Society
Conservation Chair

Ashley Short
Tualatin Riverkeeper
Riverkeeper & In-house counsel

Samantha Hernandez
Oregon Physicians for Social Responsibility
Climate Justice Organizer

Jennifer Fairbrother
Native Fish Society
Conservation Director

Dave Mellinger
Audubon Society of Corvallis
Co-president

Nancy Webster
North Coast Communities for Watershed Protection
Founder

Grace Brahler
Beyond Toxics
Oregon Climate Action Plan & Policy Manager

Daniel Frye
Multnomah Climate Action Team
Steering Committee Member

Gail Cordell
Clackamas Climate Action Coalition
Co-Facilitator

Bob Van Dyke
Wild Salmon Center
Oregon Policy Director

David Moskowitz
The Conservation Angler
Executive Directors

Ann Vileisis
Kalmiopsis Audubon Society
President

Lauren Anderson
Oregon Wild
Forest Climate Policy Coordinator

Patricia Hine
350 Eugene
President

Julia DeGraw
Oregon League of Conservation Voters
Coalition Director

Rebecca White
Cascadia Wildlands
Wildlands Director

Submitted: Thu 10/28/2021 5:13 PM

Subject: Department of Forestry Climate Change and Carbon Plan

Message:

Dear Chair Kelly and Members of the Board,

Thank you for the opportunity to speak to you as you consider adoption of the Department of Forestry Climate Change and Carbon Plan. I come to you as a small woodlands owner. My wife Karyn and I own and manage 38 acres of mixed species woodlands near Sweet Home in Linn County. These woodlands contain mature Willamette Valley Ponderosa Pine, Oregon White Oak, Oregon Ash, Incense Cedar, and Douglas Fir. We have been directly affected by climate change. Many of our Douglas Fir and Incense Cedar have died in the last 4 years from the effects of drought. A mineral spring on our property that is very important to the life cycle of the Band Tailed Pigeon went dry in August this year, about a month earlier than normal. In September of 2020, we were within ½ mile of Level 3 evacuations for the Holiday Farm wildfire.

I believe that addressing climate change as quickly and thoroughly as possible is extremely important. I applaud the efforts of the Department of Forestry (DOF) in developing the Climate Change and Carbon Plan. The DOF must take broad-based actions to enable Oregon's public and private forests to become net sinks of carbon through increased carbon sequestration. This will involve longer harvest rotations of 80+ years, moving away from tree farm monocultures where a diversity of species will be more resilient, increased conservation of mature forests managed for carbon sequestration, and the development of nursery capacity to support the planting of many more trees.

I urge the Board of Forestry to adopt the Department of Forestry Climate Change and Carbon Plan, and to take further action in the future to address climate change.

Sincerely,

Phillip Callaway

Crawfordsville, Oregon

Testimony of the ODF Climate Change and Carbon Plan

Nov 3 2021

For the record, my name is Josie Koehne and I am a small woodland owner with 80 acres with a forest management plan.

I whole-heartedly support the CCCP. I **know** there are many small woodland owners like myself who manage our land for the various ecological benefits they provide for us and for future generations. This year the USDA Forest Service reported on a 2018 national survey **of small woodland owners** with some interesting findings.

In the ***Oregon*** survey of **family forest owners with ten or more acres**, the top three reasons given for owning their land, indicating **very important,** were for 1**) beauty or scenery (64%), 2) for nature protection (60%),** and 3) **for wildlife habitat (59%**), followed by water protection (56%) and privacy at 51%. These responses are very similar to the national survey of small forest owners.

On the question of **timber products** as a reason for owning, **only 16%** of small forest owners indicated this was **very important,** and **17%** as an **important** factor for owning land, **while 38% indicated that timber products were not important** and **14%** said **of little importance**. Together, **52% said forest products was not an important** factor in their ownership decision.

Conclusion: There are far more small family forest owners who own their land **primarily for conservation reasons** compared to those interested in harvesting forest products. Most managing their land for environmental reasons recognize that **mature trees and older forests** also serve as natural carbon sinks that mitigate climate impact.

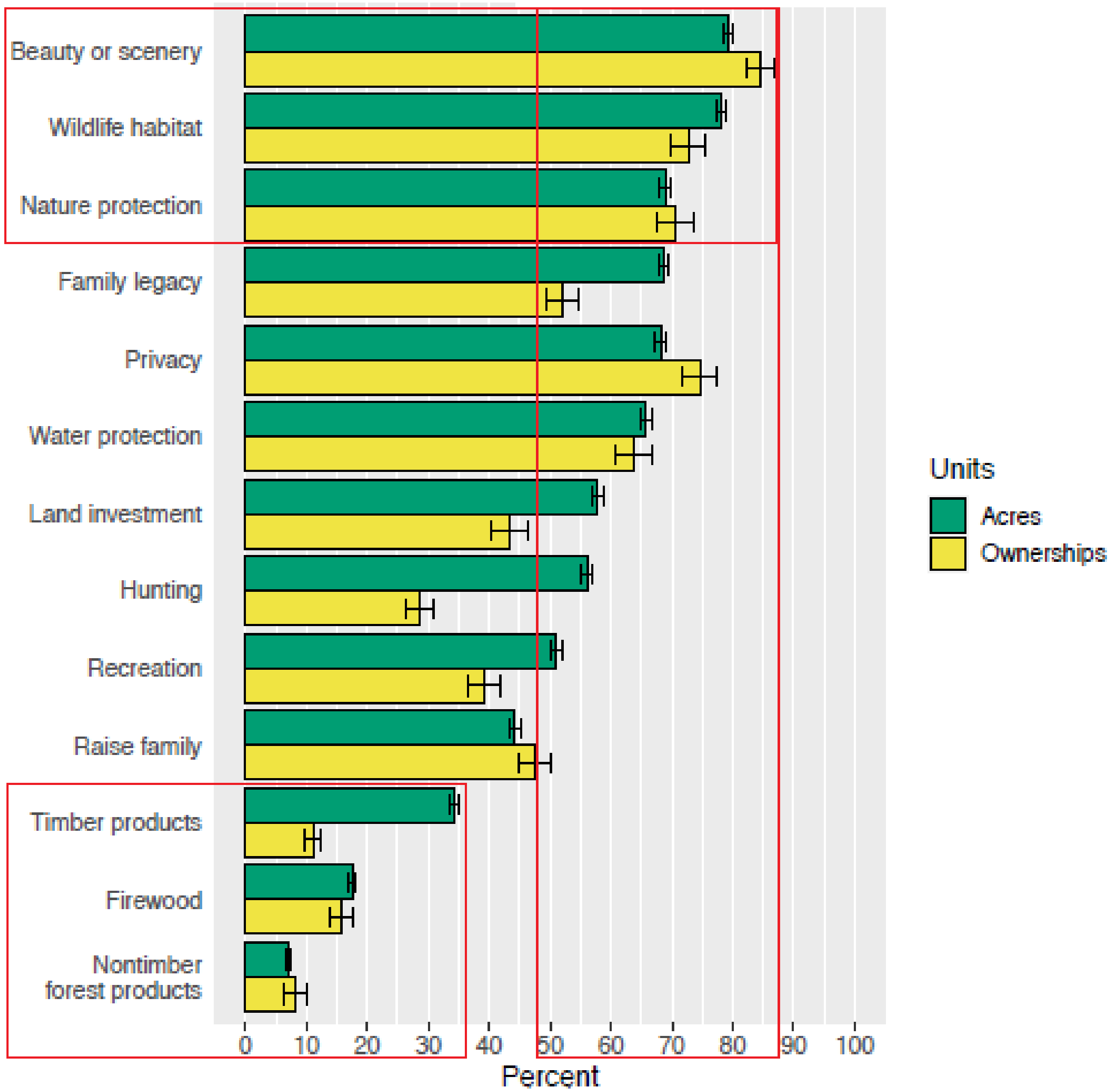
Our interests are not aligned with **commercial industry's management goals of maximizing profit** with short-term harvest rotations and acres of clear-cuts. I certainly am not aligned with the interests of Wall Street logging companies or real estate i**nvestors** who extract our natural resources, don't adequately protect our water resources, and pay virtually no Oregon income taxes. Yes, we need a profitable timber industry, but we need to consider the tradeoffs with climate and environmental priorities. ***There are successful*** operators managing with **these values** in mind.

Many small family forest owners are delighted to see this recent draft of the CCCP addressing the issue of climate change by encouraging **longer rotations** and supporting **climate smart forest practices** among other important steps. I expect this plan will raise strong industry opposition, but **we conservation-minded small forest owners** are thrilled to see that ODF is taking seriously their mandate to take bold steps to combat climate change and we enthusiastically support this plan.

Thank you for this opportunity to express our views.

Reasons for Owning

There are many reasons that people own forest land. The 2018 NWOS asked respondents to rate the importance of 13 potential reasons for owning forest land on a five-point Likert scale that ranged from "Very Important" to "Not Important." The vast majority of family forest land is owned for multiple reasons (Table US-7 in appendix 1, NWOS_2018_FFO_TENPLUS_US.pdf). In terms of acreage, the three most commonly cited reasons for owning forest land are: "To enjoy beauty or scenery," "To protect or improve wildlife habitat," and "To protect nature or biological diversity" (Figure 17). In terms of numbers of ownerships, the most common reasons are: "To enjoy beauty or scenery," "For privacy," and "To protect or improve wildlife habitat" (Figure 17).



Reasons for Owning

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Table OR-7 (2018; FFO, 10+).–Estimated area and estimated number of family forest ownerships (10+ acres of forest land) by reason for owning, Oregon, 2018

	Totals				Percentages				
	Acres	SE[a]	Ownerships	SE[a]	Acres	SE[a]	Ownerships	SE[a]	n
	thousands				*percent*				
Beauty or scenery									
Very important	1,339	129	21	4	44	3	64	5	67
Important	969	124	6	2	32	3	20	4	48
Moderately important	544	85	4	1	18	2	14	4	28
Of little importance	93	36	<1	<1	3	1	1	<1	5
Not important	33	25	<1	<1	1	<1	<1	<1	2
Not applicable	46	24	<1	<1	2	<1	<1	<1	2
Nature protection									
Very important	1,186	133	19	4	39	3	60	6	58
Important	778	111	6	2	26	3	20	5	42
Moderately important	694	97	5	2	23	3	15	4	32
Of little importance	177	52	<1	<1	6	2	3	2	10
Not important	99	41	<1	<1	3	1	2	<1	6
Not applicable	90	34	<1	<1	3	<1	<1	<1	4
Water protection									
Very important	1,140	125	18	4	38	3	56	6	56
Important	791	113	5	1	26	3	16	4	41
Moderately important	789	103	7	2	26	3	22	4	40
Of little importance	166	44	1	<1	6	1	4	2	8
Not important	78	35	<1	<1	3	1	1	<1	4
Not applicable	60	29	<1	<1	2	<1	<1	<1	3
Wildlife habitat									
Very important	1,251	132	19	4	41	3	59	5	65
Important	815	105	6	1	27	3	19	4	38
Moderately important	726	100	5	2	24	3	16	4	38
Of little importance	133	40	1	<1	4	1	4	2	6
Not important	55	29	<1	<1	2	<1	2	<1	3
Not applicable	43	24	<1	<1	1	<1	<1	<1	2
Land investment									
Very important	852	98	8	3	28	3	24	6	38
Important	902	119	11	3	30	3	33	6	49
Moderately important	667	99	6	2	22	3	20	4	34
Of little importance	174	55	3	1	6	2	9	4	10
Not important	367	70	4	1	12	2	12	3	18
Not applicable	62	30	<1	<1	2	<1	2	1	3
Privacy									
Very important	1,281	142	16	4	42	3	51	7	68
Important	903	114	9	2	30	3	28	6	42
Moderately important	492	82	4	1	16	2	11	3	24
Of little importance	170	55	2	<1	6	2	6	2	9
Not important	116	39	<1	<1	4	1	3	1	6
Not applicable	62	29	<1	<1	2	<1	<1	<1	3

[a] SE = standard error

Note: Data may not add to totals due to rounding.

	Totals				Percentages				
	Acres	SE[a]	Owner-ships	SE[a]	Acres	SE[a]	Owner-ships	SE[a]	n
	- - - - - - - - *thousands* - - - - - - -				- - - - - - - - *percent* - - - - - - -				
Raise family									
Very important	843	101	10	3	28	3	30	6	40
Important	561	94	5	2	19	2	14	4	30
Moderately important	333	68	3	<1	11	2	8	2	16
Of little importance	159	47	3	2	5	1	9	5	9
Not important	370	72	5	2	12	2	15	4	18
Not applicable	758	98	8	2	25	3	24	5	39
Family legacy									
Very important	1,449	129	13	3	48	3	39	6	68
Important	533	87	4	1	18	2	11	3	29
Moderately important	465	83	6	3	15	2	18	6	25
Of little importance	191	55	3	1	6	2	9	3	11
Not important	290	63	7	2	10	2	20	4	14
Not applicable	95	38	<1	<1	3	1	2	1	5
Firewood									
Very important	249	59	2	<1	8	2	6	2	12
Important	576	96	5	1	19	3	14	3	29
Moderately important	568	95	6	2	19	3	19	5	33
Of little importance	732	91	5	2	24	2	17	4	32
Not important	667	99	9	2	22	3	28	6	34
Not applicable	231	61	5	2	8	2	17	5	12
Timber products									
Very important	869	105	5	2	29	3	16	5	40
Important	557	98	5	2	18	3	17	5	32
Moderately important	516	84	3	1	17	2	10	3	26
Of little importance	311	68	5	1	10	2	14	4	16
Not important	601	94	12	3	20	3	38	6	29
Not applicable	171	48	1	<1	6	1	5	2	9
Nontimber forest products									
Very important	55	31	<1	<1	2	<1	2	2	3
Important	175	52	4	1	6	2	12	3	9
Moderately important	363	70	6	3	12	2	19	6	17
Of little importance	509	89	4	1	17	2	13	3	28
Not important	1,413	135	12	3	47	3	39	6	69
Not applicable	509	85	5	2	17	2	15	5	26
Hunting									
Very important	670	95	3	1	22	3	9	3	32
Important	656	98	4	1	22	3	13	4	30
Moderately important	642	96	4	1	21	3	13	4	35
Of little importance	237	62	2	<1	8	2	5	2	12
Not important	511	91	14	3	17	3	42	6	26
Not applicable	308	71	6	2	10	2	18	5	17

[a] SE = standard error
Note: Data may not add to totals due to rounding.

Table OR-7 (2018; FFO, 10+).–continued

	Totals				Percentages				
	Acres	SE[a]	Owner-ships	SE[a]	Acres	SE[a]	Owner-ships	SE[a]	n
	- - - - - - - - *thousands* - - - - - - -				- - - - - - - - *percent* - - - - - - -				
Recreation									
Very important	759	97	10	3	25	3	32	6	36
Important	756	108	8	2	25	3	26	5	39
Moderately important	858	105	6	2	28	3	19	4	41
Of little importance	197	57	4	2	7	2	11	4	11
Not important	365	75	3	1	12	2	11	3	20
Not applicable	90	37	<1	<1	3	1	2	<1	5

[a] SE = standard error
Note: Data may not add to totals due to rounding.

Dear Chair Kelly and Members of the Board.

As the Forestry Lead for the Metro Climate Action Team, a group comprised entirely of dedicated volunteers, which is sponsored by the Oregon League of Conservation Voters, I encourage you to adopt the Climate Change and Carbon Plan.

The CCCP is quite an extraordinary document. We are especially pleased that as stated "ODF will be a leader in promoting climate smart forestry." How wonderful that ODF acknowledges that climate change is a serious threat and that we need innovative and creative solutions to avoid catastrophic impacts. We much appreciate that the Plan acknowledges that a "business as usual" approach will no longer work to address needed mitigation and adaptation. We greatly appreciate that the Plan notes the need to account for "forestry related carbon impacts." Especially important is the acknowledgement that longer rotations are among the potential actions needed to help mitigate the amount of greenhouse gases in our atmosphere.

Research by scientists at PSU has documented that by far the biggest bang for our bucks in using natural climate solutions is to have longer logging rotations. This research was acknowledged by the Oregon Global Warming Commission and was used to help establish their goals for sequestering an additional 5 MMTCO2e annually by 2030 and an additional 9.5 MMTCO2e, annually, by 2050. ODF will be a key player in meeting these goals as the Plan recognizes that most of this sequestration will come from the forest sector.

We are concerned that unless climate smart forestry is spelled out that it could become a catch all phrase that over time becomes so general as to be meaningless. So, we want to share our working definition:

Climate smart forestry optimizes forest carbon sequestration, carbon storage and forest resilience while minimizing greenhouse gas emissions. Practices generally include longer harvest rotations, protecting old growth and mature forests, and maintaining a diversity of species, ages, and structure.

I do not believe there is much debate around the "what" – especially the need for longer rotations and the importance of preserving mature and old growth forest, especially here in the Pacific Northwest which we know are carbon eating and retaining giants – more so than any other forest on earth, a fact that the Plan acknowledges. The "how" for optimizing sequestration we know is the challenge. We look to the Board to use all its powers and influence to find ways to incentivize longer rotations.

One challenge I believe the Board will need to address is culture change which undoubtedly will be required at ODF for this plan to succeed. I spent much of my professional career working on organizational cultures. Culture change is dependent on what leaders do, model, say, reinforce, reward and punish and will only happen when the leaders at ODF are fully aligned on their mission/vision/values, and goals, which must be climate informed. If they are aligned on this CCCP, then I believe ODF can fulfill its aspirations to be a national leader. The Board has a critical role to play.

The CCCP is quite a remarkable document and points to a transformative purpose for ODF – one that has the potential to truly engage and empower staff throughout the agency. Transformative leadership will be the fuel. I applaud the Board's willingness to be a key agent of change in this transformation.

Rand Schenck
Forestry Lead, Metro Climate Action Team, MCAT

NCASI
IMPACT. SCIENCE. SOLUTIONS.

To: Members of the Oregon Board of Forestry

Comments on the Draft Climate Change and Carbon Plan (CCCP) from the Oregon Department of Forestry

The National Council for Air and Stream Improvement, Inc. (NCASI) serves forest landowners, managers, and the forest products sector as a center of excellence for providing technical information and rigorous scientific research needed to achieve the sector's environmental goals and principles, including forest carbon. NCASI (*http://www.ncasi.org*) has a long history of collaborative research and technical efforts focused on quantifying carbon stocks and sequestration in managed forests.

Summary

The Draft Climate Change and Carbon Plan (CCCP) from the Oregon Department of Forestry suggests that additional carbon sequestration is possible through changes in management of Oregon's forests, such as harvest deferrals and extended rotations. However, some studies that support this viewpoint (Diaz et al. 2018, Moomaw et al. 2019, Graves et al. 2020) are flawed in their omission of leakage and substitution and neglect to compute the cost of such management changes. If the Oregon Department of Forestry proceeds with measures intended to increase carbon sequestration from the forest sector without careful consideration of leakage and substitution, the result may be higher costs to Oregon forest landowners and wood procurement entities without the desired reductions in greenhouse gas emissions.

Leakage and Substitution

Deferring harvest of stands generally results in higher carbon stocks in forests, but lower sequestration rates, as annual carbon sequestration decreases after reaching a peak which is generally close to the average rotation age. Commercial timber harvest is carefully planned to maintain high levels of forest productivity (and sequestration rates) while meeting demand for forest products. When harvests are deferred, there are inevitable economic consequences: a combination of leakage and substitution.

Leakage occurs when identical products are purchased from another source. For example, softwood sawlogs could be purchased from California, Washington, Idaho, or Canada to compensate for the diminished Oregon supply. In this case, any CO_2 emissions associated with timber harvest still result, but are simply shifted from Oregon to another state. Oregon loses the benefit of the economic activity involved in harvest and manufacturing, while there may be no reduction in greenhouse gas emissions. This leakage can be quantified. For example, Wear and Murray (2004) determined that when federal timber harvests were reduced in the Pacific Northwest in the 1990s, 84% of that harvest reduction was shifted to private landowners in the PNW, to Canada, and to the US South. Markets for carbon offsets recognize this and employ reduction factors to account for the leakage associated with any harvest reduction (Murray et al. 2004, Galik et al. 2009, BC MECCS 2021).

NATIONAL COUNCIL FOR AIR
AND STREAM IMPROVEMENT, INC.

P.O. Box 1259
Anacortes, WA 98221

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ncasi.org

Substitution occurs when a different product is used in place of the product withheld from the market by harvest deferral. For example, a builder might use concrete or steel in place of softwood lumber. In this case, life-cycle analysis (LCA) can be used to determine the CO_2 emissions resulting from the substitute product. Many of the products substituted for wood (such as concrete or steel) have much higher embodied emissions, so reducing the availability of wood products could lead to a net *increase* in CO_2 emissions. Substitution effects can also be quantified, based on LCA studies. For example, according to Environmental Product Declarations, production of 1 m^2 of softwood lumber decking (including wood harvest) involves emissions of 2.4 kg CO_2e[1], while production of 1 m^2 of composite decking results in emission of 31.8 kg CO_2e[2], more than 13 times as much.
The Graves et al. (2020) study cited in the CCCP omitted any consideration of leakage and chose not to consider substitution "due to the large and compounding uncertainty in assumptions related to estimating substitution". While the quantity of the substitution effect may be uncertain, there is no doubt that some amount of leakage or substitution will occur when the supply of products is reduced.

Costs of carbon benefits

Thorough analysis of the both the costs and carbon benefits of harvest deferrals must include not only the increased sequestration possible within Oregon, but also the carbon storage in harvested wood products and the potential for increased emissions elsewhere through leakage and substitution. The costs incurred from harvest deferral should be divided by any net carbon benefit (after including leakage and substitution) to obtain the cost per ton of increased sequestration to determine if the proposed management changes are efficient and effective.

Example analysis

For example, NCASI conducted an analysis of the effect of deferred harvests on carbon storage, carbon sequestration rates, CO_2 emissions, and costs in a review document titled "NCASI Review of Carbon Implications of Proforestation"[3]. The analysis was based on recent forest inventory data on private, planted Douglas-fir forests in Oregon and Washington. One of the scenarios included a 10% reduction in overall harvest volumes compared to a current baseline, resulting in extending the average harvest age by 12 years. Emissions from substitute products were estimated using published displacement factors, which express the emissions from a non-wood product per unit of emissions from the use of a comparable wood product. Positive values indicate that using a non-wood substitute causes more GHG emissions than using a wood product. Reported average factors for construction lumber substitutes range from 0.54 (Smyth et al. 2017) to 1.2 (Leskinen et al. 2018) to 2.1 (Sathre and O'Connor 2010).
The deferred harvest scenario resulted in about a 4.5% reduction in annual net sequestration rates after considering substitution effects (using the most conservative displacement factor). Even if substitution effects were ignored, the increase in carbon stocks came at a cost (in terms of foregone stumpage revenue to landowners) of more than $300 per MT CO_2. This greatly exceeds the average payments to landowners engaged in carbon offset markets, which may be in the range of $13 to $15 per MT CO_2e. Thus, it is unlikely that landowners could be compensated by carbon markets for the costs of such harvest deferral. Furthermore, lost stumpage revenue is clearly not the only cost associated with harvest reductions but remains the easiest to quantify.

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[1] Environmental Product Declaration, North American Softwood Lumber: https://www.awc.org/pdf/greenbuilding/epd/AWC_EPD_NorthAmericanSoftwoodLumber_20200605.pdf
[2] Environmental Product Declaration, Innowood: https://innowood.com/wp-content/uploads/2017/07/INNOWOOD-EPD-Brochure.pdf
[3] https://www.ncasi.org/resource/ncasi-review-of-carbon-implications-of-proforestation/

Recommendation

Climate change mitigation benefits are highest when policies and regulations are based on the best available scientific information and current data. Numerous studies have examined the carbon dynamics resulting from forest management alternatives and have made it clear that carbon storage and emissions occur well beyond the boundary of the forest. Evaluation of the net climate effect of such policies and regulations should include economic displacement of emissions due to leakage and/or substitution. If they don't, it is likely that disruptions to existing markets will be costly and may not result in the desired climate benefits.

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NCASI
PO Box 1259 | Anacortes, WA 98221
(360) 873-5012

Submitted: Sat 10/30/2021 4:17 PM

Subject: Public Comment on Agenda Item 8 for the November 3, 2021 Board of Forestry Meeting

Message:
Dear Chair Kelly and Members of the Board,

My name is Annabelle Valdini, I'm 14 years old, and I live in Portland, Oregon. This comment is about Agenda Item 8 for the November 3, 2021 Board of Forestry Meeting. I'm writing to beg the Board of Forestry to support the Oregon Department of Forestry's Climate Change & Carbon Plan (CCCP).

Throughout Oregon this year, we have seen some of the worst drought conditions and wildfires in the history of the state. If you support and adopt the CCCP, it will slow down and mitigate the effects of climate change across Oregon and the United States as a whole, something we desperately need.

Every day, more trees are cut down, more carbon that had been stored in those trees is released into the air, and more animals lose their habitat. More drinking water is polluted, more streams run dry, and more threatened species go extinct. You can change all that. The Board of Forestry has powers I have never had, and I probably never will–powers to protect forests, powers to help slow down climate change–but there isn't actually a rule about protecting mature and old growth forests in the CCCP. This needs to change; we need to protect the trees, which would in turn protect the human species, and every other species from eventual extinction at the hands of the monster humankind has created.

I'm writing to you today because I am so tired of adults not doing anything real to stop climate change, with catastrophic implications for every person, animal, and plant on Earth. I am so tired of watching the news every day and seeing that things are just getting worse and worse, while the politicians just sit there and let it happen. We elected them because we thought they would help lead us through these scary and dangerous times. Will you, the Board of Forestry, help us by supporting the CCCP?

Thank you for providing this opportunity to comment publicly, and once again, please adopt the CCCP and add on a rule about protecting mature and old growth forests.

Annabelle Valdini

Written Comments to Oregon Board of Forestry: CCCP

October 23, 2021

Chair Kelly, Acting State Forester Hirsch, and Members of the Board:

Audubon Society of Lincoln City and Salem Audubon Society strongly support approval of ODF's Climate Change and Carbon Plan. We believe the plan, while long overdue, is a necessary first step and demonstrates the Department's willingness to engage in honest, authentic efforts to address the dangers we all face as a result of increasing atmospheric temperatures.

We are pleased to see the CCCP recognizes the importance of the Natural and Working Lands recommendations put forward by the Oregon Greenhouse Gas Commission. We encourage the Oregon Board of Forestry to prioritize natural climate solutions. Science tells us Oregon's temperate rain forests could be our greatest resource in the fight against climate change if we truly take the lead in climate smart forestry.

We appreciate the focus on environmental justice put forward in the CCCP. Residents of our counties have seen first hand the devastating effects extreme weather events bring about. The poor and disadvantaged residents of rural areas are the first to suffer and the last to receive that attention of policy makers. It is time to change our business practices and take aggressive steps to reduce emissions in all sectors of our economy. It truly is time for an "all-hands-on-deck" approach. No one should have the right to push a private agenda at the expense of society as a whole.

We wish the plan were stronger. We would like to see a greater commitment to carbon sequestration in large mature trees. We would like to see establishment of carbon sequestration reserves. We would like to see more aggressive development of a carbon pricing market. We wish DEQ and ODF would commit more fully to a complete accounting of emissions from all activities related to forest management including fire protection. We wish it dealt more honestly with the ideas of "leakage" or substitution and the real sequestration capacity of wood products. But all that said, we strongly support the plan and ask the Oregon Board of Forestry to approve it.

We look forward to working with the Board and the Department in the future as you move the vision and aspirations of the CCCP into concrete actions through new Forest Management Plans, Implementation Plans, and AOPs.

Thank you.

Campaign Title: Submitting Public Comment on Draft Climate Change and Carbon Plan

Campaign Sponsor: 350 PDX, https://350pdx.org/

Campaign Message:

Dear Oregon Board of Forestry,

This letter regards Agenda Item 8 for the November 3, 2021 Board of Forestry Meeting. I urge the Board of Forestry to support the Oregon Department of Forestry's Climate Change & Carbon Plan (CCCP).

We have all seen the wildfires and some of the worst drought conditions in our state's history: the climate crisis is here. Oregon's forests could play a critical role in sequestering & storing carbon, but through current forest management policies, our forests are net greenhouse gas emitters.

Right now, rural communities' drinking water supplies are running dry and polluted by industrial chemicals. Carbon-rich forest ecosystems are logged for private profit, rapidly releasing stored carbon into the atmosphere. Threatened species have fewer and fewer cool places where they can shelter from the heat.

The Board of Forestry can change all of this by supporting the CCCP. Oregon's temperate rainforests are some of the most carbon-rich landscapes in the world, and by protecting them, we could play an important role in slowing the climate crisis. With better management, our forests could protect our communities in a changing climate, reducing wildfire impacts and producing clean drinking water to help us battle worsening droughts. Forests would fulfill their natural role as climate allies.

By adopting the CCCP, the Board of Forestry would take a crucial first step towards Oregon becoming a leader in climate-smart forestry, and creating a model for how to best use forests as a critical natural climate solution.

We strongly support the CCCP's recommendations to:
- Ensure forest policies will be shaped through the lens of social justice and equity;
- Identify and protect climate refugia;
- Use the Oregon Global Warming Commission's Natural and Working Lands goals to guide the Department;
- Revise the Oregon Forest Practices Act to better prioritize climate change and carbon storage;
- Incentivize the adoption of climate-smart forestry practices on private lands;
- Incorporate climate change into the Forest Management Plan (FMP) process;
- Restore ecological function when addressing the need to manage forests for increased wildfire severity and develop a prescribed fire program within the Department;
- Work with landowners and managers, large and small, to create resilient landscapes;
- Account for forestry related carbon impacts, including the emissions of all proposed actions; and
- Ensure climate change is a foundational consideration in all agency planning processes.

Protecting mature and old growth forests – the best known way to increase carbon storage and climate resiliency – was not explicitly included in the CCCP. I encourage the Board of Forestry to enact rules to protect older trees and forests, in particular in state forests where the Board has the greatest authority.

Thank you for the opportunity to comment, and again, I urge you to support the CCCP.

Message Senders: 217 as of 11/05/2021, 2 p.m.

From:	Daniel Jaffee
To:	ODF_DL_Board of Forestry
Subject:	Submitting Public Comment on Draft Climate Change and Carbon Plan
Date:	Wednesday, October 27, 2021 7:25:02 AM

Dear Oregon Board of Forestry,

Dear Chair Kelly and Members of the Board of Forestry,

I am writing to comment on Item 8 on the agenda for the November 3, 2021 Board Meeting. I want to urge the Board of Forestry to support the Oregon Department of Forestry's Climate Change & Carbon Plan (CCCP).

The climate crisis has clearly arrived. Oregon's forests can play a critical role in sequestering & storing carbon, but because of current forest management policies, our forests are instead net greenhouse gas emissions.

Carbon-rich forest ecosystems are being logged for private profit, rapidly releasing stored carbon into the atmosphere. Threatened species have fewer and fewer cool places where they can shelter from the heat.

You, as the Board of Forestry, can change all of this by supporting the CCCP.

Oregon's temperate rainforests are some of the most carbon-rich landscapes in the world. With better management, our forests could protect our communities in a changing climate, reducing wildfire impacts and producing clean drinking water to help battle worsening droughts.

Please take this crucial step towards Oregon becoming a leader in climate-smart forestry, and creating a model for how to best use forests as a critical natural climate solution.

I strongly support the CCCP's recommendations to ensure forest policies will be shaped through the lens of social justice and equity; identify and protect climate refugia; use the Oregon Global Warming Commission's Natural and Working Lands goals to guide the Department; revise the Oregon Forest Practices Act to better prioritize climate change and carbon storage; incentivize the adoption of climate-smart forestry practices on private lands; incorporate climate change into the Forest Management Plan (FMP) process; and many more areas.

However, protecting mature and old growth forests – the best known way to increase carbon storage and climate resiliency – was not explicitly included in the CCCP. I urge the Board of Forestry to enact rules to protect older trees and forests, in particular in state forests where the Board has the greatest authority.

I urge you to support the CCCP.

Thank you for your attention.

Sincerely,
Daniel Jaffee
4723 NE 14th Ave

Portland, OR 97211

Submitted: Sat 10/30/2021 2:23 PM

Subject: Submitting Public Comment on Draft Climate Change and Carbon Plan

Message:
Oregon Board of Forestry Members,

My name is Spencer Kroll and I live outside of Vernonia, OR in unincorporated Columbia County. My husband and I own 36 acres of timberland surrounded by tens of thousands of acres of Weyerhaeuser forest.

As a 34 year-old timber property owner, I am deeply concerned as to what the future holds for us regarding the impacts of catastrophic climate change on Oregon forests. Following the heat blast this past June, many young firs and cedars have continued to wilt, brown and die and I worry that unless we take real action, our forests will not be around much longer. It is so deeply sad, disturbing and frustrating to witness these anthropogenic changes in the climate and feel so helpless as someone that works in and cares deeply about the woods.

In lieu of this, I am asking that you all adopt the CCCP as a necessary step in bringing the way we manage our forests into the 21st century. Among many other things, this would create a framework that recognizes the impacts of climate change as an actual, real threat instead of continuing to kick this can down the road.

I am ready to do everything I can to make sure my forest is healthy for the next generation to come, but we all need your help as leaders to show us the way.

Again, please adopt the CCCP! I want a future with forests in Oregon, not ashes and memories.

Thanks for your time,

Spencer Kroll

From:	Harry Kershner
To:	ODF_DL_Board of Forestry
Subject:	Submitting Public Comment on Draft Climate Change and Carbon Plan
Date:	Friday, October 29, 2021 9:49:08 AM

Dear Oregon Board of Forestry,

Dear Chair Kelly and Members of the Board,

Re: Agenda Item 8 for the November 3, 2021 Board of Forestry Meeting. I urge the Board of Forestry to support the Oregon Department of Forestry's Climate Change & Carbon Plan (CCCP).

Sincerely,
Harry Kershner
9322 N Oswego
Portland, OR 97203

Campaign Title: Tell the Oregon Board of Forestry to adopt its Climate Change and Carbon Plan now

Campaign Sponsor: Unknown

Campaign Message:

Dear Jim Kelly,

I very much appreciate the Department's efforts to undertake climate-smart forestry and address the threat of climate change. The Board of Forestry and ODF must prioritize our state public forests as part of Oregon's strategy to confront the growing threat of climate change.

Oregon's temperate rainforests represent some of the most carbon rich landscapes in the world and ODF has a critical role to play in demonstrating what ambitious, visionary, climate-smart forest policy looks like for the temperate rainforest regions in the United States and beyond. The Climate Change and Carbon Plan is an important first step to recognizing and supporting this potential.

Oregon's state public forests, in particular, are a key part of the solutions that Oregon can provide. Our state forestland can help reduce the future impacts of climate change by sequestering more carbon, and help the state adapt to impacts in the near term, such as heat waves, drought, flooding, and more severe wildfires.

The management strategies for using our state forests to fight climate change are not in conflict with promoting vibrant and prosperous rural communities. Practices like longer logging rotations, bigger riparian buffers, more green tree retention, and conserving mature and old growth forests will produce water quality and quantity needed for drinking sources and fish, reduce wildfire risk, and allow for a sustainable timber supply while also enhancing outdoor recreation and wildlife habitat. The Board's obligation to achieve Greatest Permanent Value on these lands demands action in favor of all of these values, not just timber harvest.

On behalf of current and future generations of Oregonians, we must adapt our forestry management practices to reflect the realities of climate change. Greatest Permanent Value itself depends on this.

Thank you for the steps you have begun to take towards making Oregon a leader in natural climate solutions. As a next step in advancing needed, visionary actions to counter the climate crisis we face today, I urge you to adopt the Climate Change and Carbon Plan and direct ODF to translate it into meaningful actions on state forest lands as part of the ongoing Forest Management Plan process.

Message Senders: 410 as of 11/05/2021, 2 p.m.

From:	yuiqwe1@everyactioncustom.com on behalf of Theodore Chu
To:	ODF_DL_Board of Forestry
Subject:	Tell the Oregon Board of Forestry to adopt its Climate Change and Carbon Plan now
Date:	Thursday, October 28, 2021 5:28:06 PM

Dear Jim Kelly,

Short and sweet - please adopt the Climate Change and Carbon Plan. I live surrounded by state forest and part of the drainage for my culinary water is on state forest. The greatest value to be derived from our public lands is no longer timber production. It is now and into the future preservation and recovery of healthy forest and its ability to slow climate change and sequester carbon.

Sincerely,
Mr. Theodore Chu
41400 Anderson Rd Nehalem, OR 97131-9555
yuiqwe1@gmail.com

From:	ggreyhnd@everyactioncustom.com on behalf of Paul Daniello
To:	ODF_DL_Board of Forestry
Subject:	Tell the Oregon Board of Forestry to adopt its Climate Change and Carbon Plan now
Date:	Thursday, October 28, 2021 6:43:13 PM

Dear Jim Kelly,

I urge the Oregon Board of Forestry to adopt the Climate Change and Carbon Plan. It is urgent that the Department implements the plan now.

Sincerely,
Mr. Paul Daniello
509 NW 11th St Pendleton, OR 97801-1363
ggreyhnd@me.com

From:	andy.freed@everyactioncustom.com on behalf of Andy Freed
To:	ODF_DL_Board of Forestry
Subject:	Tell the Oregon Board of Forestry to adopt its Climate Change and Carbon Plan now
Date:	Friday, October 29, 2021 11:10:11 AM

Dear Jim Kelly,

Please use this important moment to adopt the climate and carbon plan. The timing is critical if we want to prevent further decline and lower the quality of life for all Oregonians, human or not.

Sincerely,
Mr. Andy Freed
2821 N Willis Blvd Portland, OR 97217-7017
andy.freed@gmail.com

From:	nholmes105@everyactioncustom.com on behalf of Nancy Holmes
To:	ODF_DL_Board of Forestry
Subject:	Tell the Oregon Board of Forestry to adopt its Climate Change and Carbon Plan now
Date:	Thursday, October 28, 2021 12:07:19 PM

Dear Jim Kelly,

Please tell the Oregon Board of Forestry to adopt its Climate Change and Carbon Plan now. Time is wasting as we all learned in the last two years about wildfires which were particularly devastating in clear cut and over grazed areas of this state and others.

I am 86 years old and when I became away of climate change in the 60s and 70s I had no idea I would live to see the animals moving north and out of their livable habitat, killing heat waves and drought in the Cascades. But now sadly I can see climate change by looking at our sunburned trees here on the coast and on highway 26.

We all know we need trees to breath clean air. ALL of us. Let's be smart about this. It is almost too late.

Thanks,
Nancy Holmes

Sincerely,
Ms. Nancy Holmes
1520 Cooper St Seaside, OR 97138-7848
nholmes105@yahoo.com

From:	jacobgk@everyactioncustom.com on behalf of Greg Jacob
To:	ODF_DL_Board of Forestry
Subject:	Tell the Oregon Board of Forestry to adopt its Climate Change and Carbon Plan now
Date:	Thursday, October 28, 2021 11:44:03 AM

Dear Jim Kelly,

All of us must address the threat of climate change, and it is my hope that the Board of Forestry and ODF will manage state forests to help confront the growing threat of climate change.

The forests of the Pacific Northwest are greater storers of carbon than the Amazon forests. For our forests to play that critical role we need to set aside old stands of trees for posterity, have longer rotations between harvest, and wide stream buffers that benefit fish, wildlife, and recreation opportunities. The Climate Change and Carbon Plan is an important first step to recognizing and supporting this potential.

The Board's obligation to achieve Greatest Permanent Value on these lands demands action in favor of all of these values, not just timber harvest. Forestry management values must address the reality of climate change.

I urge you to adopt the Climate Change and Carbon Plan.

Sincerely,
Mr. Greg Jacob
1331 NE Parkside Dr Hillsboro, OR 97124-4096
jacobgk@comcast.net

From: SUNNYBENDGIRL@everyactioncustom.com on behalf of Karen Kassy
To: ODF_DL_Board of Forestry
Subject: Tell the Oregon Board of Forestry to adopt its Climate Change and Carbon Plan now
Date: Thursday, October 28, 2021 11:44:00 AM

Dear Jim Kelly,

I live in Sisters. I so appreciate all your hard work!
I hope you will continue to adapt forestry management that reflect climate change. It is a real thing that will affect many future generations. Thank you for the work you've already doe for this. Please adopt the Climate Change and Carbon Plan and direct ODF to help it be meaningful & purposeful in actions on state forest lands as well as continuing Forest Management Plan process.

be/stay well.

Sincerely,
Ms Karen Kassy
223 E Hood Ave # 1421 Sisters, OR 97759-1128
SUNNYBENDGIRL@GMAIL.COM

From:	caroltov@everyactioncustom.com on behalf of Carol Newman
To:	ODF_DL_Board of Forestry
Subject:	Tell the Oregon Board of Forestry to adopt its Climate Change and Carbon Plan now
Date:	Thursday, October 28, 2021 8:26:06 PM

Dear Jim Kelly,

I live in rural Oregon east of Astoria and know how important our state forests are in our lives now and in the future.

Thank you for the steps you have begun to take towards making Oregon a leader in natural climate solutions. I hope you will take the opportunity to move this along when you vote on November 3rd..

I urge you to adopt the Climate Change and Carbon Plan and to direct ODF to translate it into meaningful actions on state forest lands as part of the ongoing Forest Management Plan process. Practices like longer logging rotations, bigger riparian buffers, more green tree retention, conserving mature and old growth forests to produce water quality and quantity needed for drinking sources, for fish and to reduce wildfire risk. We can allow for a sustainable timber supply while also enhancing outdoor recreation and wildlife habitat.

I urge you to fulfill the Board's obligation to achieve Greatest Permanent Value on these lands by fulfilling all of these values, not just timber harvest.

Thank you.

Sincerely,
Ms. Carol Newman
44331 Peterson Ln Astoria, OR 97103-8413
caroltov@pacifier.com

-----Original Message-----
From: rogerrocka@everyactioncustom.com <rogerrocka@everyactioncustom.com>
Sent: Thursday, October 28, 2021 3:15 PM
To: ODF_DL_Board of Forestry <odf_dl_BoardofForestry@oregon.gov>
Subject: Tell the Oregon Board of Forestry to adopt its Climate Change and Carbon Plan now

Dear Jim Kelly,

I listen to meetings of the Forest Trust Land Advisory Committee and note that their absolute and entire focus is on extracting money from the forest. The same is true of many investment trusts. The problems of our people, our communities and our planet can't be solved with that narrow goal. Places like Rockaway Beach lose their source of clean water, Wall Street interests mow down forests before they are old enough to sequester carbon, fish stocks decline becuase cool, protective juvenile habitat is lost, herbicides are widely sprayed destroying other species of insects, plants and animals. It's a destructive imbalance with no positive end. ODF has the power to restore balance and health. Please use it.

[CAMPAIGN MESSAGE]

Sincerely,
Mr. Roger Rocka
362 Duane St Astoria, OR 97103-4419
rogerrocka@icloud.com