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Re: Public Workshop: 2022 Scoping Plan Update – Natural and Working Lands Technical Workshop; nwl-2021-tech-ws.

The Center for Biological Diversity submits the following comments on CARB's July 20, 2021, Natural and Working Lands Technical Workshop. We would like thank CARB staff for presenting the workshop to share CARB's concept for quantifying a natural and working lands ("NWL") carbon target. These comments make recommendations on improving the process for setting a NWL target and recommend numerous published scientific studies that should be included in the literature review and meta-analyses that CARB is undertaking to inform the process and target.

I. California must focus climate action on rapidly phasing out fossil fuel production and use—the primary drivers of the climate emergency—which will provide most certainty for achieving greenhouse gas emissions reductions.

We support the goal of protecting carbon storage on California's NWL while simultaneously supporting and prioritizing ecosystem protection and the many co-benefits provided by these lands. However, we caution that, if improperly administered, NWL interventions can harm carbon stocks, fuel climate change, and reduce ecosystem function and resilience, which is a particular risk for forest lands which are the focus of these comments. To reduce greenhouse gas emissions, the state should prioritize policies that halt new fossil fuel extraction and phase out existing fossil fuel extraction and use, given that fossil fuels are the primary driver of the climate emergency and rapid fossil fuel phase-out is most certain and effective way to confront the climate crisis. The need for a fossil fuel phase-out and just transition to clean, renewable energy is urgent. The IPCC and United Nations scientific bodies have established that limiting warming to 1.5°C requires cutting global fossil CO_2 emissions by half by 2030—nine years from now—and reaching near zero by 2050,[1] with faster reductions needed in California and the U.S.[2]

II. Policy options must include land protection across all land types which promotes carbon storage, climate resilience, and co-benefits provided by intact ecosystems.

CARB must model land protection as a key policy option across all the NWL land types which will promote carbon storage and sequestration while protecting ecological functions and their many co-benefits. For forest ecosystems, CARB must model forest protection—meaning no logging, thinning, or biomass energy—as a discrete policy option. In addition, CARB should model the policy options of reduced logging on private lands and managed wildland fire**.**

Protecting existing forests from logging/thinning and allowing logged forests to continue to grow and reach their full biological carbon sequestration potential is a highly and immediately effective, low- or zero-cost approach to removing carbon dioxide from the atmosphere.[3] As detailed in an analysis by **Moomaw et al. (2019),** growing existing forests intact to their ecological potential—termed *proforestation*—maximizes forest biological carbon sequestration and is critical for limiting global warming to 1.5°C and avoiding the worst harms from the climate crisis.[4] As summarized by **Moomaw et al. (2020),** numerous studies support forest protection as an important carbon and climate solution:

> **Erb *et al* (2018)** demonstrate that forests could be absorbing twice as much carbon as currently, and **Houghton and Nassikas (2018)** estimate that if all secondary forests were allowed to continue growing, abandoned agricultural lands returned to forests and forest land conversion were halted, sequestration rates could be 4.3 GtC/y. A more recent study by **Moomaw *et al* (2019)** demonstrate that since the average age of most managed forests is so young, allowing some of them to grow to meet their ecological potential for carbon sequestration accelerates as the forest ages for decades to a century or more. They call this

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[1] Intergovernmental Panel on Climate Change, Global warming of 1.5°C at 12-14, Figure 2.6, (2018), *available at* https://www.ipcc.ch/sr15/.

[2] Climate Equity Reference Project, Climate Equity Reference Calculator, https://calculator.climateequityreference.org/ (last visited July 27, 2021).

[3] Buotte, P.C. et al., Carbon sequestration and biodiversity co-benefits of preserving forests in the western United States, 30 Ecological Applications e02039 (2020) https://esajournals.onlinelibrary.wiley.com/doi/10.1002/eap.2039; Moomaw, William R. et al., Intact forests in the United States: Proforestation mitigates climate change and serves the greatest good, 2 Frontiers in Forests and Global Change (2019), https://www.frontiersin.org/articles/10.3389/ffgc.2019.00027/full; Luyssaert, S. et al, Old-growth forests as global carbon sinks, 455 Nature 213 (2008), *available at* https://www.nature.com/articles/nature07276.

[4] Moomaw, William R. et al., Intact forests in the United States: Proforestation mitigates climate change and serves the greatest good, 2 Frontiers in Forests and Global Change (2019), https://www.frontiersin.org/articles/10.3389/ffgc.2019.00027/full.

> management practice Proforestation, and it has the advantage of being very low cost, much less labor intensive than afforestation or reforestation and does not require additional land. **Brancalion *et al* (2019)** find similar carbon storage benefits with forest restoration efforts. **Lutz *et al* (2018)** find that for 48 forests of all types globally, on average, half of the living biomass carbon is sequestered in the largest one percent diameter trees, and **Stephenson *et al* (2014)** determined that for hundreds of tree species, the sequestration rate increased with size. **MacKey *et al* (2015),** find sequestration continuing in primary intact forests. It is also known that forest soil carbon increases in older forests and can account for as much or more sequestered carbon as found in living trees.[5]

Zachmann et al. (2018), a study conducted in California's West Lake Tahoe Basin, similarly supports forest protection to achieve multiple co-benefits. Specifically, the study recommended incorporating "prescribed natural regeneration" into forest management planning to increase forest resilience—that is, deliberately allowing natural processes to proceed unimpeded in some areas which "is often ignored as a viable land-use option."[6] This study found that the structure and fuel variables of mixed conifer forest stands in the Lake Tahoe basin that were treated with prescribed fire were "moving in a similar direction" as stands left to natural regeneration. The results "suggested that untreated areas may be naturally recovering from the large disturbances associated with resource extraction and development in the late 1800s [even while exposed to a changing climate and long-term fire suppression], and that natural recovery processes, including self-thinning, are taking hold." The study concluded that "incorporation of natural regeneration into forest management planning can greatly reduce the cost and resource requirements of large-scale restoration efforts, while also providing habitat for fire-dependent and undisturbed old forest dependent species."

On private forestlands, CARB should model following policy options: longer harvest rotations, avoidance of clearcutting and other intensive forms of tree removal, and the retention of larger trees, all of which allow forests to accumulate more carbon. A comprehensive study by **Law et al. (2018)** concluded that lengthened harvest cycles on private lands and restricting logging/thinning on public lands are the most effective management measures for increasing net ecosystem carbon balance, followed by reforestation and afforestation.[7] In contrast, using forest harvest residue for bioenergy production increased cumulative net emissions compared to leaving residues in the forest to slowly decompose.

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[5] Moomaw, William R. et al., Focus on the role of forests and soils in meeting climate change mitigation goals: summary, 15 Environmental Research Letters 045009 (2020), https://iopscience.iop.org/article/10.1088/1748-9326/ab6b38.

[6] Zachmann, L.J. et al., Prescribed fire and natural recovery produce similar long-term patterns of change in forest structure in the Lake Tahoe basin, California, 409 Forest Ecology and Management 276 (2018), *available at* https://www.sciencedirect.com/science/article/abs/pii/S037811271731530X?via%3Dihub.

[7] Law, B.E. et al., Land use strategies to mitigate climate change in carbon dense temperate forests, 115 PNAS 3663-3668 (2018), https://www.pnas.org/content/115/14/3663.

CARB should also model managed wildland fire in which land managers decide to allow lightning-caused fires to burn in order to protect carbon storage, enhance natural heterogeneity, increase forest health and resilience, and benefit wildlife. **Schoennagel et al. (2018)** highlighted that "[m]anaging rather than aggressively suppressing wildland fires can promote adaptive resilience as the climate continues to warm."[8] In California, **Boisrame et al. (2018)** found that the managed wildfire policy in Yosemite National Park over the past several decades has returned diversity to this fire-suppressed landscape, even after protracted fire suppression, and demonstrated that "management of forests to restore fire regimes has the potential to maintain healthy, resilient landscapes in frequent fire-adapted ecosystems."[9] Managed wildland fire is an important policy option because wildfire of all intensities, called "mixed-severity" fire, is a natural and necessary part of California's forests, with many critical functions for supporting carbon and nutrient cycling, structural heterogeneity, biodiversity, and ecosystem resilience.[10] In contrast, mechanical thinning and prescribed fires at low-severity outside of the natural fire season do not mimic the mixed-severity wildfire regime that California's forests evolved with. Wildfire levels in most forest ecosystems are well below historical levels due to a long history of fire suppression, and it is widely recognized that restoring mixed-severity wildfire is important for forest health and resilience.[11]

III. CARB must make model assumptions, limitations, inputs and outputs transparent, understandable, and open for public review and comment.

CARB announced that it is using a new carbon modeling approach for forest and shrubland ecosystems—the Regional Hydro-Ecological Simulation System (RHESys model) developed by U.C. Merced. Based on our experience with the notable limitations of the CALAND model, we urge CARB to immediately make publicly available comprehensive, clear, and understandable documentation for the RHESys model—and the models that will be chosen by CARB for other land types—including the inputs, outputs, assumptions and limitations of the model and to open public comment on the model and modeling documentation.

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[8] Schoennagel, Tania et al., Adapt to more wildfire in western North American forests as climate changes, 114 PNAS 4582 (2017), https://www.pnas.org/content/114/18/4582.

[9] Boisramé, Gabrielle F.S. et al., Vegetation change during 40 years of repeated managed wildfires in the Sierra Nevada, California, 402 Forest Ecology and Management 241 (2017), *available at* https://www.sciencedirect.com/science/article/abs/pii/S0378112717306989.

[10] Odion, D.C. et al., Examining historical and current mixed-severity fire regimes in Ponderosa pine and mixed-conifer forests of western North America, 9 Plos One e87852 (2014), https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0087852.

[11] Baker, William L., Transitioning western U.S. dry forests to limited committed warming with bet-hedging and natural disturbances, 9 Ecosphere e02288 (2018), https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/ecs2.2288.

IV. LANDFIRE, which is being used by the RHESys model for forest and shrublands, systematically overestimates wildfire emissions; we recommend using field-based empirical data based on actual wildfire emissions.

Research clearly shows that models like LANDFIRE, which is a component of the RHESys model, substantially over-estimate wildfire emissions by using unrealistic biomass combustion factors and under-representing the biomass stored in standing dead trees after fire.[12] **Stenzel et al. (2019**) highlighted that these models overestimate the wildfire emissions from California's forests by three-to-four times that of actual field-based values, based on reviewing Yosemite forests as a case study:

> Our results illustrate that the use of inaccurate combustion coefficients in models can double forest fire emissions estimates across the western United States. Overestimates increase to three to four times in carbon-dense forests such as the YFDP [Yosemite Forest Dynamics Plot], mostly because models incorrectly combust live trees. Treating carbon released over years to centuries as an immediate emission by equating combustion with mortality is simply inaccurate. Omitting snag representation in models compounds this error, because of altered decay and combustion dynamics.[13]

Stenzel et al. (2019) reported that the largest discrepancies between modeled and observed combustion of aboveground biomass exist for live, mature trees, which are the dominant pool of aboveground carbon. While models estimate live tree stem combustion at 30%–80% in high-severity events, post-fire observations in the western United States indicate actual combustion is nearly nonexistent for mature trees in fire-prone ecosystems. Most models also lack standing dead tree carbon pools.

Stenzel et al. (2019) highlighted California as an example where the state government is making land management decisions intended to mitigate climate change based on incorrect overestimates of wildfire emissions:

> Contemporary CO_2 emissions to the atmosphere from fire are often significantly exaggerated because of public and policymaker misconceptions that forests commonly "burn to the ground" during fire and that mortality equals emissions. The reality is instead negligible stem combustion of live, mature trees (i.e., <5%), followed by gradual decomposition over years to centuries. Modeled estimates of

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[12] Stenzel, Jeffrey E. et al., Fixing a snag in carbon emissions estimates from wildfires, 25 Global Change Biology 3985 (2019), https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.14716; French, Nancy H.F. et al., Model comparisons for estimating carbon emissions from North American wildland fire, 116 Journal of Geophysical Research G00K05 (2011), https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2010JG001469.

[13] Stenzel et al. (2019) at 7.

> fire emissions reinforce public misconceptions, as tree mortality is often mistranslated into 30%–80% of tree carbon emitted immediately and is in conflict with observations. It is important to rectify overestimates because governments are currently using mortality and emissions estimates from fire to inform land management decisions intended to mitigate climate change (California, Executive Department, 2018; …).[14]

Specifically, the LANDFIRE model used by RHESys classifies post-forest-fire vegetation categories as having less carbon than they actually do. First, the model does not account for the large stores of post-fire carbon persisting in killed trees and other unburned fuels.[15] In practice, the model effectively assumes that when trees are killed, they are vaporized immediately and all the carbon goes into atmosphere, which is demonstrably incorrect. Second, the model makes broad assumptions about changes in vegetation categories based on LANDFIRE satellite imagery (which the Inventory acknowledges leads to substantial vegetation category classification inaccuracy[16]) and the mean carbon density in each vegetation category. Significant wildfire emissions overestimates can occur when a mature forest that has high-intensity fire is reclassified as shrubland but still has large amounts of carbon stores in the snags and downed logs that are not counted.

CARB can correct for these flawed wildfire emissions estimates by using field data of carbon consumption from actual wildfires. For example, field studies of large, intense fires find only about 11% of carbon in forest vegetation, duff, litter, and soil is consumed in a fire, and only 3% on average of the carbon in trees is consumed.[17] In a study of moderate-intensity fire areas in the Rim Fire in California, on average, only one-tenth of one percent of the carbon in trees was consumed.[18] There was a higher level of consumption of smaller-diameter material—shrubs, needles, and twigs on the forest floor—but this accounted for only a small portion of the aboveground carbon consumed.

V. The literature review and meta-analyses process and results must be transparent and allow for public review and comment.

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[14] Stenzel et al. (2019) at 1-2.

[15] California Air Resources Board, Technical Support Document for the Natural & Working Lands Inventory, December 2018 Draft, https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory_technical.pdf (last visited July 28, 2021), at 19 ("The fire-attributed stock changes account only for carbon contained in live and dead pools associated with the post-fire (e.g. 2012) vegetation type, and have no memory of the previous vegetation type, i.e. they do not account for potential post-fire carbon persisting in unburned fuels or in killed trees.")

[16] California Air Resources Board, An Inventory of Ecosystem Carbon in California's Natural and Working Lands, 2018 Edition, https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf, at 47-48.

[17] Campbell, J., et al., Pyrogenic carbon emission from a large wildfire in Oregon, United States, 112 Journal of Geophysical Research Biogeosciences G04014 (2007), https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2007JG000451.

[18] Stenzel et al. (2019) at Table 1.

CARB indicated that they are conducting a literature review and meta-analysis on two topics to inform the NWL carbon target process, and that they are currently accepting studies. CARB should make transparent and publicly available the studies that are included and excluded and the reasoning for inclusion or exclusion. The draft results of the literature review and meta-analyses should be made available for public review and comment before they are finalized.

VI. CARB's initial results for its meta-analysis on Future Projections are not consistent with the scientific literature; we make recommendations on the literature that CARB should include.

CARB presented initial results for its meta-analysis on Future Projections which indicated that NWL have been acting as a carbon source, rather than a sink, since 2005—where forest lands represent the vast majority of carbon stores and are also acting as a source. This does not correspond with the conclusions from comprehensive published research and the state's own Forest Carbon Plan.

Hudiburg et al. 2019 ("Meeting GHG reduction targets requires accounting for all forest sector emissions")[19] developed an accurate, transparent, and transferable accounting method of all forest-derived carbon for California, Oregon and Washington. The study, conducted by foremost forest carbon experts, laid out a regionally calibrated life-cycle assessment that uses data from thousands of forest inventory and analysis (FIA) plots and data on forest product output in each region. The study concluded that California forests are acting as net carbon sinks because net forest carbon uptake resulting from biological processes exceed losses due to logging/thinning, wood product use, and wildfire combustion. The California Forest Carbon Plan also concludes that California's forests have been acting as a net sink and sequestering carbon based on FIA Program data from 2006-2015.[20]

When asked at the workshop about this discrepancy, staff replied that forest lands are acting as a carbon source because they are being converted to shrub or grassland following high-severity fire and these ecotypes hold less carbon. However, empirical studies in California that have investigated this issue have found that high-severity fire is not resulting in type conversion to non-forest nor conversion from pine forest to white-fir, Doug fir, and incense cedar forest.[21]

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[19] Hudiburg, Tara W. et al., Meeting GHG reduction targets requires accounting for all forest sector emissions, 14 Environmental Research Letters 095005 (2019), https://iopscience.iop.org/article/10.1088/1748-9326/ab28bb.

[20] California Air Resources Board, California Forest Carbon Plan (2018), *available at* https://ww2.arb.ca.gov/resources/documents/forest-carbon-plan at 103-104.

[21] Baker, William L., Transitioning western U.S. dry forests to limited committed warming with bet-hedging and natural disturbances, 9 Ecosphere e02288 (2018) https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/ecs2.2288; Hanson, Chad T., Landscape heterogeneity following high-severity fire in California's forests, 42 Wildlife Society Bulletin 264 (2018), *available at* https://wildlife.onlinelibrary.wiley.com/doi/10.1002/wsb.871; Hanson, Chad T. & Tonja Y.

Instead, studies have documented substantial natural conifer regeneration following high-severity fire in mixed-conifer and yellow pine forests.[22] In addition, CARB's conclusion that forest lands are acting as a carbon source appears to be based largely on the Inventory of Ecosystem Carbon in California's Natural and Working Lands.[23] As described above, the Inventory's use of LANDFIRE results in faulty classifications of vegetation type post-fire and underestimates of carbon in post-fire ecosystems.

VII. We recommend that CARB include the following studies in its literature review and meta-analysis on Carbon Impacts from Actions.

Numerous studies, summarized below, show that logging/thinning not only reduce current standing carbon stocks, but also reduce the forest's future rate of carbon sequestration and its future carbon storage capacity, by removing trees that otherwise would have continued to grow and remove CO_2 from the atmosphere. In addition, research shows that thinning forests to reduce fire activity decreases forest carbon stocks and results in increased carbon emissions to the atmosphere that can persist for decades. Forest biomass energy is extremely carbon-intensive and detrimental from a climate, carbon, ecosystem, and public health and safety perspective. In addition to being polluting for the climate, all of these practices are harmful to biodiversity and wildlife habitat, air and water quality, public health, and forest connectivity. We ask that you include the following studies in the literature review and meta-analysis on Carbon Impacts from Actions.

(1) Research showing that the largest losses of carbon from U.S. and California forests are from logging/thinning practices, not wildfire or other natural disturbance processes.

McIntyre et al. (2015) showed that California's forests are much less dense in terms of basal area than they were historically due to a long, ongoing history of logging.[24] Sierra Nevada forests are about 30% less dense, and Tranverse and Peninsular Range forests are 40% less dense, in terms of basal area in the 2000s compared to the 1930s,[25] largely due to logging.

Harris et al. (2016) estimated that 85% of carbon emissions from US forests between 2006 and 2010 were caused by timber harvest, compared to 12% from wildfire, insect outbreaks, wind

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Chi, Impacts of postfire management are unjustified in spotted owl habitat, Frontiers in Ecology and Evolution (2021), https://doi.org/10.3389/fevo.2021.596282.

[22] Id.

[23] California Air Resources Board, An Inventory of Ecosystem Carbon in California's Natural and Working Lands, 2018 Edition, https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf (last visited July 28, 2021).

[24] McIntyre, P.J. et al., Twentieth-century shifts in forest structure in California: denser forests, smaller trees, and increased dominance of oaks, 112 PNAS 1458 (2015), https://www.pnas.org/content/112/5/1458?__cf_chl_jschl_tk__=pmd_5a506da1630d871238d983cfe8f6f69e367c259e-1627494006-0-gqNtZGzNAeKjcnBszQii.

[25] *Id*. at Figure 1a.

damage and drought combined.[26] In California, logging was responsible for 60% of the carbon emissions from forests, compared to 32% from wildfire.[27] This is because wildfire consumes a small percentage of forest carbon while improving availability of key nutrients and stimulating rapid forest regeneration. When trees die from drought and native bark beetles, no carbon is consumed or emitted initially, and carbon emissions from decay are small and slow; meanwhile, decaying wood keeps forest soils productive and enhances carbon sequestration capacity over time.

Berner et al. (2017) reported that logging was the largest cause of tree mortality in California forests between 2003 and 2012, followed by wildfire and then bark beetles.[28]

Merrell et al. (2018) showed that on federal forestlands, logging is the largest source of emissions in the conterminous 48 states, twice as much as wildfire emissions[29] and more in some regions.[30]

(2) Research showing that logging/thinning forests, including for the purposes of reducing fire activity, decreases forest carbon stocks and results in increased carbon emissions to the atmosphere that can persist for decades.

Hudiburg et al. (2019) documented the carbon consequences of different forest management measures, showing that logging leads to the largest losses of forest carbon in California.[31]

Harmon et al. (2019) reviewed carbon storage in woody products and concluded that the long-term benefits of substituting wood for more fossil carbon intensive building materials may be overestimated by two to 100 times.

Law et al. (2018) found that lengthened harvest cycles on private lands and restricting harvest on public lands are the most effective management measures for increasing net ecosystem carbon

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[26] Harris, N.L. et al., Attribution of net carbon change by disturbance type across forest lands of the conterminous United States, 11 Carbon Balance and Management 24 (2016), https://cbmjournal.biomedcentral.com/articles/10.1186/s13021-016-0066-5.

[27] Harris et al. (2016) at Table 5.

[28] Berner, Logan T. et al., Tree mortality from fires, bark beetles, and timber harvest during a hot and dry decade in the western United States (2003-2012), 12 Environmental Research Letters 065005 (2017), https://iopscience.iop.org/article/10.1088/1748-9326/aa6f94/meta.

[29] Merrill, M.D. et al., Federal lands greenhouse gas emissions and sequestration in the United States—Estimates for 2005-14: U.S. Geological Survey Scientific Investigations Report 2018–5131 (2018), https://pubs.usgs.gov/sir/2018/5131/sir20185131.pdf.

[30] Law, B.E. et al., Land use strategies to mitigate climate change in carbon dense temperate forests, 115 PNAS 3663-3668 (2018), https://www.pnas.org/content/115/14/3663.

[31] Hudiburg, Tara W. et al., Meeting GHG reduction targets requires accounting for all forest sector emissions, 14 Environmental Research Letters 095005 (2019), https://iopscience.iop.org/article/10.1088/1748-9326/ab28bb.

balance, followed by reforestation and afforestation.[32] In contrast, using forest harvest residue for bioenergy production increased cumulative net emissions compared to leaving residues in the forest to slowly decompose.

Chiono et al. (2017) evaluated the carbon balance of thinning and prescribed fire treatment scenarios in the Sierra Nevada compared to a no treatment scenario.[33] They found that all fuel treatment scenarios resulted in higher carbon emissions than the no-treatment scenarios because treatment-related emissions exceeded avoided wildfire emissions. The researchers concluded that "[d]ue to the significant emissions associated with treatment and the low likelihood that a wildfire will encounter a given treatment area, forest management that is narrowly focused on C accounting alone would favor the no-treatment scenarios." Although they suggest that an increasing frequency of large wildfires might shift the carbon balance, scenarios where fuel treatments were followed by large wildfire emitted more carbon than untreated stands that subsequently experienced large wildfire. This study also noted the high carbon costs of fuel treatments: "fuel treatments are associated with significant C emissions, releasing C into the atmosphere during harvest operations, burning, and/or biomass transport, and the C cost of treating forest fuels may exceed its C benefits." The authors acknowledged that "[t]he circumstances under which treatments might lead to a net gain in C [carbon] have yet to be resolved."

DellaSala and Koopman (2016) noted that because severe wildfires have only a low likelihood (2%) of occurring in thinned areas (based on Rhodes and Baker 2008), thinning operations must be repeated frequently over very large areas to maintain treatment efficacy, further increasing net emissions over the life of a project.[34] A report from Oregon found that thinning operations resulted in a net loss of forest carbon stocks for up to 50 years.[35]

Tan et al. (2015) found that, by 2050, the climate change scenario that most heavily emphasized protection of forests from logging (B1) resulted in the highest levels of forest carbon storage and rates of carbon sequestration, while the scenarios that emphasized forest cutting (A1B and A2)

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[32] Law, B.E. et al., Land use strategies to mitigate climate change in carbon dense temperate forests, 115 PNAS 3663-3668 (2018), https://www.pnas.org/content/115/14/3663.

[33] Chiono, L.A. et al., Landscape-scale fuel treatment and wildfire impacts on carbon stocks and fire hazard in California spotted owl habitat, 8 Ecosphere e01648 (2017), https://www.fs.fed.us/psw/publications/collins/psw_2017_collins001_chiono.pdf.

[34] DellaSala, D.A. & M. Koopman, Thinning Combined with Biomass Energy Production Impacts Fire-Adapted Forests in Western United States and May Increase Greenhouse Gas Emissions, 1 Reference Module in Earth Systems and Environmental Sciences 491 (2016); Rhodes, J.J. & W.L. Baker, Fire probability, fuel treatment effectiveness and ecological tradeoffs in western U.S. public forests, 1 Open Forest Science Journal 1 (2008), *available at* https://benthamopen.com/ABSTRACT/TOFSCIJ-1-1.

[35] Clark, J. et al., Impacts of Thinning on Carbon Stores in the PNW: A Plot Level Analysis, Final Report, Oregon State University College of Forestry (2011), *available at* https://www.nrdc.org/resources/impacts-thinning-carbon-stores-pnw-plot-level-analysis.

reduced the proportional contribution of federal forestlands to the nation's overall carbon storage levels (see Table 2).[36]

Loehman et al. (2014) concluded that fuel treatments are "not an effective method for protecting carbon stocks at the stand level" in fire-prone and fire-adapted forests for a number of reasons, including the high carbon costs of thinning and the low probability that treated areas will be exposed to wildfire during the life expectancy of the treatment:

> The stochastic and variable nature of fires, the relatively fine scale over which fuels treatments are implemented, and potentially high carbon costs to implement them suggest that fuel treatments are not an effective method for protecting carbon stocks at a stand level (Reinhardt et al., 2008; Reinhardt and Holsinger, 2010). For example, in fire-prone forests of the western US, because of the relative rarity of large wildfires and limited spatial scale of treatments, most treated areas will not be exposed to wildfire within the 10–25 year life expectancy of the treatment (Rhodes and Baker, 2008; Campbell et al., 2012; North et al., 2012). Further, some studies show that the difference in carbon emissions between low-severity and high-severity fire is small when scaled across an entire wildfire because consumption of fine surface fuels associated with low-severity fire occurs across broad spatial extents, while consumption of standing fuels associated with high-severity fires occurs in small patches within the larger wildfire perimeter (Campbell et al., 2012). Fuel treatments designed to reduce wildfire severity and wildfire-related carbon emissions have carbon costs in the form of fossil fuel emissions from harvesting activities, transportation of removed material, and milling waste (North et al., 2009).[37]

Campbell and Ager (2013) assessed the long-term impact of fuel treatment on the carbon balance of fire-prone forests, by simulating long-term landscape-wide carbon stocks under a wide range of treatment efficacy, treatment lifespan, fire impacts, forest recovery rates, forest decay rates, and the longevity of wood products. The study concluded that none of the fuel treatment simulation scenarios resulted in increased system carbon.[38]

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[36] Tan, Z. et al., Ecosystem carbon stocks and sequestration potential of federal lands across the conterminous United States, 112 PNAS 12723 (2015), https://www.pnas.org/content/112/41/12723?__cf_chl_jschl_tk__=pmd_b098054781367f1e82afd05664c4e14564e82f77-1627497899-0-gqNtZGzNAeKjcnBszQki, at 12724 and Table 2.

[37] Loehman, R.A., Wildland fire emissions, carbon, and climate: Seeing the forest and the trees – A cross-scale assessment of wildfire and carbon dynamics in fire-prone, forested ecosystems, 317 Forest Ecology and Management 9 (2014), *available at* https://www.fs.usda.gov/treesearch/pubs/45724.

[38] Campbell, J.L. & A.A. Ager, Forest wildfire, fuel reduction treatment, and landscape carbon stocks: a sensitivity analysis, 121 Journal of Environmental Management 124 (2013), *available at* https://www.fs.usda.gov/treesearch/pubs/45344.

Restaino et al. (2013) found that "[s]tudies at large spatial and temporal scales suggest that there is a low likelihood of high-severity wildfire events interacting with treated forests, negating any expected C benefit from fuels reduction."[39]

Campbell et al. (2012) concluded that thinning forests to avoid high-severity fire can reduce forest carbon stocks and increase overall carbon emissions.[40] Because the probability of a fire on any given acre of forest is relatively low, forest managers must treat many more acres than will actually burn, and thinning ends up removing more carbon than would be released in a fire. The researchers estimated that thinning operations typically tend to remove about three times as much carbon from the forest as would be avoided in wildfire emissions. They cautioned that "current claims that fuel-reduction treatments function to increase forest C sequestration are based on specific and sometimes unrealistic assumptions regarding treatment efficacy, wildfire emissions, and wildfire burn probability." The study concluded that "we found little credible evidence that such efforts [fuel-reduction treatments] have the added benefit of increasing terrestrial C stocks" and "more often, treatment would result in a reduction in C stocks over space and time."

Law and Harmon (2011) concluded that "[t]hinning forests to reduce potential carbon losses due to wildfire is in direct conflict with carbon sequestration goals, and, if implemented, would result in a net emission of CO_2 to the atmosphere because the amount of carbon removed to change fire behavior is often far larger than that saved by changing fire behavior, and more area has to be harvested than will ultimately burn over the period of effectiveness of the thinning treatment."[41]

Mitchell et al. (2009) examined the effects of thinning for fire reduction on the long-term carbon dynamics of three Pacific Northwest forest ecosystems. The study reported that nearly all fuel reduction treatments resulted in lower stand carbon storage because the carbon that was removed by fuels treatments exceeded the carbon released by high-severity wildfires.[42]

Depro et al. (2008) found that carbon storage on public forests is maximized when protection from logging is greatest; a ''no timber harvest'' scenario eliminating harvests on public lands

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[39] Restaino, J.C. & D.L. Peterson., Wildfire and fuel treatment effects on forest carbon dynamics in the western United States, 303 Forest Ecology and Management 46 (2013), *available at* https://www.fs.usda.gov/treesearch/pubs/45169.

[40] Campbell, J.L. et al., Can fuel-reduction treatments really increase forest carbon storage in the western US by reducing future fire emissions? 10 Frontiers in Ecology and the Environment 83 (2012), *available at* https://esajournals.onlinelibrary.wiley.com/doi/full/10.1890/110057.

[41] Law, B.E. & M.E. Harmon, Forest sector carbon management, measurement and verification, and discussion of policy related to climate change, 2 Carbon Management 73 (2011), *available at* https://www.tandfonline.com/doi/abs/10.4155/cmt.10.40?journalCode=tcmt20.

[42] Mitchell, S.R. et al., Forest fuel reduction alters fire severity and long-term carbon storage in three Pacific Northwest ecosystems, 19 Ecological Applications 643 (2009), *available at* https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/08-0501.1?sid=nlm%3Apubmed.

resulted in an increase up to 43% over current sequestration levels on public timberlands, while moving to a more intense harvesting policy resulted in a significant decline in carbon sequestration.[43]

Hurteau and North (2010) and Wiechmann et al. (2015)[44] showed that thinned stands have lower overall carbon storage than untreated stands for at least 10 years after treatment. Specifically, understory thin and burn, overstory thin, and overstory thin and burn treatments produced large carbon deficits that were ongoing 10 years after treatment. Even after thinned stands were estimated to have regained the carbon lost from thinning, the overall carbon storage in the thinned stands remained lower than untreated stands due to the treatments' removal of live tree biomass that reduced carbon sequestration capacity. As noted by Hurteau and North (2010), "thinning treatments likely result in a permanent reduction in the live tree carbon stock."[45] It is also important to note that Hurteau and North (2010) and Weichmann et al. (2015) use carbon accounting that underestimates the emissions from fuel treatments. For example, the 60% of carbon that was removed by thinning and made into wood products was counted "as permanently sequestered" which is not an accurate assumption.

(3) Research showing that biomass energy is California's most carbon-polluting energy source.

Center for Biological Diversity (2021): This comprehensive literature review documents that biomass power plants are California's dirtiest electricity source—releasing more carbon at the smokestack than coal per unit of electricity produced.[46] Incinerating biomass for energy instantaneously releases stored carbon to the atmosphere, increasing greenhouse gas emissions and creating a "carbon debt." Numerous studies show that, even if forests cut for bioenergy are allowed to regrow, it can take several decades to more than a century, if ever, to capture the carbon that was released, and to discharge the "carbon debt." This is the case even where "waste" materials like timber residues and thinning debris are used for fuel. Meanwhile, that carbon pollution worsens the climate crisis and contributes to the probability of passing climate tipping points, causing irreversible harms. Cutting trees for biomass energy also reduces the

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[43] Depro, B.M. et al., Public land, timber harvests, and climate mitigation: Quantifying carbon sequestration potential on U.S. public timberlands, 255 Forest Ecology and Management 1122 (2008), *available at* https://www.fs.usda.gov/treesearch/pubs/33137.

[44] Hurteau, M.D. & M. North, Carbon recovery rates following different wildfire risk mitigation treatments, 260 Forest Ecology and Management 930 (2010), *available at* https://www.fs.usda.gov/treesearch/pubs/36883; Weichmann, M.L. et al., The carbon balance of reducing wildfire risk and restoring process: an analysis of 10-year post-treatment carbon dynamics in a mixed-conifer forest, 132 Climatic Change 709 (2015), *available at* https://www.fs.usda.gov/treesearch/pubs/49313.

[45] Hurteau & North (2010) at 936.

[46] Center for Biological Diversity, Forest Bioenergy Briefing Book (March 2021), https://www.biologicaldiversity.org/campaigns/debunking_the_biomass_myth/pdfs/Forest-Bioenergy-Briefing-Book-March-2021.pdf.

forest's ability to sequester and store carbon.[47] In sum, scientific research shows that biomass power emits more carbon at the smokestack than coal and leaves less carbon stored in the forest.

(4) Research on soil carbon losses from logging/thinning activities.

Logging is well-documented to compact and damage forest soils with heavy machinery and remove vital nutrients stored in trees, leading to significant loss of soil carbon.[48] These harms to soils also significantly reduce forest productivity (the rate at which trees and plants will grow), which substantially reduces the capacity of forest ecosystems to absorb, sequester, and store carbon.[49] Available estimates from the scientific literature can be used to estimate the soil carbon losses, and prolonged loss of forest cover from soil damage, resulting from forest management activities.

Thank you for your consideration of these comments. We assume that CARB has pdf copies of the studies cited in this letter since we have submitted them with many of our previous comment letters. However, please let us know if you need pdfs of any or all of the cited studies and we will be happy to provide them. Please feel free to contact me with any questions.

Sincerely,

Shaye Wolf

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[47] Moomaw, William R. et al., Intact forests in the United States: proforestation mitigates climate change and serves the greatest good, 2 Frontiers in Forests and Global Change (2019), https://www.frontiersin.org/articles/10.3389/ffgc.2019.00027/full

[48] Elliot, William J. et al., The Effects of Forest Management on Erosion and Soil Productivity, Symposium on Soil Quality and Erosion Interaction, Keystone, CO, July 7, 1996, *available at* https://forest.moscowfsl.wsu.edu/engr/library/Elliot/Elliot1996c/1996c.pdf; Walmsley, J.D. et al., Whole tree harvesting can reduce second rotation forest productivity, 257 Forest Ecology and Management 1104 (2009), *available* at https://www.sciencedirect.com/science/article/abs/pii/S0378112708008402; Buccholz, Thomas et al., Mineral soil carbon fluxes in forests and implications for carbon balance assessments, 6 GCB Bioenergy 305 (2014), *https://onlinelibrary.wiley.com/doi/full/10.1111/gcbb.12044*; Achat, David et al., Forest soil carbon is threatened by intensive biomass harvesting, 5 Scientific Reports 15991 (2015), https://www.nature.com/articles/srep15991; Achat, David et al., Quantifying consequences of removing harvesting residues on forest soils and tree growth – A meta-analysis, 348 Forest Ecology Management 124 (2015), *available at* https://www.sciencedirect.com/science/article/abs/pii/S0378112715001814.

[49] *Id*.; see also Hanson, C.T., & T.Y. Chi, Impacts of postfire management are unjustified in spotted owl habitat, 9 Frontiers in Ecology and Evolution Article 596282 (2021), https://www.frontiersin.org/articles/10.3389/fevo.2021.596282/full (34% of previously forested areas rendered deforested for decades due to impacts of logging, including logging roads, skid trails, and landings).

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