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California Air Resources Board
1001 I Street, Sacramento, CA 95814

RE: 2022 Scoping Plan Update – Initial Modeling Results Workshop

To the California Air Resources Board:

The Center for Biological Diversity appreciates this opportunity to provide input regarding the initial modeling results for the 2022 Scoping Plan Update presented at the March 15 workshop. The modeling results presented were quite general with little detail, limiting a comprehensive assessment by the public. Here we focus on instances where the modeling assumptions appear to be faulty or unsubstantiated, and we recommend ways to make the modeling analyses as robust, science-based, and transparent as possible.

I. Natural and Working Lands Scenarios

These comments focus on the modeling assumptions and results for the forest sector, which contain by far the most stored carbon of any of the NWL sectors evaluated. As an initial matter, the forest results are difficult to evaluate due to the aggregation of forest types and ecotypes across California. We are particularly concerned about incorrect modeling assumptions regarding the effects of forest management on fire behavior and tree mortality; estimates of wildfire emissions and carbon storage post-fire; natural forest regeneration post-fire; and carbon storage in wood products—which when corrected will significantly alter the modeling results.

(1) First, it is important to note that the Forest Results presented in slide 27 indicate that increased forest management is detrimental to forest carbon storage. Under scenarios 2, 3, and 4 representing increased management of ~1M acres/year, 2 to 2.5M acres/year and ~5 to 5.5M acres/year respectively, total biomass stock from years 2040-2050 is less than under business-as-usual management, defined as the level of management between 2001-2014. These results make clear that spending billions of dollars on increased forest cutting is detrimental to forest carbon storage and the climate, as well as the harms it causes to biodiversity and ecosystem services.

Nonetheless, the forest modeling appears to include a number of faulty assumptions that artificially increase the biomass carbon stock values for the management scenarios and lower the biomass carbon stock values for the no-management scenario. When corrected, the carbon costs of the increased forest cutting scenarios will become even more apparent.

(2) The modeling appears to include unsubstantiated assumptions regarding the effects of thinning on fire behavior and associated tree mortality—specifically, that increasing thinning will decrease fire severity and therefore decrease the loss of forest carbon stocks. However, a current review of the status of the science of forest carbon management by forest carbon scientists Beverly Law, William Moomaw, Tara Hudiburg, William Schlesinger, John Sterman, and George Woodwell explains why these assumptions are incorrect, concluding that "[b]road-scale thinning to reduce fire severity results in more carbon emissions than would be released by fire, creating a multi-decade carbon deficit that conflicts with climate goals":

> The amount of carbon removed by thinning is much larger than the amount that might be saved from being burned in a fire, and far more area is harvested than would actually burn (Mitchell et al. 2009, Rhodes et al. 2009, Law & Harmon 2011, Campbell et al. 2011, Hudiburg et al. 2011, Hudiburg et al. 2013). Most analyses of mid- to long-term thinning impacts on forest structure and carbon storage show there is a multi-decadal biomass carbon deficit following moderate to heavy thinning (Zhou et al. 2013). A thinning study in a young ponderosa pine plantation vulnerable to drought in Idaho found that removal of 40% of the live biomass from the forest would subsequently release about 60% of that carbon over the next 30 years (Stenzel et al. 2021). Although thinning is commonly used to reduce fire severity and associated tree mortality, a comparison of thinned with adjacent unthinned stands in the burn area of a large California wildfire showed that thinning resulted in more tree mortality than unthinned stands, i.e. fire killed more trees than thinning prevented from being killed (Hanson 2022).
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> As to the effectiveness and likelihood that thinning might have an impact on fire behavior, a multi-year study of forest treatments like thinning and prescribed fire across the western US found that only 1% of those treatment areas experience wildfire each year. The potential effectiveness of treatments lasts only 10-20 years, diminishing annually (Schoennagel et al. 2017). There are high forest carbon losses associate with thinning, only minor differences in the combustive losses associated with high severity fire and the low-severity fire that fuel treatment is meant to encourage, and a low likelihood that thinned forests will be exposed to fire during treatment effectiveness (Campbell et al. 2011).[1]

[1] Law, Beverly E., Moomaw, William R., Hudiburg, Tara W., Schlesinger, William H., Sterman, John D. and George Woodwell, The Status of Science on Forest Carbon Management to Mitigate Climate Change and Protect Water and Biodiversity (March 9, 2022).

(3) The models used for forest and shrublands systematically overestimate wildfire emissions and under-estimate the carbon stored in standing dead trees after fire; correcting these model biases based on published, field-based empirical data on wildfire combustion of forest biomass will substantially alter the model results. As detailed in our July 29, 2021, comments on the NWL modeling, the RHESys model being used for forest and shrublands substantially over-estimates wildfire emissions by using unrealistic biomass combustion factors and under-representing the biomass stored in standing dead trees after fire.[2] 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.[3] 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[4]) 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 estimates by using empirical field data of forest carbon consumption based on actual wildfires.[5] Most recently, empirical research by Harmon et al. (2022) in California's Rim Fire and Creek Fire areas found that less than 2% of living tree biomass combusted.[6] Even in severe fire patches, the larger-size trees showed low combustion rates of less than 5% with most combustion coming from needles and small branches less than 2 centimeters in diameter. This study provides combustion rates for aboveground woody parts at multiple levels of organization (twigs, branches, trees, stands, and landscapes) and accounts for tree species, size, and fire severity in Ponderosa pine and mixed conifer-dominated forests of the Sierra Nevada. The review of forest carbon science by Law et al. (2022) similarly concluded that "[w]hile moderate to high severity fire can kill trees, most of the carbon remains in the forest as dead wood and it will take decades to centuries to decompose that wood":

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[2] 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.
[3] 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, 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.")
[4] 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.
[5] Campbell, J., et al., Pyrogenic carbon emission from a large wildfire in Oregon, United States, 112 Journal of Geophysical Research Biogeosciences G04014 (2007).
[6] Harmon, M.E. et al., Combustion of Aboveground Wood from Live Trees in Mega-fires, CA, USA, 13 Forests 391 (2022), https://doi.org/10.3390/f13030391.

While moderate to high severity fire can kill trees, most of the carbon remains in the forest as dead wood and it will take decades to centuries to decompose that wood. Less than 10% of the total ecosystem carbon in live and dead trees, litter, and soils combined has been found to enter the atmosphere as carbon dioxide in Pacific Northwest forest fires (Campbell et al. 2011, Law & Waring 2015). Recent field studies of combustion rates in California's large megafires show that carbon emissions were very low overall at the stand- (0.1-3.2%) and landscape-level (0.6-1.8%) because larger trees with low combustion rates comprise the majority of biomass and high severity fire patches are less than half of the area burned (Stenzel et al. 2019, Harmon et al. 2022). The results are consistent with field studies on Oregon's East Cascades wildfires and the large Biscuit Fire in southern Oregon (Campbell et al. 2007, Meigs et al. 2009), where most of the material that combusts is forest floor litter and the underlying duff. A small fraction of stemwood burns, and deadwood remaining onsite slowly decomposes.[7]

(4) The modeling appears to incorrectly assume that natural post-fire forest regeneration will be lower than in scenarios with post-fire clearcutting and replanting. Post-fire regeneration in California forests must be modeled using actual field data. For example, recent studies in California by Hanson (2018) and Hanson and Chi (2021) found substantial, heterogeneous natural conifer regeneration following high-severity fire in mixed-conifer and yellow pine forests, including regeneration at all distances into interior spaces of large high-severity fire patches, including >300m from the nearest live trees.[8] In contrast, post-fire salvage logging and re-planting—characterized by clearcutting of snag forest habitat, spraying of herbicides to eliminate native shrubs, and creation of tree plantations—have substantial carbon emissions from the removal of on-site biomass, as detailed above, and harmful to biodiversity, as detailed in the review by Law et al. (2022):

Post-fire cutting versus natural regeneration:
Many western US forest fires are mixed-severity, meaning that a large portion of the fire burns in patches of low to moderate severity and a smaller portion burns at high severity where a majority of trees are killed (Law & Waring 2015). After fires, the remaining live and dead trees in the burn area and those on the periphery provide seed sources for natural regeneration (Donato et al. 2009). Allowing natural regeneration to occur ensures that the genetic and species diversity that

[7] Law, Beverly E., Moomaw, William R., Hudiburg, Tara W., Schlesinger, William H., Sterman, John D. and George Woodwell, The Status of Science on Forest Carbon Management to Mitigate Climate Change and Protect Water and Biodiversity (March 9, 2022).
[8] Hanson, C.T., Landscape heterogeneity following high-severity fire in California's forests, 42 Wildlife Society Bulletin 264 (2018); Hanson, C.T. and T.Y. Chi, Impacts of postfire management are unjustified in Spotted Owl habitat, 9 Frontiers in Ecology and Evolution 596282 (2021).

existed prior to the fire will continue, and the diversity increases the resilience of the ecosystem to future disturbance.

> The complex early seral forest habitat that develops in high severity burns is important to a broad range of wildlife associated with these conditions (Fontaine et al. 2009). Both early- and-late-successional forests can support complex functioning and biodiversity. Post-fire harvest and felling of live and dead trees can negatively affect soil integrity, hydrology, natural regeneration, slope stability, and wildlife habitat (Beschta et al. 1995). Large standing dead, live yet possibly dying, and downed trees help forests recover and provide habitat for more than 150 vertebrates in the Pacific Northwest (Rose et al. 2001).

> By adding another stressor to burned watersheds, post-fire logging worsens degraded conditions that have accumulated from a century of human activity (Thorn et al. 2018, Karr et al. 2004). In sum, the current body of research indicates that the loss of ecosystem services that can result from post-fire treatments is significant (Beschta et al. 2004).[9]

Moreover, research indicates that post-fire clearcutting and the subsequent creation of tree plantations can lead to higher future fire severity.[10]

(5) The modeling appears to over-estimate the carbon storage in harvested wood products over time. Recent published research such as Harmon (2019)[11] corrects false assumptions related to carbon storage in wood products and provides robust estimate. These corrections are important because the Forest Modeling Results report total biomass stock as the sum of both forest biomass (above and below-ground) and biomass in harvested wood products. Correcting for the over-estimations of carbon storage in harvested wood products would provide a more accurate representation of the carbon consequences over time of the four forest management scenarios.

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[9] Law, Beverly E., Moomaw, William R., Hudiburg, Tara W., Schlesinger, William H., Sterman, John D. and George Woodwell, The Status of Science on Forest Carbon Management to Mitigate Climate Change and Protect Water and Biodiversity (March 9, 2022).

[10] Bradley, C.M. et al., Does increased forest protection correspond to higher fire severity in frequent-fire forests of the western United States? 7 Ecosphere e01492 (2016); Zald, Harold S.J. and Christopher J. Dunn, Severe fire weather and intensive forest management increase fire severity in a multi-ownership landscape, 28 Ecological Applications 1068 (2018).

[11] Harmon, Mark E. Have product substitution carbon benefits been overestimated? A sensitivity analysis of key assumptions, 14 Environmental Research Letters 065008 (2019), https://iopscience.iop.org/article/10.1088/1748-9326/ab1e95/pdf

Thank you for your consideration of these comments. Please let me know if you have any questions.

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