Battle Creek Alliance • Center for Biological Diversity • Conservation Congress •
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John Muir Project •Los Padres Forest Watch •
Sequoia ForestKeeper • Sierra Club California • Wild Nature Institute

March 17, 2017

Via e-mail: fcat.calfire@fire.ca.gov

Forest Carbon Action Team
c/o California Department of Forestry and Fire Protection
1416 Ninth Street
PO Box 944246
Sacramento, CA 94244-2460

Re: Comments on California Forest Carbon Plan (January 20, 2017 Draft)

Dear Members of the Forest Carbon Action Team,

The undersigned organizations, which include scientific institutions as well as local, state, national, and international environmental organizations collectively representing well over a million members and activists, respectfully submit the following comments on the January 20, 2017 Draft of the California Forest Carbon Plan (the "Plan") prepared by the Forest Carbon Action Team ("FCAT") under the auspices of the California Department of Forestry and Fire Protection ("CalFIRE"). As detailed below, the Plan's assumptions and conclusions lack a sound scientific basis. Moreover, the actions proposed therein are unlikely to achieve the Plan's stated goals and will likely cause substantial damage to forest ecosystems and habitats throughout California. Finally, CalFIRE cannot lawfully approve or take any steps to carry out the Plan absent full compliance with the California Environmental Quality Act ("CEQA"). For all of these reasons, we request that the FCAT withdraw the draft Plan and prepare a revised Plan that rigorously considers the full range of available scientific information and potential alternatives for managing California forests in an era defined by climate change.

I. The Forest Carbon Plan's Core Proposed Actions are Scientifically Unfounded, Likely to Reduce Forest Carbon Storage, and Likely to Cause Substantial Harm to California's Forest Ecosystems

The primary goal of the Forest Carbon Plan is to sustain California's forests as a net sink of carbon.[1] However, a large body of scientific evidence indicates that the Plan's core proposed

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[1] The Forest Carbon Plan states its goals in different ways in different parts of the Plan, but it appears that the primary goal of the plan is to sustain California's forests as a net sink of carbon. Plan at 2: "The California Forest Carbon Plan seeks to reverse these trends and firmly establish California's forests as a more resilient and reliable long-term carbon sink, rather than a GHG and black carbon emission source"; Plan at 7: "Secure California's forests as a healthy, resilient net sink of carbon, while conferring a range of ecosystem and societal benefits, and minimizing the GHG and black carbon emissions associated with management activities, conversion, wildfire events, and other disturbances."

management actions — massive increases in thinning/logging paired with burning of woody biomass in bioenergy facilities — will reduce (not increase) overall forest carbon storage and lead to higher greenhouse gas emissions in the state.

The Plan must be based on an unbiased, science-based analysis of the management practices that best promote forest carbon capture and long-term storage, increase resilience (for example, by preparing forests for climate change), and protect ecological values and functions. In its current draft, the Plan misrepresents the state of science and scientific uncertainty on core issues, omits mention of hundreds of highly relevant studies, and is founded on scientifically unsupported assertions. The Plan's core management actions are not only poorly conceived and unsupported, but are also likely to undermine the goal of maintaining California's forests as a carbon sink while causing substantial environmental harm to California's forest ecosystems.

Due to these fundamental deficiencies, revising the Plan will require far more than edits and amendments. We strongly recommend that the FCAT undertake a scientifically rigorous analysis of the fundamental questions of how to best maintain carbon storage in California's forests while promoting forest resilience (i.e., preparing forests for climate change) and protecting ecological functions and values, fully utilizing the comprehensive body of scientific research on this topic. The FCAT should identify the research questions that need to be addressed before beginning this new analysis, many of which are correctly identified by the Plan in the final section on Research Needs.

These comments outline the extensive deficiencies in the Plan, and then provide recommendations for the forest management alternatives that FCAT should consider in a new analysis and new set of proposed actions.

A. The Plan's assertion that increased thinning/logging will increase carbon storage in forests is unsupported by the best available science.

The Plan's core proposed actions are to "significantly increase" the rate of fuels treatment on both private and public lands in California, paired with an significant expansion of woody biomass burning, construction of new bioenergy facilities, and expansion of wood products manufacturing.[2] The Plan proposes to double the rate of fuels treatment on nonfederal forest lands by 2020 above recent average levels, and increase it by nearly 3.5 times by 2030.[3] The Plan explicitly defines fuels treatments as commercial thinning and regeneration harvests (i.e. clearcuts) but not use of prescribed fire.[4] The proposed actions for federal forest lands are to double the rate of fuel treatments on Forest Service lands by 2020 from 250,000 acres/year to a massive 500,000 acres/year and to increase fuel treatments on BLM managed lands from 9,000 acres/year to 10-15,000 acres/year.[5] The plan proposes to remove biomass generated by fuels

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[2] Plan Proposed Actions A, B, and D at 3-4.
[3] Plan Proposed Action A at 3.
[4] *Id.*
[5] Plan Proposed Action B at 4.

treatments from the forests and burn it in bioenergy plants, with some potential to convert woody biomass into transportation fuel or compost.[6]

In section 6.3, entitled "Forest Carbon Storage Dynamics," the Plan attempts to justify the large-scale increases in thinning/logging and massive removal of carbon from forests with the claim that these practices will increase overall carbon storage in California's forests.[7] This claim is not supported by the cited studies, and contradicts the best available science.

1. Scientific studies indicate that thinning does not increase forest carbon storage.

Harvest of live trees from the forest not only reduces current standing carbon stocks, but also reduces 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.[8] Numerous studies, which were not mentioned by the Plan, indicate that protection from logging increases forest carbon storage, while thinning forests to reduce fire activity decreases forest carbon stocks and results in increased carbon emissions to the atmosphere that can persist for decades.

For example, 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) reduced the proportional contribution of federal forestlands to the nation's overall carbon storage levels (see Table 2).[9] Similarly, a study by 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 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.[10]

Campbell et al. (2012) concluded that thinning forests to avoid high-severity fire could actually reduce forest carbon stocks and increase overall carbon emissions.[11] Because the

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[6] Plan Proposed Action D at 4.

[7] Plan at 59: "California's forests currently have higher densities of small trees and fewer large trees on the landscape compared to historic conditions …Stands that have reduced competition, achieved by fire or mechanical treatment, can experience greater growth rates in the live trees that remain [Stephenson et al. 2014] allowing carbon sequestration rates to continue increasing over time."

[8] Holtsmark, B. 2013. The outcome is in the assumptions: analyzing the effects on atmospheric CO_2 levels of increased use of bioenergy from forest biomass. Global Change Biology Bioenergy 5: 467-473.

[9] Tan, Z. et al. 2015. Ecosystem carbon stocks and sequestration potential of federal lands across the conterminous United States. PNAS 112: 12723-12728, at 12724 and Table 2.

[10] Depro, B.M. et al. 2008. Public land, timber harvests, and climate mitigation: Quantifying carbon sequestration potential on U.S. public timberlands. Forest Ecology and Management 255: 1122-1134.

[11] Campbell, J.L. et al. 2012. Can fuel-reduction treatments really increase forest carbon storage in the western US by reducing future fire emissions? Frontiers in Ecology and the Environment 10: 83-90.

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.”

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.[12]

Mitchell et al. (2009) examined the effects of thinning for fire reduction on the long-term carbon dynamics of three Pacific Northwest forest ecosystems: east Cascades ponderosa pine forests, west Cascades western hemlock–Douglas-fir forests, and Coast Range western hemlock–Sitka spruce forests. 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.[13]

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.[14] A report from Oregon found that thinning operations resulted in a net loss of forest carbon stocks for up to 50 years.[15]

A review of forest carbon management by 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

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[12] Campbell, J.L. and A.A. Ager. 2013. Forest wildfire, fuel reduction treatment, and landscape carbon stocks: a sensitivity analysis. Journal of Environmental Management 121: 124-132.

[13] Mitchell, S.R. et al. 2009. Forest fuel reduction alters fire severity and long-term carbon storage in three Pacific Northwest ecosystems. Ecological Applications 19: 643-655.

[14] DellaSala, D.A. and M. Koopman 2016. Thinning Combined with Biomass Energy Production Impacts Fire-Adapted Forests in Western United States and May Increase Greenhouse Gas Emissions. Reference Module in Earth Systems and Environmental Sciences; Rhodes, J.J. and W.L. Baker. 2008. Fire probability, fuel treatment effectiveness and ecological tradeoffs in western U.S. public forests. Open Forest Science Journal 1: 1-7.

[15] Clark, J. et al. 2011. Impacts of Thinning on Carbon Stores in the PNW: A Plot Level Analysis, Final Report (Ore. State Univ. College of Forestry May 25, 2011).

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."[16]

Another forest carbon review by Loehman et al. (2014) similarly 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).[17]

As summarized by Restaino et al. (2013), "[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."[18]

2. The Plan misrepresents the forest carbon losses caused by thinning.

The Plan acknowledges that thinning causes immediate forest carbon losses, but asserts that lost carbon can be quickly recovered if large trees "are not removed in large quantities."[19]

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[16] Law, B.E. and M.E. Harmon. 2011. Forest sector carbon management, measurement and verification, and discussion of policy related to climate change. Carbon Management 2: 73-84.

[17] Loehman, R.A. et al. 2014. Wildland fire emissions, carbon, and climate: Seeing the forest and the trees – A cross-scale assessment of wildfire and carbon dynamics in fire-prone, forested ecosystems. Forest Ecology and Management 317: 9-19. *See also* Rhodes, J.J. and W.L. Baker. 2008 (see footnote 14).

[18] Restaino, J.C. and D.L. Peterson. 2013. Wildfire and fuel treatment effects on forest carbon dynamics in the western United States. Forest Ecology and Management 303: 46-60.

[19] Plan at 61.

This assertion is misleading in several ways. First, the Plan fails to clarify that the cited studies show that thinned stands have lower overall carbon storage than untreated stands for at least 10 years after treatment (e.g., Hurteau and North 2010, Dore et al. 2012, Wiechmann et al. 2015a). 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.[20] As noted by Hurteau and North (2010), "thinning treatments likely result in a permanent reduction in the live tree carbon stock."[21] Moreover, carbon recovery from thinning was not necessarily "quick." Dore et al. (2012), for example, estimated that it would likely take about 19 years for recovery of all thinning-related carbon releases for the thinned site.[22]

Second, Chiono et al. (2017), which was not cited by the Plan, provides further evidence that fuels treatment does not provide a carbon benefit.[23] This study evaluated the carbon balance of thinning and prescribed fire treatment scenarios in the Sierra Nevada compared to a no treatment scenario. 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." Contrary to the Plan's assertions that fuel treatments lead to increased forest carbon storage, the authors acknowledged that "[t]he circumstances under which treatments might lead to a net gain in C [carbon] have yet to be resolved."

Third, the Plan allows fuel treatment practices that remove larger trees, such as overstory thinning[24] and commercial logging,[25] yet fails to mention that these more aggressive fuels

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[20] It is also important to note that Hurteau and North (2010) and Weichmann et al. (2015a) use carbon accounting that likely 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.

[21] Hurteau, M. and M. North. 2010. Carbon recovery rates following different wildfire risk mitigation treatments. Forest Ecology and Management 260: 930-937, at 936.

[22] Dore, S. et al. 2012. Recovery of ponderosa pine ecosystem carbon and water fluxes from thinning and stand-replacing fire. Global Change Biology 18: 3171-3185, at 3184.

[23] Chiono, L.A. et al. 2017. Landscape-scale fuel treatment and wildfire impacts on carbon stocks and fire hazard in California spotted owl habitat. Ecosphere 8(1):e01648.

[24] Plan at 19.

[25] Plan at 3 and 26.

treatment types produce long-term carbon debts. According to studies cited by the Plan (e.g., Hurteau and North 2010, Wiechmann et al. 2015a), understory thin and burn, overstory thin, and overstory thin and burn treatments produced large carbon deficits that were ongoing 10 years after treatment.

B. Scientific research indicates that the Plan's proposal for increased mechanical thinning paired with biomass burning for energy will increase carbon emissions and create a carbon debt.

As noted above, one of the Plan's core proposed actions is to burn the woody biomass generated from thinning in biomass facilities, including additional, newly constructed bioenergy plants. For example, the Plan proposes to"[i]nnovate solutions for wood products and biomass utilization to support ongoing forest management activities" including an increase in wood-fired bioenergy facilities and the maintenance of large-scale bioenergy capacity in the short term.[26] The Plan envisions "working forests that produce wood products and biomass for energy."[27] The Plan's recommendations for implementation include development of new biomass facilities,[28] and its goals for wildland forests include innovations in biomass utilization that result in use of harvested woody material.[29]

Because burning biomass is not carbon neutral, a fundamental task for the Forest Carbon Plan is to analyze the carbon consequences of burning the woody mass generated by thinning in bioenergy facilities (i.e., life cycle analysis of upstream and downstream emissions). However, the Plan never conducts this key analysis. Instead, the Plan vaguely asserts that "woody residues used in place of fossil fuels for energy may result in overall reductions in GHG emissions"[30] without providing any citations or support. However, a large body of scientific studies indicates that biomass combustion is extremely carbon-intensive, and that mechanical thinning paired with biomass burning for energy increases carbon emissions and creates a carbon debt.

1. Burning woody biomass is more carbon-intensive than burning fossil fuels.

Woody biomass combustion is not carbon-neutral as acknowledged by numerous scientific studies (see, e.g., Brandão et al. 2013, Repo 2010, Searchinger 2009), the Intergovernmental Panel on Climate Change (IPCC),[31] and the EPA's science advisors.[32] The

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[26] Plan at 4.
[27] Plan at 7.
[28] Plan at 6.
[29] Plan at 24.
[30] Plan at 69.
[31] IPCC Task Force on National Greenhouse Gas Inventories, Frequently Asked Questions, at http://www.ipcc-nggip.iges.or.jp/faq/faq.html (last visited March 16, 2017) (Q2-10) ("The IPCC Guidelines do not automatically consider biomass used for energy as 'carbon neutral,' even if the biomass is thought to be produced sustainably . . . . [T]he IPCC approach of not including [CO_2 emissions from

combustion of wood for energy instantaneously releases virtually all of the carbon in the wood to the atmosphere as CO_2. Burning wood for energy is typically less efficient, and thus far more carbon-intensive per unit of energy produced, than burning fossil fuels (even coal). Measured at the stack, biomass combustion produces significantly more CO_2 per megawatt-hour than fossil fuel combustion. A large biomass-fueled boiler may have an emissions rate far in excess of 3,000 lbs CO_2 per MWh.[33] Smaller-scale facilities using gasification technology are similarly carbon-intensive; the Cabin Creek bioenergy project recently approved by Placer County would have an emissions rate of more than 3,300 lbs CO_2/MWh.[34] By way of comparison, California's 2012 baseline emissions rate from the electric power sector was 954 lbs CO_2 per MWh.[35] As one recent scientific article noted, "[t]he fact that combustion of biomass generally generates more CO_2 emissions to produce a unit of energy than the combustion of fossil fuels increases the difficulty of achieving the goal of reducing GHG emissions by using woody biomass in the short term."[36] Put more directly, replacing California grid electricity with biomass electricity likely more than *triples* smokestack CO_2 emissions. Thus, measured at the smokestack, replacing fossil fuels with biomass actually *increases* CO_2 emissions.[37] One recent study found that the climate

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the use of bioenergy] in the Energy Sector total should not be interpreted as a conclusion about the sustainability or carbon neutrality of bioenergy.").

[32] U.S. EPA, Accounting Framework for Biogenic CO_2 Emissions from Stationary Sources 11-12 (Sept. 2011) ("The IPCC . . . eschewed any statements indicating that its decision to account for biomass CO_2 emissions in the Land-Use Sector rather than the Energy Sector was intended to signal that bioenergy truly has no impacton atmospheric CO_2 concentrations."); see also Deferral for CO_2 Emissions from Bioenergy and Other Biogenic Sources Under the Prevention of Significant Deterioration (PSD) and Title V Programs, 76 Fed. Reg. 43,490, 43,498 (July 20, 2011); Science Advisory Board Review of EPA's Accounting Framework for Biogenic CO_2 Emissions from Stationary Sources 7 (Sept. 28, 2012) at 3.

[33] The Central Power and Lime facility in Florida, for example, is a former coal-fired facility recently permitted to convert to a 70-80 MW biomass-fueled power plant. According to permit application materials, the converted facility would consume the equivalent of 11,381,200 MMBtu of wood fuel per year. *See* Golder Assoc. 2011. Air Construction Permit Application: Florida Crushed Stone Company Brooksville South Cement Plant's Steam Electric Generating Plant, Hernando County Table 4-1 (Sept. 2011). Using the default emissions factor of 93.8 kg/MMBtu CO_2 found in 40 C.F.R. Part 98, and conservatively assuming both 8,760 hours per year of operation and electrical output at the maximum 80 MW nameplate capacity, the facility would produce about 3,350 lbs/MWh CO_2. If the plant were to produce only 70 MW of electricity, the CO_2 emissions rate would exceed 3,800 lbs/MWh. If such a facility were dispatched to replace one MWh of fossil-fuel fired generation with one MWh of biomass generation, the facility's elevated emissions rate would also result in proportionately higher emissions on a mass basis.

[34] Ascent Environmental. 2012. Cabin Creek Biomass Facility Project Draft Environmental Impact Report, App. D (July 27, 2012) (describing 2 MW gasification plant with estimated combustion emissions of 26,526 tonnes CO_2e/yr and generating 17,520 MWh/yr of electricity, resulting in an emissions rate of 3,338 lbs CO2e/MWh).

[35] See Energy and Environment Daily, Clean Power Plan Hub, at http://www.eenews.net/interactive/clean_power_plan/states/california (visited May 18, 2016).

[36] Bird, D.N. et al. 2011. Zero, one, or in between: evaluation of alternative national and entity-level accounting for bioenergy. Global Change Biology Bioenergy 4: 576-587.

[37] Typical CO2 emission rates for facilities:
Gas combined cycle 883 lb CO2/MWh

impact per unit of CO_2 emitted seems to be even higher for the combustion of slow-growing biomass than for the combustion of fossil carbon in a 100-year time frame.[38] Thus the warming effect from biogenic CO_2 can continue for decades or even centuries depending on the "feedstock."

In addition to producing large amounts of CO_2, biomass energy generation can result in significant emissions of other pollutants that worsen climate change and harm human health, including nitrogen oxides, carbon monoxide, particulate matter, and black carbon. Many biomass emissions can exceed those of coal-fired power plants even after application of best available control technology. [39]

2. Even if harvested biomass is substituted for fossil fuels, it can be decades to centuries before the harvested forest achieves the same CO_2 reductions that could be achieved by leaving the forest unharvested.

Biomass and fossil CO_2 are indistinguishable in terms of their atmospheric forcing effects.[40] Claims about the purported climate benefits of biomass energy thus turn entirely on "net" carbon cycle effects, particularly the possibility that new forest growth will resequester carbon emitted from combustion, and/or the possibility that biomass combustion might "avoid" emissions that would otherwise occur. Multiple studies have shown that it can take a very long time to discharge the "carbon debt" associated with bioenergy production, even where fossil fuel displacement is assumed, and even where "waste" materials like timber harvest residuals are used for fuel.[41] Thus, even if harvested biomass is substituted for fossil fuels, it can be decades or

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Gas steam turbine 1,218 lb CO2/MWh
Coal steam turbine 2,086 lb/CO2/MWh
Biomass steam turbine 3,029 lb CO2/MWh
Sources: EIA, Electric Power Annual, 2009: Carbon Dioxide Uncontrolled Emission Factors. Efficiency values used to calculate emissions from fossil fuel facilities calculated using EIA heat rate data. (http://www.eia.gov/cneaf/electricity/epa/epat5p4.html); biopower efficiency value is 24%, a standard industry value.

[38] Holtsmark, B. 2013 (see footnote 8).

[39] Booth, Mary S. 2014. Trees, Trash and Toxics: How biomass energy has become the new coal. Partnership for Policy Integrity (April 2, 2014). Available at: pfpi.net/wp-content/uploads/2014/04/PFPI-Biomass-is-the-New-Coal-April-2-2014.pdf (visited March 16, 2017).

[40] U.S. EPA Science Advisory Board. 2012. Science Advisory Board Review of EPA's Accounting Framework for Biogenic CO_2 Emissions from Stationary Sources 7 (Sept. 28, 2012); *see also Center for Biological Diversity, et al. v. EPA*, 722 F.3d 401, 406 (D.C. Cir. 2013) ("In layman's terms, the atmosphere makes no distinction between carbon dioxide emitted by biogenic and fossil-fuel sources").

[41] *See, e.g.*, Mitchell, S.R. et al. 2012. Carbon debt and carbon sequestration parity in forest bioenergy production. Global Change Biology Bioenergy 4: 818-827; Schulze, E.-D. et al. 2012. Large-scale bioenergy from additional harvest of forest biomass is neither sustainable nor greenhouse gas neutral. Global Change Biology Bioenergy 4: 611-616; McKechnie, J. et al. 2011. Forest bioenergy or forest carbon? Assessing trade-offs in greenhouse gas mitigation with wood-based fuels. Environ. Sci. Technol. 45: 789-795; Repo, A. et al. 2010. Indirect carbon dioxide emissions from producing bioenergy from

centuries before the harvested forest achieves the same CO_2 reductions that could be achieved by leaving the forest unharvested (depending on harvest intensity, frequency, and forest characteristics).[42] One study, using realistic assumptions about initially increased and subsequently repeated bioenergy harvests of woody biomass, concluded that the resulting atmospheric emissions increase may even be permanent.[43]

Hudiburg et al. (2011) examined forest carbon responses to three different levels of fuel reduction treatments in 19 West Coast ecoregions containing 80 different forest types and different fire regimes.[44] In nearly all forest types, intensive harvest for bioenergy production resulted in net carbon emissions to the atmosphere, at least over the 20-year time frame of the study. Even lighter-touch fire prevention scenarios produced net carbon emissions in most ecoregions. The study demonstrated that across a wide range of ecosystems, thinning for fuels reduction and using the by-products for bioenergy increases CO_2 concentrations, at least in the short term.

A review by Schulze et al. (2012) concluded that "large-scale production from forest biomass is neither sustainable nor GHG neutral. [A]n increase in biomass harvest would result in younger forests, lower biomass pools, depleted soil nutrient stocks and a loss of other ecosystem functions. Large-scale woody bioenergy is likely to miss its main objective, i.e. to reduce greenhouse gas (GHG) emissions, because it would result in a reduction of biomass pools that may take decades to centuries to be paid back by fossil fuel substitution, if paid back at all."[45]

3. Forest management policies that promote fuels reduction and biomass burning for energy are inconsistent with achieving California climate goals.

The Governor's Executive Order B-30-15 and Senate Bill 32 establish a mid-term greenhouse gas emissions reduction target for California of 40 percent below 1990 levels by 2030. Executive Order S-3-05 calls for the state to reduce emissions levels by 80 percent below 1990 levels by 2050. These targets require increasingly steep reductions in emissions over the next three decades. Yet the science shows this is precisely the time period during which the carbon emitted from fuels reduction practices and biomass burning will increase atmospheric CO_2 levels. At a time when we need to reduce emissions dramatically in the short term and keep

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forest harvest residues. Global Change Biology Bioenergy 3: 107-115; Gunn, J., et al., Manomet Center for Conservation Sciences. 2010. Massachusetts Biomass Sustainability and Carbon Policy Study: Report to the Commonwealth of Massachusetts Department of Energy Resources.

[42] Searchinger, T.D. et al. 2009. Fixing a Critical Climate Accounting Error. Science 326: 527; Hudiburg, T.W. et al. 2011. Regional carbon dioxide implications of forest bioenergy production. Nature Climate Change 1: 419-423; Campbell, J.L. et al. 2012 (see footnote 11); Mitchell, S.R. et al. 2012 (see footnote 41).

[43] Holtsmark, B. 2013 (see footnote 8).

[44] Hudiburg, T.W. et al. 2011 (see footnote 42).

[45] Schulze et al. 2012 (see footnote 41).

them down, California forest policy should not be promoting intensive fuels reduction and biomass burning that will exacerbate climate change.

C. Numerous statements in the Plan about California forest carbon dynamics are scientifically unsupported and/or demonstrably incorrect.

The Plan's narrative on forest carbon dynamics is riddled with statements that are scientifically unsupported or demonstrably false, as detailed below:

(1) The Plan's statement that "stands that have reduced tree competition, achieved by fire or mechanical treatment, can experience greater growth rates in the live trees that remain"[46] is not supported by the cited reference, Stephenson et al. (2014), which documented continuous increases in tree mass growth rate (and rates of carbon gain) with tree size across all competitive environments.

(2) The Plan's statement that "under stressful conditions, such as drought, overly dense stands can stunt their growth and take years to recover once the drought subsides, while healthier stands may continue sequestering carbon across those years"[47] is not supported by the two cited studies, Anderegg et al. (2015) and Dore et al. (2012). For example, Anderegg et al. (2015) found evidence of "drought legacies" of reduced growth and incomplete recovery for 1 to 4 years after severe drought across many forest types, but did not look at the effects of tree density on drought recovery.

(3) The Plan's statement that "in dense forest stands, large trees are more vulnerable to forest pests and drought, causing large trees to experience higher-than-normal levels of mortality"[48] is not supported by the cited reference, North et al. (2009), which looks at the effects of fire suppression and fuels treatment on carbon storage.

(4) The Plan states that "[l]arge trees also contribute the greatest amount of carbon sequestration on an annual basis in California, as shown in Table 7, while smaller trees are a net negative… The carbon benefits from treatments that promote growth and retention of larger trees include increased sequestration rates, more stable carbon storage, and decreased risk from the growing threats of climate change."[49] Here, once again the Plan promotes logging, and removal of carbon from forests, ostensibly for the goal of increasing carbon storage. However, the reference to Table 7 is misleading. The data in that Table are from the November 22, 2016 update from Christensen et al. (2016), using data from the Forest Service's Forest Inventory and Analysis (FIA) field plots. What Christensen et al. (2016), and Table 7 of the Plan, actually show is a trend of increased medium and large trees and decreased small trees, not the opposite. This does not suggest a need for logging, as the Plan incorrectly suggests.

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[46] Plan at 59.
[47] Plan at 59.
[48] Plan at 59.
[49] Plan at 59-60.

(5) The Plan states that "…more of the carbon pool is shifted into dead material which is unstable, and the overall sequestration rate of the stand slows and may be negated by emissions from increased decay over time…"[50] The Plan offers no citations to any scientific sources for this statement, and fails to explain why, following mortality of canopy trees from drought, there would not occur a resulting "greater growth rate[]", as the Plan (p. 59) says will occur after fire or removal of some trees by logging. Nor does the Plan explain why dead trees, after falling and decaying into soil over decades, would not enhance the productivity of the forests by providing essential nutrients to forest soil.

(6) The Plan cites Battles et al. (2015) to assert that the removal of smaller trees will allow the stand to grow faster compared to untreated forest.[51] However, it is not clear what passage of this report the Plan is referencing, as Battles et al. (2015) simply does not establish this and cannot legitimately be cited as evidence for this proposition.

(7) The Plan states that "[i]n comparing rates of sequestration between nonfederal and federal forestlands, note that while nonfederal sequestration rates were 1.9 times those of federal lands, the area of nonfederal forestlands is just 73% the area of federal forestlands… On reserved lands [federal protected forests] mortality outpaced growth…which indicates that these lands were net sources of GHGs to the atmosphere."[52] These statements are misleading on multiple levels. First, the Forest Service report cited as the basis of these claims, Christensen et al. (2016), states the following on pp. 27-29 with regard to attempts to compare growth/mortality figures between federal and non-federal lands based on the FIA data: "Owing to numerous differences between the current inventory and those prior measurements [on private, state, and local government lands], comparing current volume estimates with those published from previous inventories will not produce valid change estimates… Average annual mortality rates on NFS land…were relatively high compared to private ownerships. However, the timeframe for assessment of change between NFS and private ownerships is vastly different and therefore cannot be compared directly."

Christensen et al. (2016), on p. 29, also noted the following: "Although not statistically significant, average annual cubic feet volume loss through tree mortality exceeded growth on reserved forest land… However, biomass mortality was significantly less than growth." The authors make clear that the timeframe for comparison on federal lands was very short (only five years on average between plot re-measurements), unlike the data for private lands, and they note (p. 29) that the results for this short time period on the small portion of the forested landscape within protected forests (like wilderness) was heavily influenced by a very unusual year (2008) in the more recent timeframe of the comparison, where lightning fires just happened to occur disproportionately within wilderness areas.

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[50] Plan at 59.

[51] Plan at 61: "The net result is that, within a decade or two, the larger, more resilient remaining trees and other forest carbon pools (e.g., soils) will contain the carbon lost due to the treatment removal of smaller trees and material and the stand will be growing faster than if the treatment had not occurred [Battles et al. 2015]."

[52] Plan at 72.

Further, Figure 32 of Christensen et al. (2016) shows that, on federal lands other than national forests (i.e., mostly protected forests in national parks, with some BLM lands), growth exceeded mortality by about fivefold, so the implication in the Forest Carbon Plan that increased logging and carbon removal, and decreased forest protection, somehow results in increased carbon storage, is not scientifically sound and does not faithfully convey the findings of the cited sources.

(8) The Plan claims that there is growing evidence that California's forests have become net emitters of carbon due primarily to "uncharacteristic fire and mortality."[53] The Plan does not cite any evidence that substantiates this assertion. Instead, the FIA Program data discussed in the Plan estimated a net increase in carbon stocks on federal forestlands for the decade starting in 2001, not a decrease.[54]

(9) The Plan states that "[c]onversion to shrub or grassland would have a significant impact on California's future carbon storage, since these land types contain 10% or less carbon per acre than forested acres [Gonzalez et al. 2015]."[55] Citation to this study for this proposition is misleading because it implies that conifer forests are generally converting permanently to shrubs and grassland following high-severity fire, but Gonzalez et al. (2015) provides no such evidence. Most published studies that have investigated this issue have found substantial, heterogeneous natural conifer regeneration following high-severity fire in mixed-conifer and yellow pine forests (Raphael et al. 1987, Shatford et al. 2007, Donato et al. 2009, Haire and McGarigal 2010, Crotteau et al. 2013, DellaSala and Hanson 2015),[56] especially given that natural post-fire conifer regeneration continues to occur in successive years post-fire (Shatford et al. 2007). This is especially true when such studies assess natural succession over time, since in the driest forests natural post-fire conifer regeneration in high-severity fire patches may be very sparse or absent for the first decade or so post-fire, but then increases substantially (Haire and McGarigal 2010).

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[53] Plan at 1.

[54] Plan at 72.

[55] Plan at 67.

[56] Raphael, M.G. et al. 1987. Breeding bird populations during twenty-five years of postfire succession in the Sierra Nevada. The Condor 89: 614-626; Shatford, J.P.A. et al. 2007. Conifer regeneration after forest fire in the Klamath-Siskiyous: how much, how soon? Journal of Forestry, April/May: 139-146; Donato, D.C. et al. 2009. Vegetation response to a short interval between high-severity wildfires in a mixed-evergreen forest. Journal of Ecology 97: 142-154; Haire, S.L. and K. McGarigal. 2010. Effects of landscape patterns of fire severity on regenerating ponderosa pine forests (*Pinus ponderosa*) in New Mexico and Arizona, USA. Landscape Ecology 25: 1055-1069; Crotteau, J.S. et al. 2013. Post-fire regeneration across a fire severity gradient in the southern Cascades. Forest Ecology and Management 287: 103-112; DellaSala, D.A. and C.T. Hanson (eds). 2015. The ecological importance of mixed-severity fires: nature's phoenix. Elsevier, United Kingdom.

D. The Plan's characterization of fire activity in California's forests is incorrect.

One of the Plan's core arguments is that California's forests are experiencing uncharacteristically severe and large wildfires that are "out of the historical norm"[57] as a justification for massive increases in thinning in order to reduce fire activity. The Plan also states that forests that have missed fire cycles are burning more severely,[58] and that high severity burn patches are increasing in size.[59] However, the body of scientific studies on fire trends does not support these assertions, and instead demonstrates (1) no increasing trend in fire severity in California's forests, (2) no increasing trend in high-severity patch size, (3) the most fire-suppressed forests are not burning more severely, and (4) no clear trends in fire size.

1. Fire severity is not increasing in California's forests.

The Plan repeatedly asserts that fire severity is increasing in California's forests.[60] For this proposition, the Plan cites to three sources (e.g., Miller and Safford 2012, Mallek et al. 2013, unpublished draft Cal Fire report), but omits any mention of the much larger number of recent published, peer-reviewed studies that have found that fire severity is not increasing in California's forests. These studies are summarized in a scientific literature review by Doerr and Santin (2016), which concluded: "For the western USA, [current studies] indicate little change overall [in high-severity fire trends], and also that area burned at high severity has overall declined compared to pre-European settlement."[61]

Specifically, the Plan fails to mention nine studies that analyzed recent trends in fire severity in California's forests in terms of proportion, area, and/or patch size found no significant trend in fire severity: Schwind 2008 (California forests), Collins et al. 2009 (central Sierra Nevada), Hanson et al. 2009 (Klamath, southern Cascades), Dillon et al. 2011 (Northwest California), Miller et al. 2012 (four Northwest CA forests), Hanson and Odion 2014 (Sierra Nevada, southern Cascades), Odion et al. 2014 (eastern and western Sierra Nevada, eastern

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[57] Plan at 12:"Fire severity has been increasing as well, which is out of the historical norm" and at 1: "Decades of fire exclusion, coupled with ongoing drought and the growing impacts of climate change, have dramatically increased the size and intensity of wildfires."

[58] Plan at 10: "Today, many forested areas have missed five or more natural cycles and the biomass buildup, species change, and other factors have led to an increase in fire severity when fire does finally return to those areas, compared to historical levels."

[59] Plan at 12: "High severity burn patches were historically small, commonly under 10 acres in size… In contrast to this healthy functionality, the King Fire had a single high-severity burn patch of over 30,000 acres in size and the Rim Fire had a high-severity burn patch over 50,000 acres."

[60] Plan at 17: "Like wildfire activity overall, fire severity has been increasing over the last few decades as demonstrated in the Moonlight, Chips, King, and Rim fires, for example"; Plan at 60: "Wildfire burned area and severity has been increasing in recent decades…"

[61] Doerr, S.H. and C. Santin. 2016. Global trends in wildfire and its impacts: perceptions versus realities in a changing world. Philosophical Transactions Royal Society B 371: 20150345.

Cascades), Baker 2015 (California dry pine and mixed conifer forests), and Picotte et al. 2016 (California forest and woodland).[62]

Hanson and Odion (2014) conducted the first comprehensive assessment of fire intensity since 1984 in the Sierra Nevada using 100% of available fire intensity data, and found no increasing trend in terms of high-intensity fire proportion, area, mean patch size, or maximum patch size. Hanson and Odion (2014) and Hanson and Odion (2015)[63] reviewed the approach of the two studies cited by the Plan as reporting an increasing trend in fire severity (Miller and Safford 2012, Mallek et al. 2013) and found that these studies had a methodological flaw that resulted in the erroneous exclusion of much of the high-severity fire data in conifer forests in the earlier years of the time series, leading to the false appearance of increasing high-severity fire.

Of note, Baker (2015) found that the rate of recent (1984–2012) high-severity fire in dry pine and mixed conifer forests in California is within the range of historical rates, or is too low. There were no significant upward trends from 1984–2012 for area burned and fraction burned at high severity. The author concluded that “[p]rograms to generally reduce fire severity in dry forests are not supported and have significant adverse ecological impacts, including reducing habitat for native species dependent on early-successional burned patches and decreasing landscape heterogeneity that confers resilience to climatic change.”

2. High-severity patch size is not increasing in California’s forests.

The Plan suggests that high-severity burn patches are increasing in size, without citing any supporting studies.[64] In contrast to this assertion, Hanson and Odion (2014) analyzed all available fire severity data, 1984–2010, over the entire Sierra Nevada ecoregion and found no trend in high-severity fire mean annual patch size or maximum annual patch size, but this study was even not mentioned. Furthermore, the Plan’s statements on the sizes of high severity burn

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[62] Schwind, B. 2008. Monitoring trends in burn severity: report on the Pacific Northwest and Pacific Southwest fires (1984 to 2005). US Geological Survey; Collins, B.M. et al. 2009. Interactions among wildland fires in a long-established Sierra Nevada natural fire area. Ecosystems 12:114–128; Hanson, C.T. et al. 2009. Overestimation of fire risk in the Northern Spotted Owl Recovery Plan. Conservation Biology 23: 1314–1319; Dillon, G.K., et al. 2011. Both topography and climate affected forest and woodland burn severity in two regions of the western US, 1984 to 2006. Ecosphere 2: Article 130; Miller, J.D. et al. 2012. Trends and causes of severity, size, and number of fires in northwestern California, USA. Ecological Applications 22: 184-203; Hanson, C.T., and D.C. Odion. 2014. Is fire severity increasing in the Sierra Nevada mountains, California, USA? International Journal of Wildland Fire 23: 1-8; Odion, D.C. et al. 2014. Examining historical and current mixed-severity fire regimes in Ponderosa pine and mixed-conifer forests of western North America. PLoS ONE 9(2): e87852; Baker, W.L. 2015. Are high-severity fires burning at much higher rates recently than historically in dry-forest landscapes of the Western USA? PLoS ONE 10(9): e0136147; Picotte, J.J. et al. 2016. 1984-2010 trends in fire burn severity and area for the coterminous US. International Journal of Wildland Fire 25: 413-420.

[63] Hanson, C.T. and D.C. Odion. 2015. Sierra Nevada fire severity conclusions are robust to further analysis: a reply to Safford et al. International Journal of Wildland Fire 24: 294-295.

[64] Plan at 12: “Over the last few decades, wildfires in California’s conifer forests…have exhibited larger and larger uniform patches of severe fire.”

patches are demonstrably false. The Plan asserts that the Rim Fire of 2013 and King Fire of 2014 were almost 40% and 50% high severity, respectively,[65] whereas the Forest Service's MTBS (Monitoring Trends in Burn Severity) data indicate that the Rim Fire was 20% high severity and the King Fire was 44% high severity.[66] In addition, MTBS mapping data clearly show that the Plan's assertion of a 50,000-acre high severity patch in the Rim Fire and a 30,000-acre high-severity patch in the King Fire[67] are incorrect and dramatically over-estimated.[68]

3. Forest areas in California that have missed the largest number of fire return intervals are not burning at higher fire severity.

Empirical studies have found that forest areas in California that have missed the largest number of fire return intervals are not burning at higher fire severity. Specifically, six empirical studies found that the most long-unburned (most fire-suppressed) forests burned mostly at low/moderate-severity, and did not have higher proportions of high-severity fire than less fire-suppressed forests. Forests that were not fire suppressed (e.g., those that had not missed fire cycles, i.e., Condition Class 1, or "Fire Return Interval Departure" class 1) generally had levels of high-severity fire similar to, or higher than, those in the most fire-suppressed forests, as found by Odion et al. 2004 (Klamath-Siskiyou), Odion and Hanson 2006 (Sierra Nevada), Odion and Hanson 2008 (Sierra Nevada), Odion et al. 2010 (Klamath Mountains), Miller et al. 2012 (Sierra Nevada), and van Wagtendonk et al. 2012 (Sierra Nevada).[69]

Recently, Steel et al. (2015) reported modeling results that predicted a modest increase in fire severity with increasing time since fire: 12% high-severity fire at 10 years after fire up to 20% high-severity fire at 75 years post-fire.[70] Thus, even the most long-unburned forests (>75 years since the last fire) were predicted to have mostly low/moderate-severity fire effects. Moreover, even the modest predicted increase in fire severity reported by Steel et al. (2015) must be viewed with caution because it was based upon almost no data for mixed-conifer stands that had experienced fire less than 75 years previously (see Fig. 4 of Steel et al. 2015).

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[65] Plan at 12.

[66] U.S. Forest Service and U.S. Geological Survey. 2014. Acreage of burn severity for the California Rim Fire, 2013.

[67] Plan at 12.

[68] U.S. Forest Service and U.S. Geological Survey. 2015. Acreage of burn severity for the California King Fire, 2014.

[69] Odion, D.C. et al. 2004. Patterns of fire severity and forest conditions in the Klamath Mountains, northwestern California. Conservation Biology 18: 927-936; Odion, D.C. and C.T. Hanson. 2006. Fire severity in conifer forests of the Sierra Nevada, California. Ecosystems 9: 1177-1189; Odion, D.C. and C.T. Hanson. 2008. Fire severity in the Sierra Nevada revisited: conclusions robust to further analysis. Ecosystems 11: 12-15; Odion, D.C. et al. 2010. Alternative community states maintained by fire in the Klamath Mountains, USA. Journal of Ecology; Miller, J.D. et al. 2012. Trends and causes of severity, size, and number of fires in northwestern California, USA. Ecological Applications 22:184-203; van Wagtendonk, J.W. et al. 2012. Factors associated with the severity of intersecting fires in Yosemite National Park, California, USA. Fire Ecology 8: 11-32.

[70] Steel, Z. L. et al. 2015. The fire frequency-severity relationship and the legacy of fire suppression in California forests. Ecosphere 6(1):8.

4. There is no clear trend in fire size in California's forests.

The Plan asserts that wildfires in California's conifer forests have grown larger over the last few decades.[71] The Plan cites Westerling (2016) which reported a significant increase in the percent change in area burned by large fires between two decades (1973-1982 and 2003-2012) in the Sierra Nevada. However, the use of the extreme unnaturally low fire period of 1973-1982 as the baseline in Westerling (2016) is reflective of a "shifting baselines" problem where the baseline is erroneously shifted to a more recent period (*see* Hanson et al. 2015),[72] and suggests a lack of basic familiarity with the numerous scientific studies on fire history detailed below in Section I.E., which consistently indicate that there is currently far less fire in our forests now than there was historically.

Furthermore, other studies not mentioned by the Plan have not found significant increases in area burned in recent decades. Dennison et al. (2014) found no significant increase in annual fire area in the Sierra Nevada/Klamath/Cascades forest ecoregion in California during the 1984-2011 study period, nor a significant trend toward an earlier fire season in this or any other western ecoregion.[73] Similarly, Dillon et al. (2011) detected no trends in annual area burned in the two ecoregions that occur in part in northern California (i.e., Pacific and Inland Northwest) during the 1984-2006 study period.[74]

On a final note, in its ecoregional analyses, the Plan makes the unsupported statement that National Forests in Southern California have been burning at higher frequencies.[75] The study cited by the Plan, Safford and van de Water (2014), found that a substantial portion of the foothill chaparral in southern California, including chaparral on southern California national forests (which are predominantly comprised of foothill chaparral), is experiencing higher fire frequencies than likely occurred historically, but the study did not make this conclusion for the conifer forests of California.

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[71] Plan at 12: "Over the last few decades, wildfires in California's conifer forests have grown bigger."

[72] Hanson, C.T. et al. 2015. Setting the stage for mixed- and high-severity fire. Chapter 1 in DellaSala, D.A., and C.T. Hanson (Editors). The ecological importance of mixed-severity fires: nature's phoenix. Elsevier Inc., Waltham, MA, USA.

[73] Dennison, P.E., Brewer, S.C., Arnold, J.D., and M.A. Moritz. 2014. Large wildfire trends in the western United States, 1984-2011. Geophysical Research Letters 41: 2928–2933.

[74] Dillon, G.K., et al. 2011 (see footnote 62).

[75] Plan at 216: "Compared to the FRID maps for the other ecoregions, this ecoregion has a significant proportion of areas that are seeing more frequent fire than they have historically. This observation comports with USDA Forest Service findings that National Forests in Southern California have large areas that have been burning at higher frequencies than under presettlement conditions [Safford and van de Water 2014]."

E. California's forests are experiencing much less fire than there was historically.

The Plan does not candidly disclose the fact that the overwhelming weight of scientific evidence indicates we currently have substantially less fire of all severities in the great majority of western U.S. mixed-conifer, mixed-evergreen, and yellow pine forests than we did historically (*see* literature summarized in Hanson et al. 2015).[76] It is well-established that California's forests are experiencing a significant fire deficit compared with pre-settlement conditions (Mouillet and Field 2005, Stephens et al. 2007, Marlon et al. 2012, Odion et al. 2014, Parks et al. 2015).[77]

According to Stephens et al. (2007), prior to 1800, an estimated 18 to 47 times more area burned each year in California, including 20 to 53 times more forest area, than has burned annually during recent decades: "skies were likely smoky much of the summer and fall." This study estimated that 1.8 million to 4.8 million hectares burned each year in California prior to 1800, of which 0.5 million to 1.2 million hectares were forest, compared to just 102,000 hectares burned each year between 1950-1999, of which 23,000 hectares were forest. Based on this extreme fire deficit, Stephens et al. (2007) recommend "increasing the spatial extent of fire in California [as] an important management objective."

The recent analysis by Parks et al (2015) reported that California forests, including Sierra Nevada and southern Cascades forests, experienced a significant fire deficit during the 1984-2012 study period, attributed to fire suppression activities. Odion et al. (2014) similarly found multiple lines of corroborating evidence that there is currently much less high-severity fire in California's mixed-conifer and ponderosa pine forests than compared with historical levels. Mallek et al. (2013) also confirmed the fire deficit in California's forests, concluding that "modern rates of burning are far below presettlement levels for all forest types."

F. California's mixed conifer forests are characterized by a mixed severity fire regime, not by a predominantly low severity fire regime as the Plan asserts.

The Plan inaccurately asserts that the wildfire regime in California's mixed conifer forests was historically low intensity and that "high severity fire made up a low percentage of many historic fires."[78] The Plan argues, as a result, that forests were very open in structure with lots of large trees and that "very little carbon was emitted post-disturbance" creating a "stable

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[76] Hanson et al. 2015 (see footnote 72).

[77] Mouillot, F. and C. Field. 2005. Fire history and the global carbon budget: a 1° x 1° fire history reconstruction for the 20th century. Global Change Biology 11: 398-420; Stephens, S.L. et al. 2007. Prehistoric fire area and emissions from California's forests, woodlands, shrublands and grasslands. Forest Ecology and Management 251: 205-216; Marlon, J.R. et al. 2012. Long-term perspective on wildfires in the western USA. PNAS 109: E535–E543; Odion, D.C. et al. 2014 (see footnote 62); Parks, S.A. et al. 2015. Wildland fire deficit and surplus in the western United States, 1984-2012. Ecosphere 6: Article 275.

[78] Plan at 9: "Prior to 1900, wildfires in the many California mixed conifer forests were predominately low-intensity and removed excess fuel, thinned vegetation, and reduced competition for nutrients and water, resulting in healthy forests resilient against drought and native bark beetle outbreaks."

forest carbon landscape."[79] The Plan uses the assertion that California's forests were mostly low-severity to justify massive thinning projects with the purported purpose of reducing wildfire activity, particularly high-severity fire.

However, a robust body of scientific evidence and multiple lines of evidence demonstrate that California's mixed-conifer and ponderosa pine forests were characterized by mixed-severity fire that includes ecologically significant amounts of high-severity fire, as detailed in Appendix A. Mixed-severity fire has played an important role in creating heterogeneity, including complex structural diversity and high biological diversity, across California's forested landscapes. As summarized by Odion et al. (2014):

> Mixed-severity fire regimes are characterized by more variable fire and forest structure across a wide range of spatial and temporal scales. The creation of complex early seral vegetation by high-severity fire often occurs in irregular patches across the landscape and at irregular intervals. Over time, the complex early successional vegetation created by fire, if not reburned, transitions to mid- and then late successional forest, often containing pre-disturbance legacies, such as standing or fallen dead trees and often some fire resistant, large trees that survive fire crown fire. Thus, mixed-severity fire regimes create complex successional diversity, high beta diversity, and diverse stand-structure across the landscape.[80]

As summarized by Loehman et al. (2014), the carbon ecosystem balance is stable in these fire-prone landscapes when integrated over large landscapes and long time scales: "ecosystem carbon balance integrated over long periods of time in fire-adapted systems with constant fire return intervals is zero, meaning that carbon losses from tree mortality, wildfire combustion, and decomposition are balanced by carbon accumulation in live and dead vegetation and soils."[81]

It is important that the Plan recognize that California's forest landscape was shaped by mixed-severity wildfire and other natural disturbances that create complex structural heterogeneity and high biological diversity,[82] so that management decisions for enhancing forest resilience are using an accurate model of natural, historic ecosystem conditions. At present, the Plan is based on a faulty model of the historic fire regime in California's forests.

G. The Plan fails to recognize the significant role of historic and current logging in reducing forest biomass and carbon storage.

The Plan is eager to institute large increases in mechanical thinning, including commercial logging, but refuses to recognize the significant impacts of historic and current

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[79] Plan at 9.

[80] Odion et al. 2014 (see footnote 62).

[81] Loehman et al. 2014 (see footnote 17).

[82] DellaSala, D.A. et al. 2014. Complex early seral forests of the Sierra Nevada: what are they and how can they be managed for ecological integrity? Natural Areas Journal 34:310-324.

logging practices in reducing forest biomass and carbon storage in California's forests. Historic and current logging has removed massive amounts of biomass from California's forests.[83] As detailed above, logging significantly reduces forest carbon storage. Harvest of live trees from the forest not only reduces current standing carbon stocks, but also reduces 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.[84] A recent study found that logging also homogenizes forest structure in way that exacerbates the effects of fire suppression, leading the study authors to caution against the current push to increase mechanical fuel treatments in forests.[85]

Despite these well-documented harms, "logging" is mentioned only once in the 119 pages of the main body of the plan.[86] The Plan completely ignores the long-term impacts of high-grading, clear-cutting, and plantation forestry implemented expansively throughout much of the state. The Plan must present a historically accurate representation of past and current forest management as a basis for developing the Plan's management goals.

H. The Plan's claims about forest density as related to forest health are inaccurate.

The Plan makes numerous statements that forests are too dense and therefore "unhealthy," as a justification for thinning/logging.[87] Not only is the Plan's representation of forest density misleading and simplistic, but scientific research has not concluded that denser forests are categorically less healthy or resilient. Instead current research suggests that forest

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[83] In the Sierra Nevada, logging is estimated to have removed most (82%) of the historical acreage of old-growth mixed conifer forests, largely due to clear-cutting, high-grading of big trees, and other logging practices. See Beesley, D. 1996. Reconstructing the landscape: an environmental history, 1820-1960. *In* Sierra Nevada Ecosystem Project: final report to Congress. Vol. II. Assessments and scientific basis for management options. Centers of Water and Wildland Resources, Davis, Calif. Pp. 1-24.

[84] Holtsmark et al. 2013 (see footnote 8).

[85] Naficy, C. et al. 2010. Interactive effects of historical logging on fire exclusion on ponderosa pine forest structure in the northern Rockies. Ecological Applications 20: 1851-1864 ("The extent to which modern mechanical treatments could have similar long term counterproductive effects to those reported here for historically logged sites when treated stands are left unattended is largely still unknown." The authors also pointed to "growing evidence that labor intensive and costly mechanical treatments in many unlogged, fire-excluded forests may not be necessary to restore wildfire despite structural departures from historical conditions (Brown et al. 1994, Odion and Hanson 2006, 2008, Collins and Stephens 2007, Collins et al. 2007, Fule and Laughlin 2007, Holden et al. 2007, Safford et al. 2008; but see Goforth and Minnich 2008)."

[86] Plan at 9: "logging removed many of the larger old growth species,…[and] removed much of the live forest carbon from the forest."

[87] Plan at 1:"Today, many forests are unhealthy, with unnaturally dense stands that lack resilience, making them more susceptible to drought, disease, insect pests, and uncharacteristically large, severe wildfires."; Plan at 59: "California's forests currently have higher densities of small trees and fewer large trees on the landscape overall compared to historic forest conditions.133, 134, 135 These conditions have detrimental implications for both the resilience of the forest and quality of the forest as a carbon sink."

management treatments focused on thinning trees to increase resilience can be counter-productive, and many studies recommend restoring natural disturbance processes to increase resilience.

First, it is important to recognize that California's forests are much less dense in terms of basal area than they were historically.[88] Although not acknowledged by the Plan, Sierra Nevada forests were estimated to be about 30% less dense, and Tranverse and Peninsular Range forests were 40% less dense, in terms of basal area in the 2000s compared to the 1930s,[89] largely due to past and present logging.

Second, historically, California's mixed-conifer and ponderosa pine forests had a wide range of densities. For example, Hodge (1906) reported that ponderosa pine forests of the western Sierra Nevada had density ranges generally from about 100 to 1000 trees per acre, and were dominated by smaller trees.[90] A reconstruction of historical forest structure in Sierra mixed-conifer forests based on 1865-1885 survey data suggests that historical forests "were open and park-like in places, but generally dense, averaging 293 trees/ha" with smaller pines and oaks numerically dominant, as indicative of mixed- rather than low-severity fire regimes.[91] An assessment of US Forest Service forest survey data from 1910 and 1911 for central and southern Sierra Nevada ponderosa pine and mixed-conifer forests similarly indicates that historical forests had a high variability in density, again indicative of varied disturbance intensities and frequencies.[92]

Third, numerous studies indicate that increased forest density does not equate to a lack of resilience, as measured by tree mortality and physiological stress levels. In the mixed conifer forests of California's Lake Tahoe Basin, a recent study found "a nuanced relationship between stocking level [density], forest mortality and drought effects."[93] In mid- to upper-elevation forests, increased density was associated with decreased probability of mortality, especially during wetter periods, whereas increased density was more associated with increased probability of mortality in lower elevation forests and drier climate periods. The researchers suggested that "no single density-reduction forest management strategy will increase forest resilience under all climate periods and in all forest types."

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[88] McIntyre, P.J. et al. 2015. Twentieth-century shifts in forest structure in California: denser forests, smaller trees, and increased dominance of oaks. PNAS 112: 1458-1463.

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

[90] Hodge (1906) as cited in Hanson, C.T. and D.C. Odion. 2016. Historical forest conditions within the range of the Pacific fisher and spotted owl in the Central and Southern Sierra Nevada, California, USA. Natural Areas Journal 36: 8-19, at 17.

[91] Baker, W. L. 2014. Historical forest structure and fire in Sierran mixed-conifer forests reconstructed from General Land Office survey data. Ecosphere 5:79.

[92] Hanson, C.T. and D.C. Odion. 2016 (see footnote 90).

[93] Van Gunst, K.J. et al. 2016. Do denser forests have greater risk of tree mortality: a remote sensing analysis of density-dependent forest mortality. Forest Ecology and Management 359: 19-32.

A study in the Douglas fir forests of northeastern Washington found that competition [i.e., higher density] did not affect tree responses to extreme drought.[94] Importantly, trees with more competition from neighbors appeared to have higher drought resistance (i.e., a significantly higher proportion of sapwood area in latewood, which is a trait associated with drought resistance). The authors suggested that "a tree's ability to cope with environmental variability is driven not just by the proximate effects of neighbours on resource availability, but also by phenotypic plasticity and long-term adaptations to competitive stress."

A study that directly investigated the lack of fire on the physiological status of old-growth ponderosa pine trees in unlogged forests in Idaho found that, contrary to predictions, old-growth trees in stands that were unburned for at least 70 years showed no significant differences in multiple stress indicators compared to non-fire-suppressed stands, indicating that these trees may be "more resilient to increased stand density associated with the lack of fire than previously thought."[95]

Many studies note that the relationships between tree density and resilience are complex, and that stand density is not a significant contributor to tree mortality:

> Recent studies of epidemic forest mortality events have not found stand density to be a significant contributor to tree death and instead, have attributed forest declines to the effects of top-down drivers such as moisture stress and drought, and associated spread and proliferation of bark beetle populations (Ganey and Vojta, 2011; Lines et al., 2010; Sánchez-Martínez and Wagner, 2002; van Mantgem and Stephenson, 2007). During episodic forest mortality events, the role of site environment, spatial proximity and landscape configuration can become more important than stand characteristics for predicting mortality patterns (MacQuarrie and Cooke, 2011; Powers et al., 1999; Simard et al., 2012). Differences in the importance of tree vigor and spatial aggregation may help explain why hazard ratings based on stand characteristics have little predictive power when applied to landscapes (Logan et al., 1998; Nelson et al., 2007). A comprehensive understanding of the role of density dependence during both epidemic and non-epidemic (''background") mortality periods remains elusive (Stamp, 2003).[96]
>
> Recent findings that stands with higher density do not necessarily exhibit greater physiological stress (Keeling, Sala & DeLuca 2011) or experience lower tree mortality in extreme drought events (e.g. Floyd et al. 2009; van Mantgem et al. 2009; Ganey & Vojita 2011) lend support to this idea but other studies have

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[94] Carnwath, G.C. and C.R. Nelson. 2016. The effect of competition on response to drought and interannual climate variability of a dominant conifer tree of western North America. Journal of Ecology 104: 1421-1431.

[95] Keeling, E.G. et al. 2011. Lack of fire has limited physiological impact on old-growth ponderosa pine in dry montane forests of north-central Idaho. Ecological Applications 21: 3227-3237.

[96] Van Gunst, K.J. et al. 2016 (see footnote 93).

> shown the opposite relationship between density and mortality (Negron et al. 2009; Kane & Kolb 2014) or that this relationship is inconsistent and context dependent (Meddens et al. 2015; Van Gunst et al. 2016).[97]
>
> However, the available evidence suggests that density-dependent mortality is not as typical of old and large tree subpopulations in conifer forests (Acker et al., 1996; Das et al., 2011; Aakala et al., 2012; Silver et al., 2013; Larson et al., 2015) as it is in the smaller size classes (Das et al., 2011; Lutz et al., 2014).[98]

As a result of this complexity, numerous studies caution against forest management treatments aimed at reducing density to increase forest resilience. Carnwath et al. (2016) noted that management activities to reduce tree density with the purpose of increasing stand resilience often target trees that may be the most drought-resilient, producing counter-productive results. Similarly, D'Amato et al. (2013) concluded that "heavy thinning treatments applied to younger populations, although beneficial at reducing drought vulnerability at this stage, may predispose these populations to greater long-term drought vulnerability."[99] Van Gunst et al. (2016) concluded that "no single density-reduction forest management strategy will increase forest resilience under all climate periods and in all forest types." As summarized by Van Mantgem et al. (2016), "published findings on mechanical thinning and drought response provide mixed results."

Keeling et al. (2006) emphasized the importance of restoring ecological processes, especially wildfire, rather than management that tries to create specific stand conditions.[100] Keeling's study in ponderosa pine/Douglas-fir communities found that "fire and absence of fire produce variable effects in the understory and different rates of successional change in the overstory across varied landscapes." The authors cautioned "against specific targets for forest structure in restoration treatments, and underscore the importance of natural variability and heterogeneity in ponderosa pine forests." Further, "management may need to emphasize restoration of natural ecological processes, especially fire, rather than specific stand conditions."

Finally, as discussed above, the lack of fire and its associated heterogeneity, not density, is problematic for forests. It is instead important to recognize that dense forest habitat, especially dense mature forest habitat, provides critical habitat for rare species like the California spotted owl, Pacific fisher, and black-backed woodpecker (e.g., Zielinski et al. 2006, Purcell et al. 2009, Underwood et al. 2010).[101] Research indicates that these species preferentially select dense

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[97] Carnwath, G.C. and C.R. Nelson. 2016 (see footnote 94).

[98] Clyatt, K.A. et al. 2016. Historical spatial patterns and contemporary tree mortality in dry mixed-conifer forests. Forest Ecology and Management 361: 23-37.

[99] D'Amato, A.W. et al. 2013. Effects of thinning on drought vulnerability and climate response in north temperate forest ecosystems. Ecological Applications 23: 1735-1742.

[100] Keeling, E.G. et al. 2006. Effects of fire exclusion on forest structure and composition in unlogged ponderosa pine/Douglas-fir forests. Forest Ecology and Management 327: 418-428.

[101] Zielinski, W.J. et al. 2006. Using forest inventory data to assess fisher resting habitat suitability in California. Ecological Applications 16: 1010-25; Purcell, K.L. et al. 2009. Resting structures and resting

mature forest habitat pre-fire *and* post-fire. Therefore, for rare species like the spotted owl and fisher, it is critical to acknowledge the importance of dense habitat and ensure its protection.

I. The Plan misrepresents the role of native bark beetles in California's forests, the effects of bark beetle outbreaks on fire, and the effects of thinning on beetle outbreaks.

1. The Plan fails to recognize that bark beetle outbreaks are part of an important natural disturbance regime in California's forests, and incorrectly labels bark beetles as "pests."

The Plan is incoherent on the role of bark beetles in California's forests. While the Plan briefly acknowledges that native insects "provide important ecosystem functions"[102] and are "part of the natural forest cycle,"[103] the Plan subsequently labels bark beetles as "pests."[104] Characterization of native bark beetles as pests, rather than as part of a natural disturbance process, is pervasive throughout the Plan and may unfairly prejudice its conclusions.

2. Bark beetle outbreaks do not increase fire severity or extent.

The Plan asserts that beetle outbreaks lead to more severe wildfire.[105] To the contrary, multiple studies demonstrate that trees killed by beetles and drought do not increase fire severity or extent. Similarly, multiple studies from different locations have also shown that high-severity fire reduces forest susceptibility to future beetle outbreaks, and that widespread and severe beetle outbreaks restrict subsequent outbreaks, as detailed below.

a. Trees killed by beetles and drought do not increase fire severity or extent.

Several empirical studies have investigated the effects of actual fires in areas with known pre-fire snag levels from recent drought and bark beetles, and which pertained to ponderosa pine

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habitats of fishers in the southern Sierra Nevada, California. Forest Ecology and Management 258: 2696-706; Underwood, E.C. et al. 2010. Using topography to meet wildlife and fuels treatment objectives in fire-suppressed landscapes. Environmental Management 46: 809-819.

[102] Plan at 54: "Native insects and diseases are an integral part of California's forests and provide important ecosystem functions. Most are host specific, only attacking one or a few closely related tree species. At endemic levels, insects and diseases and the dead trees they leave behind provide food or habitat for wildlife, recycle nutrients within the environment, thin over-stocked stands, create essential snags and forest openings and help maintain forest diversity."

[103] Plant at 12: "Tree mortality from native bark beetles and cycles of drought are part of the natural forest cycle in many forests in California."

[104] Although the Plan at first appears to define pests as "non-native" (Plan at 54), the Plan in the next paragraph labels bark beetles as "pests" (Table 6 titled "Major California Forest Pests" at 55).

[105] Plan at 53: "In a cyclical fashion, increased beetle activity from climate change leaves behind greater tree mortality, which in turn contributes to more severe wildfires."

and mixed-conifer forests. These studies have found that trees killed by bark beetles and drought do not influence fire severity or extent.

Bond et al. (2009) was conducted in mixed-conifer and ponderosa/Jeffrey-pine forests of the San Bernardino National Forest in southern California, where fires occurred immediately after a large pulse of snag recruitment from drought/beetles. Bond et al. (2009) "found no evidence that pre-fire tree mortality influenced fire severity."[106]

Hart et al. (2015a) investigated whether there is a relationship between snag levels from drought/beetles and the rate of fire spread in conifer forests across the western U.S., including ponderosa pine-dominated forests of California.[107] Hart et al. (2015a) found the following: "Contrary to the expectation of increased wildfire activity in recently infested red-stage stands, we found no difference between observed area and expected area burned in red-stage or subsequent gray-stage stands during three peak years of wildfire activity, which account for 46% of area burned during the 2002–2013 period." In other words, in both the initial stage of snag recruitment, when dead needles are still on the trees ("red-stage"), and in the later stage, years later, after needles and some snags have fallen ("gray-stage"), fire did not spread faster or burn more area in forests with high levels of snags from drought and native beetles. This was also true specifically in ponderosa pine forests, where there was no significant effect on fire spread of tree mortality from drought/beetles, and where fire spread was nearly identical regardless of snag levels (see Figure 3D).

Meigs et al. (2016) was conducted in mostly mixed-conifer and ponderosa pine forests of the Pacific Northwest (south to the California border), and found the following: "In contrast to common assumptions of positive feedbacks, we find that insects generally reduce the severity of subsequent wildfires. Specific effects vary with insect type and timing, but both insects [mountain pine beetle and western spruce budworm] decrease the abundance of live vegetation susceptible to wildfire at multiple time lags. By dampening subsequent burn severity, native insects could buffer rather than exacerbate fire regime changes expected due to land use and climate change."[108] Specifically with regard to the mountain pine beetle, a native species associated with the current snag recruitment in California's ponderosa pine and mixed-conifer forests, Meigs et al. (2016) found that fire severity was the same between stands with high levels of snags from drought/beetles and unaffected forests, when fires occurred during or immediately after the pulse of snag recruitment, and then fire severity consistently declined in the stands with high snag levels in the following decades (see Figure 3a).

The two studies cited by the Plan to support the assertion that "increased beetle activity from climate change leaves behind greater tree mortality, which in turn contributes to more

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[106] Bond, M.L. et al. 2009. Influence of pre-fire tree mortality on fire severity in conifer forests of the San Bernardino Mountains, California. The Open Forest Science Journal 2: 41-47.
[107] Hart, S.J. et al. 2015a. Area burned in the western United States is unaffected by recent mountain pine beetle outbreaks. PNAS 112: 4375-4380.
[108] Meigs, G.W., et al. 2016. Do insect outbreaks reduce the severity of subsequent forest fires? Environmental Research Letters 11: 045008.

severe wildfires…" are misrepresented and do not support this claim. Simard et al. (2010) concluded that bark beetle outbreaks may reduce the probability of crown fire: "Our results suggest that mountain pine beetle outbreaks in Greater Yellowstone may reduce the probability of active crown fire in the short term by thinning lodgepole pine canopies." Hood et al. (2015) concluded that "low-severity fire can trigger a long-lasting induced defense that may increase tree survival from subsequent herbivory."

b. High-severity fire reduces forest susceptibility to future beetle outbreaks.

Studies investigating how previous fire affects subsequent bark beetle outbreaks have found that high-severity fire reduces forest susceptibility to future outbreaks (e.g., Veblen et al. 1994, Kulakowski et al. 2012, Black et al. 2013, Seidl et al. 2016).[109] For example, Seidl et al. (2016) concluded that spatial variability in tree regeneration following large high-severity wildfire in Yellowstone National Park dampened and delayed future bark beetle outbreaks. The authors recommended that managers "embrace rather than reduce disturbance-created variability to strengthen negative feedbacks between successive disturbances." The study suggests that thinning/logging is likely to homogenize forests and exacerbate outbreaks: "postdisturbance salvage logging, removal of legacy trees or undisturbed forest patches, and extensive tree planting generally reduce disturbance-induced variability and thus likely weaken negative feedbacks between disturbance events."

c. Widespread and severe beetle outbreaks reduce forest susceptibility to future outbreaks.

Hart et al. (2015b) conducted the first broad-scale analysis of how prior bark beetle outbreaks affect susceptibility to future outbreaks.[110] The study found that a widespread, severe spruce beetle outbreak reduced forest susceptibility to spruce beetle infestation 60 years later. Importantly, the study concludes that "failure to incorporate negative feedbacks into prediction of future bark beetle outbreaks is likely to over-predict the extent or severity of future outbreaks and by implication under-estimate forest resistance to altered disturbance regimes under climate change."

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[109] Veblen, T.T. et al. 1994. Disturbance regime and disturbance interactions in a Rocky Mountain subalpine forest. Journal of Ecology 82: 125–35; Kulakowski, D. et al. 2012. Stand-replacing fires reduce susceptibility of lodgepole pine to mountain pine beetle outbreaks in Colorado. Journal of Biogeography 39: 2052–60; Black, S.H. et al. 2013. Do bark beetle outbreaks increase wildfire risks in the Central U.S. Rocky Mountains: Implications from Recent Research. Natural Areas Journal 33: 59-65; Seidl, R. et al. 2016. Spatial variability in tree regeneration after wildfire delays and dampens future bark beetle outbreaks. PNAS 113: 13075-13080.

[110] Hart, S.J. et al. 2015b. Negative feedbacks on bark beetle outbreaks: widespread and severe spruce beetle infestation restricts subsequent infestation. PLoS ONE 10(5): e0127975.

3. Mechanical thinning has not been shown to be the "most effective tool for reducing bark-beetle caused tree mortality" as claimed by the Plan, and can be counter-productive.

The Plan asserts without any supporting citation that thinning is "the most effective tool we have for reducing bark beetle-caused tree mortality."[111] However, recent reviews by Black et al. (2013) and Six et al. (2014) found that thinning treatments have mixed results and can fail to protect stands.[112] For example, Black et al. (2013) concluded that "[i]nsect containment measures have yielded mixed results and may pose significant risks to forested ecosystems." Six et al. (2014) noted that "many studies assessing the efficacy of thinning have been conducted under non-outbreak conditions" and therefore their results do not reflect how stands perform during an outbreak. Furthermore, "failures are often not reported" and "studies conducted during outbreaks indicate that thinning can fail to protect stands."

Importantly, Six et al. (2014) cautioned that the pressure to thin forests as beetle treatments, often as a means to provide revenue to the commercial timber industry, without scientific understanding of treatment effects can lead to "more harm than good":

> That pressure, to "do something", might also interact with the uncertainty about which choices are effective and appropriate (as with beetle timber harvest treatments) to create an opportunity for political pressures to force the adoption of particular choices that benefit specific interest groups [143]. It is perhaps no accident that the beetle treatments that have been most aggressively pushed for in the political landscape allow for logging activities that might provide revenue and jobs for the commercial timber industry. The result is that the push to "do something," uncertainty, and political pressures might lead us to act to respond to climate change before we understand the consequences of what we are doing, in the end producing more harm than good.[113]

In sum, the evidence discussed above demonstrates that while thinning/logging treatments homogenize forests and may reduce resilience, natural disturbance regimes such as wildfire and beetle outbreaks have been shown to be effective in supporting forest heterogeneity and dampening subsequent beetle outbreaks.

4. Bark beetles may be helpful in supporting forest resilience to climate change.

Although the Plan laments that bark beetle outbreaks decrease forest resilience, three studies suggest that bark beetles may act as a selective agent in shifting forest stands to those

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[111] Plan at 16-17: "Vegetation management (thinning) is the most effective tool we have for reducing bark beetle-caused tree mortality."

[112] Black, S.H. et al. 2013 (see footnote 109); Six, D.L. et al. 2014. Management for mountain pine beetle outbreak suppression: does relevant science support current policy? Forests 5: 103-133.

[113] Six, D.L. et al. 2014 at 124 (see footnote 112).

most suited to the prevailing climate conditions (Millar et al. 2007, Millar et al. 2012, Knapp et al. 2013).[114]

J. The Plan must develop a meaningful context for the recent tree mortality.

The Plan places much weight on recent tree mortality rates in the southern Sierra Nevada and beyond, estimated by the Forest Service as 102 million new snags since 2010.[115] For these mortality statistics to be meaningful, it is absolutely critical to place current snag densities into the context of historical levels and within the context of management objectives.

First, the current amount of complex early seral forests, or "snag forest habitat," created by native bark beetles, drought, and fire is estimated to be lower than natural, historical levels[116] and not in excess of the upper bounds of the natural range of variability in Sierra Nevada forests. Estimates indicate that about 800,000 acres of complex early seral forests have been created by bark beetles, drought, and wildfires in recent decades, representing less than 6% of the 14 million acres of conifer forest in the Sierra Nevada management region.[117] By comparison, historically, at any given point in time, 14% to 30% of conifer forests were comprised of complex early seral forests, including ponderosa pine and mixed-conifer forests, in the Sierra Nevada.[118] Thus, there is still much less snag forest habitat than there was historically.

Secondly, the Plan repeatedly laments that California's forest are "overly dense." The Plan strongly implies that reductions in tree density due to natural processes such as beetles, fire and drought have purely negative ecological consequences, while similar or greater reductions due to mechanical thinning operations are purely positive. The basis for this contradictory position is not clear.

K. The projected impacts of climate change on wildfire activity in California's forests are uncertain.

The Plan states that climate change will alter natural disturbance regimes such as "wildfires, pest infestations, and other agents of disturbance."[119] However, the Plan fails to

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[114] Millar, C.I. et al. 2007. Response of high-elevation limber pine (*Pinus flexilis*) to multiyear droughts and 20th-century warming, Sierra Nevada, California, USA. Canadian Journal of Forest Research 37: 2508-2520; Millar, C.I. et al. 2012. Forest mortality in high-elevation whitebark pine (*Pinus albicaulis*) forests of eastern California, USA; influence of environmental context, bark beetles, climatic water deficit, and warming. Canadian Journal of Forest Research 41: 749-765; Knapp, P.A. et al. 2013. Mountain pine beetle selectivity in old-growth ponderosa pine forests, Montana, USA. Ecology and Evolution 3: 1141-1148.

[115] Plan at 13 and 56.

[116] DellaSala, D.A. et al. 2014 (see footnote 82); Swanson, M.E. et al. 2011. The forgotten stage of forest succession: early-successional ecosystems on forested sites. Frontiers in Ecology and Environment 9: 117-125.

[117] John Muir Project, 8 February 2017, Comments to Little Hoover Commission.

[118] Baker, W. L. 2014 (see footnote 91); Hanson, C.T. and D.C. Odion. 2016 (see footnote 90).

[119] Plan at 53.

adequately acknowledge the uncertainty with regard to the effects of climate change on future fire activity in California's forests. While climate change will almost certainly alter fire activity, studies project that future fire severity in California's forests is likely to stay the same or decrease, and show no consensus on how climate change is likely to affect future fire probability or area burned.[120]

In terms of fire severity, a recent study by Parks et al. (2016) projected that even in hotter and drier future forests, there will be a decrease or no change in high-severity fire effects in nearly every forested region of the western U.S., including California, due to reductions in combustible understory vegetation over time.[121] Studies forecasting changes in the probability of burning and/or large fire occurrence project a varied mix of local increases or decreases of fire, varying by forest region (Krawchuk and Moritz 2012, Moritz et al. 2012, and Westerling and Bryant 2008).[122]

Studies that project changes in burned area in California's forests under climate change scenarios similarly show no consensus. Four studies project a mix of increases and decreases in total area burned depending on the region (Lenihan et al. 2003, Lenihan et al. 2008, Krawchuk et al. 2009, and Spracklen et al. 2009).[123] One study projects an overall decrease in area burned (McKenzie et al. 2004), while two studies project increases (Fried et al. 2004 in a small region in the Amador-El Dorado Sierra foothills; Westerling et al. 2011).[124] The projected increases in Westerling et al. (2011) are relatively modest, with median increases in area burned of 21% and 23% by 2050, and 20% and 44% by 2085, relative to 1961-1990 under lower (B1) and higher (A2) emissions scenarios respectively. Given that the average annual burned area in California in the past several decades was many times lower than the burned area historically, these projected

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[120] Whitlock, C. et al. 2015. Climate Change: Uncertainties, Shifting Baselines, and Fire Management. Pp. 265-289 in The Ecological Importance of Mixed Severity Fires: Nature's Phoenix. D.A. DellaSala and C.T. Hanson, eds. Elsevier, Amsterdam, Netherlands.

[121] Parks, S.A. et al. 2016. How will climate change affect wildland fire severity in the western US? Environmental Research Letters 11: 035002.

[122] Krawchuk, M. A., and M. A. Moritz. 2012. Fire and Climate Change in California. California Energy Commission. Publication number: CEC-500-2012-026; Moritz, M. et al. 2012. Climate change and disruptions to global fire activity. Ecosphere 3 (6): 1-22; Westerling, A. and B. Bryant. 2008. Climate change and wildfire in California. Climate Change 87: S231– S249.

[123] Lenihan, J.M. et al. 2003. Climate change effects on vegetation distribution, carbon, and fire in California. Ecological Applications 13: 1667-1681; Lenihan, J.M. et al. 2008. Response of vegetation distribution, ecosystem productivity, and fire to climate change scenarios for California. Climate Change 87(Suppl. 1): S215-S230; Krawchuk, M.A. et al. 2009. Global pyrogeography: the current and future distribution of wildfire. PloS ONE 4: e5102; Spracklen, D.V. et al. 2009. Impacts of climate change from 2000 to 2050 on wildfire activity and carbonaceous aerosol concentrations in the western United States. Journal of Geophysical Research 114: D20301.

[124] McKenzie, D. et al. 2004. Climatic change, wildfire, and conservation. Conservation Biology 18: 890-902; Fried, J.S. et al. 2004. The impact of climate change on wildfire severity: A regional forecast for northern California. Climatic Change 64 (1–2):169–191; Westerling, A.L. et al. 2011. Climate change and growth scenarios for California wildfire. Climatic Change 109 (Suppl 1): S445-S463.

increases in fire activity in California would likely remain well within the historical range of the past several centuries.

The Plan cites Hurteau et al. (2014) to support the statement that wildfire emissions will increase under climate change scenarios: "Using 1970 as a reference period, by 2085 emissions from wildfires are expected to increase between 24% and 56% on average, depending on the global emissions rate [Hurteau et al. 2014]."[125] However, this passage from the Plan incorrectly implies that this would necessarily equate to our forests being a net source of carbon emissions, rather than a sink, failing to recognize that as fires burn in forests they also cycle nutrients needed to maintain productivity, and stimulate growth and, therefore, carbon sequestration and storage.

L. The Plan must recognize the distinction between emissions from forest fire and anthropogenic sources of climate pollutants in its call to reduce black carbon and GHGs.

The Plan states that one of the goals of the Forest Carbon Plan is reduce black carbon and GHGs from wildfires in California's forests.[126] At a fundamental level, the Plan fails to adequately recognize the distinction between emissions from forest fire, which is a natural process, compared to anthropogenic sources of climate pollution. Wildfire is a natural and necessary component of California's forest ecosystems, with many critical functions for diversity and wildlife. It would be a misunderstanding of the science and nature of forest and fire dynamics to approach emissions from these natural processes in the same context as anthropogenic emissions from smokestacks, bioenergy and pile burning, which are discretionary activities under direct human control. As detailed above, California's forests are experiencing a fire deficit in comparison to historic levels, and actions to reduce fire activity will contribute to the continued degradation of California's forest ecosystems.

The Plan further states that black carbon emissions from wildfire will be estimated using the inventory methods developed by ARB.[127] However, the Plan fails to acknowledge the difficulty and uncertainty in estimating black carbon emissions from wildfires, which limit ARB's inventory methods and estimates. The Plan also fails to provide the full context of emissions from wildfire, resulting in the misleading impression that reducing wildfires will result in substantial climate benefits. This conclusion is not supported by the scientific literature. These deficiencies are further explained in Appendix B.

Finally, the Plan does not explain what statutory authority CalFIRE has to regulate black carbon emissions from wildfire. Consideration of wildfire black carbon emissions was moved to

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[125] Plan at 18.

[126] Plan at 24: "California's overarching climate goals for forests are to … (b) minimize the GHG and black carbon emissions associated with … wildfire events"; Plan at 22: "Because reducing black carbon from wildfire could contribute to meeting California's climate goals, it is important to address this gap moving forward."

[127] Plan at 45.

the Plan from ARB's Short-Lived Climate Pollutant Strategy ostensibly because the statute authorizing preparation of that strategy limited its applicability to "anthropogenic" black carbon emissions. (Health & Safety Code § 39730.5(a).) The Plan claims to be a detailed implementation measure for the Scoping Plan prepared pursuant to AB 32, but black carbon is not a "greenhouse gas" as defined in AB 32 (Health & Safety Code § 38505(g)), and thus is not directly relevant to the "greenhouse gas emissions limit" established by AB 32 or the longer-term "greenhouse gas emissions reductions" required under SB 32. (*Id.*, §§ 38550, 38566). Absent some source of statutory authority, it is not clear CalFIRE can undertake to regulate natural, non-anthropogenic black carbon emissions through this Plan or otherwise.

M. The Plan should recognize the ecological importance of complex early seral forest habitat created by high-severity fire.

Section 8.5 of the Plan on "Wildlife Habitat" should discuss the importance of the biodiverse, ecologically significant, and unique "complex early seral forest" (also called "snag forest habitat") created by high-severity fire. Hundreds of scientific studies document the high levels of native biodiversity and wildlife abundance in complex early seral forest created when patches of high-severity fire occur in mature conifer forest (and where this unique wildlife habitat not been subjected to common post-fire management, such as post-fire logging and artificial tree planting, and herbicide spraying).[128] Many of the native wildlife species found in complex early seral forest are primarily or almost exclusively found in such habitat, due to the high abundance of snags (standing dead trees) and downed logs and/or the abundance of shrub patches and young natural regeneration of conifers and oaks.[129] Complex early seral forests created by high-severity fire support some of the highest levels of native biodiversity found in temperate conifer forests. A sampling of studies on the ecological importance of complex early seral forest habitat is provided in Appendix C.

N. The Plan misrepresents current scientific understanding of wildfire effects on the California spotted owl.

Section 8.5 regarding "Wildlife Habitat" focuses mainly on one subspecies, the California spotted owl, and mainly on one study, Jones et al. (2016), to portray high-severity fire as a threat to spotted owls and other wildlife species. However, at least nine prior studies of spotted owls and fire came to different conclusions, including findings that spotted owls forage in severely burned, unlogged stands[130]; spotted owls use post-fire habitat following a very large

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[128] See review in DellaSala, D.A. and C.T. Hanson (eds). 2015. The ecological importance of mixed-severity fires: nature's phoenix. Elsevier, United Kingdom.

[129] *Id.*

[130] Bond, M.L. et al. 2009. Habitat use and selection by California Spotted Owls in a postfire landscape. Journal of Wildlife Management 73: 1116-1124; Bond, M.L. et al. 2016. Foraging habitat selection by California spotted owls after fire. Journal of Wildlife Management 80: 1290-1300; Comfort, E.J. et al. 2016. Quantifying edges as gradients at multiple scales improves habitat selection models for northern spotted owl. Landscape Ecology 31: 1227-1240.

fire (Rim Fire)[131]; breeding site occupancy rates are not different between mixed-severity burned and unburned sites[132]; and mixed-severity fire does not reduce survival or reproduction.[133]

The Plan mentions only two of these studies, and when it does, it misrepresents their results. The Plan states that "post-fire extinction rates in areas of low severity burning – that which would be characteristic of prescribed fire – was estimated to be zero,"[134] citing Roberts et al. (2011) and Lee et al. (2012). However, both of those studies actually found mixed-severity fire (rather than just low-severity fire) had no effect on occupancy. Omitting this larger point is misleading. Moreover, the draft plan makes no mention of the overall findings of Lee et al. (2012) which contradict the Plan's claims about large fires as a threat to owls. Lee at al. (2012) studied the effects of numerous fires in the Sierra Nevada (not just one fire, as with Jones et al.) and found that severe fires that burned owl core areas throughout the Sierra Nevada did not reduce site occupancy.[135]

A more representative analysis of the scientific literature regarding spotted owls and fire would, for example, would note the conclusions of Lee and Bond (2015) that "[o]ur findings add to the growing body of research that fire, even high-severity fire, is not a major threat to the persistence of California Spotted Owls in the Sierra Nevada… In contrast to fire, multiple studies show that logging is detrimental to this declining subspecies (Seamans and Gutierrez 2007, Tempel et al. 2014), even when the largest trees and a minimum of 40% canopy cover is retained (Stephens et al. 2014)."[136] The latter point is particularly notable in that it shows the harms to spotted owls that could result from the types of thinning/logging promoted by the draft plan.

Moreover, the study cited by the Plan, Jones et al. (2016), mischaracterizes its own results. For example, the study area had experienced many years of decreasing occupancy prior to the fire, most likely related to logging in the region; the level of decreased occupancy in the year after fire was not significantly different from the previous 10 years of decrease prior to the fire.[137]

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[131] Lee, D.E. and M.L. Bond. 2015. Occupancy of California spotted owl sites following a large fire in the Sierra Nevada, California. The Condor 117: 228-236.

[132] Jenness, J.S. et al. 2004. Associations between forest fire and Mexican spotted owls. Forest Science 50: 765-772; Roberts, S.L., et al. 2011. Effects of fire on spotted owl site occupancy in a late-successional forest. Biological Conservation 144: 610-619; Lee, D.E. et al. 2012. Dynamics of breeding –season site occupancy of the California spotted owl in burned forests. Condor 114: 792-802.

[133] Bond, M.L. et al. 2002. Short-term effects of wildfires on spotted owl survival, site fidelity, mate fidelity, and reproductive success. Wildlife Society Bulletin 30: 1022-1028; Jenness, J.S. et al. 2004 (see footnote 132); Tempel, D.J. et al. 2014. Effects of forest management on California Spotted Owls: implications for reducing wildfire risk in fire-prone forests. Ecological Applications 24: 2089-2106.

[134] Plan at 95.

[135] Lee, D.E. et al. 2012 (see footnote 132).

[136] Lee, D.E. and M.L. Bond. 2015 at 234 (see footnote 131).

[137] *Id. at* Figure 3.

The fire-owl claims in the wildlife habitat section of the Plan cite one other source, Stephens et al. (2016), which projects that all California spotted owl habitat could be lost to fire in 75 years, but this projection is derived from a methodology that does not account for the recruitment of new owl nesting habitat during that time period. When similar claims were made about fire as a projected threat to the closely related northern spotted owl, they were shown to be erroneous.[138] Similarly, claims about the loss of mature forest habitat due to fire in the Sierra Nevada are overstated; Odion and Hanson (2013) found that even if the amount of higher severity fire doubled from current levels, it would have almost no effect on mature forests. [139]

Furthermore, Odion and Hanson (2013) showed that logging/thinning, akin to what is proposed in the draft plan, would be detrimental to black-backed woodpeckers; "a scenario based on thinning 20 percent of mature forests over a 20 year period, and post-fire logging in 33% of potential habitat created by fire, reduced the amount of primary habitat after 27 years to 30% of the amount that would occur without these treatments."[140] Likewise, in their 2016 study, Hanson and Odion (2016) concluded that "[o]ur results also indicate that current plans by the US Forest Service to create, though logging, a landscape dominated by open pine forests, maintained by lower-severity fire would result in novel, overly homogenous conditions that could exacerbate risks to California Spotted Owls and Pacific Fishers."[141]

As discussed previously, the Plan overlooks a large body of scientific research showing that a wide variety of animal species use and benefit from the complex early seral forest habitat created by high-severity fires. The recommendations for increased logging/thinning ostensibly to reduce fire amount and/or severity would be detrimental to these species in two ways. First, there are direct harms to wildlife habitat from logging. Second, if the logging achieves its stated fire-reduction goals, it would harm wildlife by reducing the amount of complex early seral forest habitat. This outcome is particularly troubling given that complex early seral forests have some of the highest abundance and diversity of wildlife of any forest habitat in California, and yet this is currently one of rarest forest habitat types in California due to the effects of logging and fire suppression.

A robust analysis of the effects on wildlife habitat related to the Plan should thoroughly incorporate research on the ecological benefits of unlogged complex early forests for wildlife and current dearth of that habitat type in California due to a shortage of high-severity fire effects. A robust analysis should also thoroughly incorporate scientific studies about potential harms to wildlife from logging/thinning, both through the direct harms to wildlife habitat from tree

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[138] Hanson, C.T., D.C. Odion, D.A. DellaSala, and W.L. Baker. 2009. Overestimation of fire risk in the Northern Spotted Owl Recovery Plan. Conservation Biology 23: 1314–1319; Hanson, C.T. et al. 2010. More-comprehensive recovery actions for Northern spotted owls in dry forests: reply to Spies et al. Conservation Biology 24: 334-337.

[139] Odion, D.C. and C.T. Hanson. 2013. Projecting impacts of fire management on a biodiversity indicator in the Sierra Nevada and Cascades, USA: the black-backed woodpecker. The Open Forest Science Journal 6: 14-23.

[140] *Id.* at 14.

[141] Hanson, C.T. and D.C. Odion. 2016 at 17-18 (see footnote 90).

removal and also through reductions in the creation of new complex early seral habitat due to fire-reduction efforts.

O. The Plan does not provide an adequate basis for regional planning; regional plans not based on a solid understanding of forest science would be highly likely to degrade forest ecological health and carbon storage.

The Plan recommends the use of local "collaborative processes" to develop "regional plans" that would "prioritize implementation of forest health protection and management and restoration practices"[142] However, for all the reasons stated above, the Plan cannot serve as a basis or guiding document for regional plans, as the Plan does not provide clear management objectives based on the best available science. Local governments, communities, and landowners must of course be included in the planning of local projects and, especially, home defense treatments, and should have extensive input into implementation, but the Plan cannot simply delegate to communities the responsibility to develop objectives and priorities that the Plan has failed to adequately understand and define.

P. Recommendations for forest management alternatives

We recommend that the Plan propose actions that truly increase the resilience and ecosystem health of California's forests by restoring forest heterogeneity and complexity through working with fire instead of against it, and supporting biodiversity and ecological functions of intact forests while promoting long-term carbon storage and sequestration. Key actions include (1) moving away from fire suppression and large-scale forest thinning policies and toward restoring natural mixed-severity fire regimes and other natural disturbance processes; (2) reducing forest degradation (logging/thinning) and keeping more biomass in the forest by reducing logging levels and lengthening harvest rotations on private lands and national forest; and (3) avoiding deforestation through land conservation.

1. Move away from fire suppression and large-scale forest thinning policies and toward restoring natural fire regimes and other natural disturbance regimes.

The Plan acknowledges that fire is a "natural and critical component" of California's forest ecosystems[143] and that the "ecosystems of these forests have adapted to fire as a primary source of disturbance.[144] The Plan then clearly establishes that many forests have a shortage of fire because of past and ongoing fire suppression.[145] However, rather than proposing to move away from a continued policy of fire suppression in California's forests, the Plan states that a top

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[142] Plan at 35.
[143] Plan at 9.
[144] Plan at 47.
[145] Plan at 10.

priority is to further reduce the extent and intensity of wildfires.[146] The Plan would thus exacerbate, not alleviate, the negative effects of fire suppression it identifies.

Restoring forest health and increasing forest resilience requires reestablishing the natural ecological disturbances that forests and wildlife evolved with. Wildlife evolved with mixed-severity fire, not mechanical treatments. Forest health is therefore best achieved through management that seeks to put mixed-severity fire back on the landscape (such as via managed wildland fire). For example, mixed-severity fire regimes are the predominant fire regime for the ponderosa pine and mixed conifer forests in California. Managers who want to integrate biodiversity conservation and climate adaptation with responsible fire management should recognize the vital role of variation in fire severity in maintaining successional diversity and fire-dependent biota, and should allow natural rates of ecological succession. These effects have generally diminished. As a result, more fire, including high-severity fire where it is in deficit, is an ecologically desirable goal.

Mechanical thinning, on the other hand, does not mimic natural wildlfire and can reduce the value of mature forest habitat by reducing structural complexity, which many rare wildlife species preferentially select. The Plan should be especially careful about the pressures to promote commercial logging under the guise of "restoration" or "resiliency." In this regard, we are reminded of Six et al.'s cautionary note regarding logging to prevent beetle outbreaks:

> That pressure, to "do something", might also interact with the uncertainty about which choices are effective and appropriate (as with beetle timber harvest treatments) to create an opportunity for political pressures to force the adoption of particular choices that benefit specific interest groups [143]. It is perhaps no accident that the beetle treatments that have been most aggressively pushed for in the political landscape allow for logging activities that might provide revenue and jobs for the commercial timber industry. The result is that the push to "do something," uncertainty, and political pressures might lead us to act to respond to climate change before we understand the consequences of what we are doing, in the end producing more harm than good.

At present the Plan has one short paragraph on potential use of prescribed and managed fire as a restoration tool.[147] The Plan must develop a clear review of the best available and most recent science on the use of wildfire as an ecosystem function and management tool. The Plan should include proposed actions for the restoration of wildfire, such as managed wildland fire in which land managers make a decision to allow lightning-caused fires to burn, with the desired ecological condition of creating mixed-severity fire effects in order to enhance natural heterogeneity and benefit wildlife. The Plan should incorporate the numerous scientific studies showing that areas that have missed multiple fire returns still burn mostly at low and moderate

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[146] Plan at 26: "Wildfire is the single largest source of carbon storage loss and GHG emissions from forested lands…Reducing the intensity and extent of these fires is therefore a top priority."

[147] Plan at 41.

severity, so it is often not necessary to thin a forest prior to restoring mixed-severity fire to these forests. In this context, thinning is unnecessary, expensive, carbon-emitting, and should not be used as a precondition to delay the restoration of mixed-severity fire to forest ecosystem through managed wildland fire and prescribed mixed-severity fire.

Hand-in-hand with restoring wildfire to California's forests, the Plan should propose actions to create fire-safe communities in forested areas. The best available science shows that California's forests need more fire, and California's forest-adjacent communities should therefore make preparations to safely coexist with more fire. Scientific studies indicate that the only effective way to protect structures from fire is to reduce the ignitability of the structure itself (e.g., fireproof roofing, leaf gutter guards) and the immediate surroundings within about 100 feet from each home, e.g., through thinning of brush and small trees adjacent to the homes (Cohen 2000, Cohen and Stratton 2008, Gibbons et al. 2012).[148] Only 3% of Forest Service "fuels reduction" projects are conducted within the WUI, adjacent to communities – and much of that 3% is well over 100 feet from homes (Schoennagel et al. 2009).[149] Efforts to promote large-scale thinning in areas far away from buildings are often wasteful, expensive, inefficient, carbon-releasing, ecologically-damaging, and relatively ineffective, compared to efforts that focus on buildings and the defensible space in their immediate vicinity. The Plan will be more cost-efficient, most effective, and better for carbon storage if it focuses on home safety work in the defensible space zone.

2. Reduce forest degradation from commercial logging and mechanical thinning, reduce forest conversion, and maintain and increase forest biomass within forest ecosystems.

The Plan should expand and amplify the forest protection actions listed on pages 24-25 to limit the rate of forest conversion and degradation, with a clear goal of halting deforestation and reversing historic trends of forest loss and degradation. Important actions include increasing habitat connectivity and decreasing fragmentation from logging to facilitate species movements; protecting forest ecosystems across environmental gradients, including north-south gradients and elevational gradients; identifying and protecting habitat that is likely to become critical habitat in the future as species' ranges shift in response to climate change; and maintaining roadless areas to preserve existing connectivity and refugia.

On public lands, managed wildland fire and prescribed fire should be prioritized over thinning on public lands. Where logging occurs, such as on private lands, carbon storage can be increased by using longer harvest rotations, avoiding clearcutting and other intensive forms of

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[148] Cohen, J.D. 2000. Preventing disaster: home ignitability in the Wildland-Urban Interface. Journal of Forestry 98: 15-21; Cohen, J.D., and R.D. Stratton. 2008. Home destruction examination: Grass Valley Fire. U.S. Forest Service Technical Paper R5-TP-026b. U.S. Forest Service, Region 5, Vallejo, CA; Gibbons, P. et al. 2012. Land management practices associated with house loss in wildfires. PLoS ONE 7: e29212.

[149] Schoennagel, T. et al. 2009. Implementation of National Fire Plan treatments near the wildland-urban interface in the western United States. PNAS 106: 10706-10711.

tree removal, retaining larger trees, and reducing the amount harvested to allow forests to accumulate more carbon (Law and Harmon 2011). For example, in the Pacific Northwest, one study estimated that the current carbon storage on forest land is half of the potential, and it could increase by 15% over the next several decades if allowed to grow and accumulate carbon (Hudiberg et al. 2009). Another study found that logging is the second largest source of greenhouse emissions in Oregon (Talberth et al., 2015). The potential increase is estimated to be greatest on private lands because of the younger age classes that currently exist in private ownership (Law and Harmon 2011). Overall, rather than promoting logging and further loss of carbon from forest ecosystems, the Plan should prioritize the opportunities to keep forest carbon/biomass circulating within forest ecosystems.

II. CalFIRE cannot approve the Plan without first complying with CEQA.

The Plan is clearly a "project" for purposes of California Environmental Quality Act ("CEQA"), Public Resources Code § 21000 et seq., and the CEQA Guidelines, title 14, California Code of Regulations, § 15000 et seq. To our knowledge, however, neither CalFIRE nor any other agency undertaken to comply with CEQA in connection with preparation and review of the Plan. Accordingly, no agency may approve, or otherwise take any steps toward implementation of, the Plan until CEQA compliance is completed.

A. The Plan is a "project" for purposes of CEQA

1. Legal Background

The Legislature enacted CEQA to "[e]nsure that the long-term protection of the environment shall be the guiding criterion in public decisions." *No Oil, Inc. v. City of Los Angeles*, 13 Cal. 3d 68, 74 (1974). The Supreme Court has repeatedly held that CEQA must be interpreted to "afford the fullest possible protection to the environment." *Wildlife Alive v. Chickering*, 18 Cal. 3d 190, 206 (1976) (quotation omitted).

CEQA also serves "to demonstrate to an apprehensive citizenry that the agency has, in fact, analyzed and considered the ecological implications of its action." *Laurel Heights Improvement Ass'n v. Regents of Univ. of Cal.*, 47 Cal. 3d 376, 392 (1988) ("*Laurel Heights I*"). If CEQA is "scrupulously followed," the public will know the basis for the agency's action and "being duly informed, can respond accordingly to action with which it disagrees." *Id.* Thus, CEQA "protects not only the environment but also informed self-government." *Id.*

CEQA applies to all "discretionary projects proposed to be carried out or approved by public agencies." Pub. Res. Code § 21080(a). Accordingly, before taking any action, a public agency must conduct a "preliminary review" to determine whether the action is a "project" subject to CEQA. *See Muzzy Ranch Co. v. Solano County Airport Land Use Comm'n*, 41 Cal. 4th 372, 380 (2007).

A "project" is "the whole of an action" directly undertaken, supported, or authorized by a public agency "which may cause either a direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment." Pub. Res. Code § 21065; CEQA Guidelines § 15378(a). Under CEQA, "the term 'project' refers to the underlying activity and not the governmental approval process." *California Unions for Reliable Energy v. Mojave Desert Air Quality Mgmt. Dist.*, 178 Cal. App. 4th 1225, 1241 (2009) (quoting *Orinda Ass'n v. Bd. of Supervisors*, 182 Cal. App. 3d 1145, 1171-72 (1986)). The definition of "project" is "given a broad interpretation in order to maximize protection of the environment." *Lighthouse Field Beach Rescue v. City of Santa Cruz*, 131 Cal. App. 4th 1170, 1180 (2005) (internal quotation omitted). A project need not even involve tangible physical activity so long as the agency's discretionary action has the potential to lead to either a direct or a reasonably foreseeable indirect physical change in the environment. *See Communities for a Better Env't v. Cal. Res. Agency*, 103 Cal. App. 4th 98, 126 (2002) ("Governmental organizational activities, such as annexation approvals and school district reorganizations, which constitute an essential step culminating in an environmental effect are 'projects' within the scope of CEQA."); *see also, e.g.*, *Muzzy Ranch*, 41 Cal. 4th at 382-83; *Fullerton Joint Union High Sch. Dist. v. State Bd. of Educ.*, 32 Cal. 3d 779, 796-97 (1982); *Bozung v. Local Agency Formation Comm'n*, 13 Cal. 3d 263, 277-81 (1975).

CEQA requires the preparation of environmental review documents "as early as feasible in the planning process to enable environmental considerations to influence project program and design and yet late enough to provide meaningful information for environmental assessment." *Laurel Heights I*, 47 Cal.3d at 395; *see also* CEQA Guidelines § 15004(b). The purpose of CEQA is to provide decision-makers and the public with environmental information before decisions are made, not after. As the California Supreme Court observed in *Laurel Heights I*, "[i]f post-approval environmental review were allowed, [CEQA analyses] would likely become nothing more than *post hoc* rationalizations to support action already taken. We have expressly condemned this [practice]." 47 Cal. 3d at 394 (citation omitted).

Moreover, "public agencies shall not undertake actions concerning the proposed public project that would have a significant adverse effect or limit the choice of alternatives or mitigation measures, before completion of CEQA compliance." CEQA Guidelines § 15004(b)(2). In particular, an agency shall not "take any action which gives impetus to a planned or foreseeable project in a manner that forecloses alternatives or mitigation measures that would ordinarily be part of CEQA review of that public project." CEQA Guidelines § 15004(b)(2)(B). CEQA review must be completed while environmental considerations still can inform CalFIRE's (or any other agency's) decision, and *before* any agency takes any step that forecloses any potential mitigation measures or alternatives. *Laurel Heights I*, 47 Cal.3d at 394-95; CEQA Guidelines § 15004(b)(2)(B). It does not matter for purposes of CEQA that other public agencies also may need to render some later decision with regard to Plan implementation. *See Fullerton Joint Union High Sch. Dist. v. State Bd. of Educ.*, 32 Cal. 3d 779, 795 (1982). Rather, environmental review must accompany a public agency's *earliest* commitment to a course of action, taking into account bureaucratic momentum; "CEQA review may not always be postponed until the last governmental step is taken." *Save Tara v. City of West Hollywood*, 45 Cal. 4th 116, 134-35 (2008).

2. The Plan is a discretionary "project" pursuant to CEQA.

Any action to approve or otherwise implement the Plan would clearly be "discretionary" for purposes of CEQA. CEQA applies to projects of a discretionary, rather than a ministerial, character. Pub. Res. Code § 21080. A discretionary action is one that "requires the exercise of judgment or deliberation" on the part of a public agency in deciding whether "to approve or disapprove a particular activity." CEQA Guidelines § 15357; *see also Mountain Lion Foundation v. Cal. Fish & Game Comm'n*, 16 Cal. 4th 105, 112 (1997) (defining discretionary projects as projects "subject to 'judgmental controls,' i.e., where the agency can use its judgment in deciding whether and how to carry out the project"). A "ministerial" decision, in contrast, "involves only the use of fixed standards or objective measurements" without any exercise of judgment. CEQA Guidelines § 15369 (citing "automobile registrations, dog licenses, and marriage licenses" as examples). Doubts should be resolved in favor of a finding that decisions are discretionary, and where a project is of a hybrid discretionary and ministerial character, CEQA applies even if the project is largely ministerial. CEQA Guidelines § 15268(d); *Friends of Westwood v. City of L.A.* 191 Cal. App. 3d 259, 271-72 (1987).

Here, CalFIRE or another agency would necessarily exercise a great deal of discretionary judgment in approving or carrying out the Plan. Its significant flaws notwithstanding, the Plan purports to review applicable science, weigh evidence, and propose a series of concrete actions to achieve particular conditions. These are hallmarks of discretionary decision-making. *See, e.g.*, *Mountain Lion Foundation*, 16 Cal. 4th at 115, 118.

The Plan also clearly may cause both direct and reasonably foreseeable indirect changes in the physical environment. Pub. Res. Code § 21065; CEQA Guidelines § 15378(a). Indeed, one core objective of the Plan is to increase logging and other forest management "treatments" on non-federal land subject to CalFIRE's jurisdiction.[150] The stated purpose of these treatments is to alter the physical condition of the forest. Beyond this clear purpose, implementation of the Plan may foreseeably cause other environmental impacts, including damage to habitat, water quality, and soil resources from logging, as well as increased greenhouse gas emissions from removal of forest carbon stocks, bioenergy and biofuels production, and wood products processing. The Plan thus meets CEQA's definition of a "project," and it may not be approved or carried out until environmental analysis in accordance with CEQA is complete.

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[150] Plan at 3 (proposing to double acres treated annually by 2020 and nearly quadruple acres treated annually by 2030).

B. There is no evidence that CalFIRE or any other agency has complied with CEQA in connection with the Plan.

There is no indication that CalFIRE, ARB, or any other public agency has even begun to undertake CEQA compliance in connection with the Plan. Nothing on CalFIRE's Forest Carbon Action Team website—where the Plan is available—discusses CEQA compliance.[151]

Nor does any other agency appear to have taken responsibility for CEQA compliance. The Plan states that it is intended to be "the detailed implementation plan for the forest carbon goals embodied in the 2030 Target Scoping Plan Update."[152] The Draft Environmental Analysis for the Scoping Plan, however, does not refer to the "Forest Carbon Plan" at all. Nor does the Plan appear among the "known commitments" and "additional measures" that "compose the proposed 'project' for purposes of [CEQA] analysis."[153] Nor does the Final EA for the Short-Lived Climate Pollutant Reduction Strategy address aspects of the Plan intended to reduce black carbon emissions from wildfire; on the contrary, in keeping with legislative direction, the Final EA addresses only anthropogenic black carbon emissions.[154]

C. CalFIRE's failure to conduct CEQA analysis is prejudicial

As discussed above, CEQA's core purposes include ensuring that both decision-makers and the public have detailed information about the environmental effects of proposed projects in hand before decisions affecting the environment are made. CEQA also requires that a range of reasonable alternatives to a proposed action be considered, and that significant environmental effects be avoided or lessened to the extent feasible, in connection with any approved project.

CalFIRE's failure to conduct CEQA review of the Plan thwarts these core purposes and requirements. For example, CEQA requires CalFIRE to disclose and analyze all potentially significant environmental effects of the Plan, and to adopt mitigation measures to avoid or

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[151] CalFIRE, Forest Climate Action Team (FCAT) webpage, http://www.fire.ca.gov/fcat/ (visited March 17, 2017).

[152] Plan at 7. The 2030 Target Scoping Plan, however, does not state this so directly; rather, it states that "the State will complete an Integrated Natural and Working Lands Climate Change Action Plan by 2018." 2030 Target Scoping Plan at 115. The relationship, if any between this as-yet-undeveloped plan and the Forest Carbon Plan is unclear. Indeed, the proposed Scoping Plan mentions the "Forest Carbon Plan" only four times: it describes a "broad tapestry" of "other climate-oriented plans and strategies," including the Forest Carbon Plan , *id.* at ES7; it states that the Scoping Plan was developed "in close coordination" with "other State agency plans," including the Forest Carbon Plan, *id.* at 7; it lists "Complete and implement the Forest Carbon Plan" among several other "Scoping and Tracking Progress" items in the Natural and Working Lands Sector, *id.* at 117; and it mentions the Plan in connection with black carbon reduction activities removed from the Short Lived Climate Pollutants Strategy. *Id.* at 14 n.28.

[153] California Air Resources Board. 2017. Appendix F: Draft Environmental analysis for the Proposed Strategy for Achieving California's 2030 Greenhouse Gas Target at 11-12 (January 20, 2017).

[154] California Air Resources Board. 2017. Final Environmental Analysis for the Revised Short-Lived Climate Pollutant Reduction Strategy at 2-5 (March 14, 2017), available at https://www.arb.ca.gov/cc/shortlived/meetings/03142017/appendixe.pdf (visited March 14, 2017).

reduce those effects, before approving or carrying out the Plan. Pub. Res. Code §§ 21002, 21002.1, 21081. Numerous "research questions" identified in the Plan—including questions concerning carbon accounting methodologies, inventories, projections of carbon storage under various treatment scenarios, and the atmospheric effects and interactions between black and brown carbon[155]—are exactly the kinds of questions that must be answered before the Plan is approved, in connection with CEQA analysis, not after the decision to carry out the plan has already been made. Finally, CEQA requires CalFIRE to consider alternatives to the approach proposed in the Plan, including but not limited to alternatives discussed in Part I of these comments.

For all of the foregoing reasons, any steps to approve or carry out any aspect of the Plan absent CEQA compliance would be unlawful and would constitute a prejudicial abuse of discretion.

III. Conclusion

Because the Plan fails to rely on the best available science, and instead relies on assumptions and preconceptions that lack empirical support, its recommendations will likely fail to achieve its aims while causing substantial damage to forest resources and habitat in California. The FCAT should withdraw the Plan; undertake a new review of the entire body of relevant scientific information (including the numerous studies discussed herein); complete the essential research tasks that should be performed *before* such a Plan is prepared, not after; and fully comply with CEQA and other applicable laws before taking any further steps to approve or implement the Plan.

Thank you for your consideration of our comments.

Sincerely,

Shaye Wolf, Ph.D.
Climate Science Director
Kevin Bundy
Senior Attorney
Brian Nowicki
California Climate Policy Director
Center for Biological Diversity

Marily Woodhouse
Director
Battle Creek Alliance/
Defiance Canyon Raptor Rescue

Denise Boggs
Executive Director
Conservation Congress

Susan Robinson
Vice President
Ebbetts Pass Forest Watch

(additional signatories on next page)

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[155] See Plan at 5.

Gary Graham Hughes
Senior California Advocacy Campaigner
Friends of the Earth — US

Dominick DellaSala, Ph.D.
President and Chief Scientist
Geos Institute

Chad Hanson, Ph.D.
Ecologist
John Muir Project of Earth Island Institute

Jeff Kuyper
Executive Director
Los Padres Forest Watch

Ara Marderosian
Executive Director
Sequoia ForestKeeper

Kathryn Phillips
Director
Sierra Club California

Derek Lee, Ph. D.
Principal Scientist
Wild Nature Institute

<u>Enclosures</u>:

List of References cited in letter and appendix
(PDF copies to be provided on CD under separate cover due to file size limitations)
Appendix A: Studies demonstrating that California's mixed conifer forests are characterized by a mixed severity fire regime
Appendix B: Black carbon emissions and consequent climate impacts of wildfire are inadequately characterized
Appendix C: Studies demonstrating the ecological importance of complex early seral forest habitat created by high-severity fire

Center for Biological Diversity, et al., Comments on Forest Carbon Plan

List of References

Ascent Environmental. 2012. Cabin Creek Biomass Facility Project Draft Environmental Impact Report, App. D (July 27, 2012)

Baker, W. L. 2014. Historical forest structure and fire in Sierran mixed-conifer forests reconstructed from General Land Office survey data. Ecosphere 5:79

Baker, W.L. 2015. Are high-severity fires burning at much higher rates recently than historically in dry-forest landscapes of the Western USA? PLoS ONE 10(9): e0136147

Beesley, D. 1996. Reconstructing the landscape: an environmental history, 1820-1960. In Sierra Nevada Ecosystem Project: final report to Congress. Vol. II. Assessments and scientific basis for management options. Centers of Water and Wildland Resources, Davis, Calif. Pp. 1-24

Bird, D.N. et al. 2011. Zero, one, or in between: evaluation of alternative national and entity-level accounting for bioenergy. Global Change Biology Bioenergy 4: 576-587

Black, S.H. et al. 2013. Do bark beetle outbreaks increase wildfire risks in the Central U.S. Rocky Mountains: Implications from Recent Research. Natural Areas Journal 33: 59-65

Bond, M.L. et al. 2002. Short-term effects of wildfires on spotted owl survival, site fidelity, mate fidelity, and reproductive success. Wildlife Society Bulletin 30: 1022-1028

Bond, M.L. et al. 2009. Habitat use and selection by California Spotted Owls in a postfire landscape. Journal of Wildlife Management 73: 1116-1124

Bond, M.L. et al. 2009. Influence of pre-fire tree mortality on fire severity in conifer forests of the San Bernardino Mountains, California. The Open Forest Science Journal 2: 41-47

Bond, M.L. et al. 2016. Foraging habitat selection by California spotted owls after fire. Journal of Wildlife Management 80: 1290-1300

Booth, Mary S. 2014. Trees, Trash and Toxics: How biomass energy has become the new coal. Partnership for Policy Integrity (April 2, 2014)

CalFire, Forest Climate Action Team (FCAT) webpage, http://www.fire.ca.gov/fcat/ (visited March 17, 2017)

California Air Resources Board. 2017. Appendix F: Draft Environmental analysis for the Proposed Strategy for Achieving California's 2030 Greenhouse Gas Target (January 20, 2017)

California Air Resources Board. Final Environmental Analysis for the Revised Short-Lived Climate Pollutant Reduction Strategy (March 14, 2017)

Campbell, J.L. and A.A. Ager. 2013. Forest wildfire, fuel reduction treatment, and landscape carbon stocks: a sensitivity analysis. Journal of Environmental Management 121: 124-132

Campbell, J.L. et al. 2012. Can fuel-reduction treatments really increase forest carbon storage in the western US by reducing future fire emissions? Frontiers in Ecology and the Environment 10: 83-90

Carnwath, G.C. and C.R. Nelson. 2016. The effect of competition on response to drought and interannual climate variability of a dominant conifer tree of western North America. Journal of Ecology 104: 1421-1431

Chiono, L.A. et al. 2017. Landscape-scale fuel treatment and wildfire impacts on carbon stocks and fire hazard in California spotted owl habitat. Ecosphere 8(1):e01648

Clark, J. et al. 2011. Impacts of Thinning on Carbon Stores in the PNW: A Plot Level Analysis, Final Report (Ore. State Univ. College of Forestry May 25, 2011)

Clyatt, K.A. et al. 2016. Historical spatial patterns and contemporary tree mortality in dry mixed-conifer forests. Forest Ecology and Management 361: 23-37

Cohen, J.D. 2000. Preventing disaster: home ignitability in the Wildland-Urban Interface. Journal of Forestry 98: 15-21

Cohen, J.D., and R.D. Stratton. 2008. Home destruction examination: Grass Valley Fire. U.S. Forest Service Technical Paper R5-TP-026b. U.S. Forest Service, Region 5, Vallejo, CA.

Collins, B.M. et al. 2009. Interactions among wildland fires in a long-established Sierra Nevada natural fire area. Ecosystems 12:114–128

Comfort, E.J. et al. 2016. Quantifying edges as gradients at multiple scales improves habitat selection models for northern spotted owl. Landscape Ecology 31: 1227-1240

Crotteau, J.S. et al. 2013. Post-fire regeneration across a fire severity gradient in the southern Cascades. Forest Ecology and Management 287: 103-112

D'Amato, A.W. et al. 2013. Effects of thinning on drought vulnerability and climate response in north temperate forest ecosystems. Ecological Applications 23: 1735-1742

DellaSala, D.A. and C.T. Hanson (eds). 2015. The ecological importance of mixed-severity fires: nature's phoenix. Elsevier, United Kingdom

DellaSala, D.A. and M. Koopman 2016. Thinning Combined with Biomass Energy Production Impacts Fire-Adapted Forests in Western United States and May Increase Greenhouse Gas Emissions. Reference Module in Earth Systems and Environmental Sciences

DellaSala, D.A. et al. 2014. Complex early seral forests of the Sierra Nevada: what are they and how can they be managed for ecological integrity? Natural Areas Journal 34:310-324

Dennison, P.E., Brewer, S.C., Arnold, J.D., and M.A. Moritz. 2014. Large wildfire trends in the western United States, 1984-2011. Geophysical Research Letters 41: 2928–2933

Depro, B.M. et al. 2008. Public land, timber harvests, and climate mitigation: Quantifying carbon sequestration potential on U.S. public timberlands. Forest Ecology and Management 255: 1122-1134.

Dillon, G.K., et al. 2011. Both topography and climate affected forest and woodland burn severity in two regions of the western US, 1984 to 2006. Ecosphere 2: Article 130

Doerr, S.H. and C. Santin. 2016. Global trends in wildfire and its impacts: perceptions versus realities in a changing world. Philosophical Transactions Royal Society B 371: 20150345.

Donato, D.C. et al. 2009. Vegetation response to a short interval between high-severity wildfires in a mixed-evergreen forest. Journal of Ecology 97: 142-154

Dore, Sabina et al. 2012. Recovery of ponderosa pine ecosystem carbon and water faluxes from thinning and stand-replacing fire. Global Change Biology 18: 3171-3185

EIA, Electric Power Annual, 2009: Carbon Dioxide Uncontrolled Emission Factors. (http://www.eia.gov/cneaf/electricity/epa/epat5p4.html)

Energy and Environment Daily, Clean Power Plan Hub, at http://www.eenews.net/interactive/clean_power_plan/states/california (visited May 18, 2016)

Fried, J.S. et al. 2004. The impact of climate change on wildfire severity: A regional forecast for northern California. Climatic Change 64 (1–2):169–191

Gibbons, P. et al. 2012. Land management practices associated with house loss in wildfires. PLoS ONE 7: e29212.

Golder Assoc. 2011. Air Construction Permit Application: Florida Crushed Stone Company Brooksville South Cement Plant's Steam Electric Generating Plant, Hernando County Table 4-1 (Sept. 2011)

Gunn, J., et al., Manomet Center for Conservation Sciences. 2010. Massachusetts Biomass Sustainability and Carbon Policy Study: Report to the Commonwealth of Massachusetts Department of Energy Resources.

Haire, S.L. and K. McGarigal. 2010. Effects of landscape patterns of fire severity on regenerating ponderosa pine forests (Pinus ponderosa) in New Mexico and Arizona, USA. Landscape Ecology 25: 1055-1069

Hanson, C.T. and D.C. Odion. 2015. Sierra Nevada fire severity conclusions are robust to further analysis: a reply to Safford et al. International Journal of Wildland Fire 24: 294-295

Hanson, C.T. and D.C. Odion. 2016. Historical forest conditions within the range of the Pacific fisher and spotted owl in the Central and Southern Sierra Nevada, California, USA. Natural Areas Journal 36: 8-19

Hanson, C.T. et al. 2015. Setting the stage for mixed- and high-severity fire. Chapter 1 in DellaSala, D.A., and C.T. Hanson (Editors). The ecological importance of mixed-severity fires: nature's phoenix. Elsevier Inc., Waltham, MA, USA

Hanson, C.T. et al. 2009. Overestimation of fire risk in the Northern Spotted Owl Recovery Plan. Conservation Biology 23: 1314–1319

Hanson, C.T. et al. 2010. More-comprehensive recovery actions for Northern spotted owls in dry forests: reply to Spies et al. Conservation Biology 24: 334-337

Hart, S.J. et al. 2015a. Area burned in the western United States is unaffected by recent mountain pine beetle outbreaks. PNAS 112: 4375-4380.

Hart, S.J. et al. 2015b. Negative feedbacks on bark beetle outbreaks: widespread and severe spruce beetle infestation restricts subsequent infestation. PLoS ONE 10(5): e0127975

Holtsmark, B. 2013. The outcome is in the assumptions: analyzing the effects on atmospheric CO2 levels of increased use of bioenergy from forest biomass. Global Change Biology Bioenergy 5: 467-473

Hudiburg, T.W. et al. 2011. Regional carbon dioxide implications of forest bioenergy production. Nature Climate Change 1: 419-423

Hurteau, M.D. & Malcolm North. 2010. Carbon recovery rates following different wildfire risk mitigation treatments. Forest Ecology and Management 260: 5 930-937

IPCC Task Force on National Greenhouse Gas Inventories, Frequently Asked Questions, http://www.ipcc-nggip.iges.or.jp/faq/faq.html (last visited October 23, 2013) (Q1-4-5, Q2-10).

Jenness, J.S. et al. 2004. Associations between forest fire and Mexican spotted owls. Forest Science 50: 765-772

John Muir Project, 8 February 2017, Comments to Little Hoover Commission

Keeling, E.G. et al. 2006. Effects of fire exclusion on forest structure and composition in unlogged ponderosa pine/Douglas-fir forests. Forest Ecology and Management 327: 418-428

Keeling, E.G. et al. 2011. Lack of fire has limited physiological impact on old-growth ponderosa pine in dry montane forests of north-central Idaho. Ecological Applications 21: 3227-3237

Knapp, P.A. et al. 2013. Mountain pine beetle selectivity in old-growth ponderosa pine forests, Montana, USA. Ecology and Evolution 3: 1141-1148

Krawchuk, M. A., and M. A. Moritz. 2012. Fire and Climate Change in California. California Energy Commission. Publication number: CEC-500-2012-026

Krawchuk, M.A. et al. 2009. Global pyrogeography: the current and future distribution of wildfire. PloS ONE 4: e5102

Kulakowski, D. et al. 2012. Stand-replacing fires reduce susceptibility of lodgepole pine to mountain pine beetle outbreaks in Colorado. Journal of Biogeography 39: 2052–60

Law, B.E. and M.E. Harmon. 2011. Forest sector carbon management, measurement and verification, and discussion of policy related to climate change. Carbon Management 2: 73-84

Lee, D.E. and M.L. Bond. 2015. Occupancy of California spotted owl sites following a large fire in the Sierra Nevada, California. The Condor 117: 228-236

Lee, D.E. et al. 2012. Dynamics of breeding –season site occupancy of the California spotted owl in burned forests. Condor 114: 792-802

Lenihan, J.M. et al. 2003. Climate change effects on vegetation distribution, carbon, and fire in California. Ecological Applications 13: 1667-1681

Lenihan, J.M. et al. 2008. Response of vegetation distribution, ecosystem productivity, and fire to climate change scenarios for California. Climate Change 87(Suppl. 1): S215-S230

Loehman, R.A. et al. 2014. Wildland fire emissions, carbon, and climate: Seeing the forest and the trees – A cross-scale assessment of wildfire and carbon dynamics in fire-prone, forested ecosystems. Forest Ecology and Management 317: 9-19

Marlon, J.R. et al. 2012. Long-term perspective on wildfires in the western USA. PNAS 109: E535–E543

McIntyre, P.J. et al. 2015. Twentieth-century shifts in forest structure in California: denser forests, smaller trees, and increased dominance of oaks. PNAS 112: 1458-1463

McKechnie, J. et al. 2011. Forest bioenergy or forest carbon? Assessing trade-offs in greenhouse gas mitigation with wood-based fuels. Environ. Sci. Technol. 45: 789-795

McKenzie, D. et al. 2004. Climatic change, wildfire, and conservation. Conservation Biology 18: 890-902

Meigs, G.W., et al. 2016. Do insect outbreaks reduce the severity of subsequent forest fires? Environmental Research Letters 11: 045008

Millar, C.I. et al. 2007. Response of high-elevation limber pine (Pinus flexilis) to multiyear droughts and 20th-century warming, Sierra Nevada, California, USA. Canadian Journal of Forest Research 37: 2508-2520

Millar, C.I. et al. 2012. Forest mortality in high-elevation whitebark pine (Pinus albicaulis) forests of eastern California, USA; influence of environmental context, bark beetles, climatic water deficit, and warming. Canadian Journal of Forest Research 41: 749-765

Miller, J.D. et al. 2012. Trends and causes of severity, size, and number of fires in northwestern California, USA. Ecological Applications 22: 184-203

Mitchell, S.R. et al. 2009. Forest fuel reduction alters fire severity and long-term carbon storage in three Pacific Northwest ecosystems. Ecological Applications 19: 643-655

Mitchell, S.R. et al. 2012. Carbon debt and carbon sequestration parity in forest bioenergy production. Global Change Biology Bioenergy 4: 818-827

Moritz, M. et al. 2012. Climate change and disruptions to global fire activity. Ecosphere 3 (6): 1-22

Mouillot, F. and C. Field. 2005. Fire history and the global carbon budget: a 1º x 1º fire history reconstruction for the 20th century. Global Change Biology 11: 398-420

Naficy, C. et al. 2010. Interactive effects of historical logging on fire exclusion on ponderosa pine forest structure in the northern Rockies. Ecological Applications 20: 1851-1864

Odion, D.C. and C.T. Hanson. 2006. Fire severity in conifer forests of the Sierra Nevada, California. Ecosystems 9: 1177-1189

Odion, D.C. and C.T. Hanson. 2008. Fire severity in the Sierra Nevada revisited: conclusions robust to further analysis. Ecosystems 11: 12-15

Odion, D.C. and C.T. Hanson. 2013. Projecting impacts of fire management on a biodiversity indicator in the Sierra Nevada and Cascades, USA: the black-backed woodpecker. The Open Forest Science Journal 6: 14-23.

Odion, D.C. et al. 2004. Patterns of fire severity and forest conditions in the Klamath Mountains, northwestern California. Conservation Biology 18: 927-936

Odion, D.C. et al. 2010. Alternative community states maintained by fire in the Klamath Mountains, USA. Journal of Ecology

Odion, D.C. et al. 2014. Examining historical and current mixed-severity fire regimes in Ponderosa pine and mixed-conifer forests of western North America. PLoS ONE 9(2): e87852

Parks, S.A. et al. 2015. Wildland fire deficit and surplus in the western United States, 1984-2012. Ecosphere 6: Article 275

Parks, S.A. et al. 2016. How will climate change affect wildland fire severity in the western US? Environmental Research Letters 11: 035002

Picotte, J.J. et al. 2016. 1984-2010 Trends in fire burn severity and area for the coterminous US. International Journal of Wildland Fire 25: 413-420

Purcell, K.L. et al. 2009. Resting structures and resting habitats of fishers in the southern Sierra Nevada, California. Forest Ecology and Management 258: 2696-706

Raphael, M.G. et al. 1987. Breeding bird populations during twenty-five years of postfire succession in the Sierra Nevada. The Condor 89: 614-626

Repo, A. et al. 2010. Indirect carbon dioxide emissions from producing bioenergy from forest harvest residues. Global Change Biology Bioenergy 3: 107-115

Restaino, J.C. and D.L. Peterson. 2013. Wildfire and fuel treatment effects on forest carbon dynamics in the western United States. Forest Ecology and Management 303: 46-60

Rhodes, J.J. and W.L. Baker. 2008. Fire probability, fuel treatment effectiveness and ecological tradeoffs in western U.S. public forests. Open Forest Science Journal 1: 1-7

Roberts, S.L., et al. 2011. Effects of fire on spotted owl site occupancy in a late-successional forest. Biological Conservation 144: 610-619

Schoennagel, T. et al. 2009. Implementation of National Fire Plan treatments near the wildland-urban interface in the western United States. PNAS 106: 10706-10711

Schulze, E.-D. et al. 2012. Large-scale bioenergy from additional harvest of forest biomass is neither sustainable nor greenhouse gas neutral. Global Change Biology Bioenergy 4: 611-616

Schwind, B. 2008. Monitoring trends in burn severity: report on the Pacific Northwest and Pacific Southwest fires (1984 to 2005). US Geological Survey

Searchinger, T.D. et al. 2009. Fixing a Critical Climate Accounting Error. Science 326: 527

Seidl, R. et al. 2016. Spatial variability in tree regeneration after wildfire delays and dampens future bark beetle outbreaks. PNAS 113: 13075-13080

Shatford, J.P.A. et al. 2007. Conifer regeneration after forest fire in the Klamath-Siskiyous: how much, how soon? Journal of Forestry, April/May: 139-146

Six, D.L. et al. 2014. Management for mountain pine beetle outbreak suppression: does relevant science support current policy? Forests 5: 103-133

Spracklen, D.V. et al. 2009. Impacts of climate change from 2000 to 2050 on wildfire activity and carbonaceous aerosol concentrations in the western United States. Journal of Geophysical Research 114: D20301

Steel, Z. L. et al. 2015. The fire frequency-severity relationship and the legacy of fire suppression in California forests. Ecosphere 6(1):8

Stephens, S.L. et al. 2007. Prehistoric fire area and emissions from California's forests, woodlands, shrublands and grasslands. Forest Ecology and Management 251: 205-216

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

Tan, Z. et al. 2015. Ecosystem carbon stocks and sequestration potential of federal lands across the conterminous United States. PNAS 112: 12723-12728

Tempel, D.J. et al. 2014. Effects of forest management on California Spotted Owls: implications for reducing wildfire risk in fire-prone forests. Ecological Applications 24: 2089-2106

U.S. Environmental Protection Agency Science Advisory Board. 2012. Science Advisory Board Review of EPA's Accounting Framework for Biogenic CO2 Emissions from Stationary Sources 7 (Sept. 28, 2012)

U.S. Environmental Protection Agency. Deferral for CO2 Emissions from Bioenergy and Other Biogenic Sources Under the Prevention of Significant Deterioration (PSD) and Title V Programs. 76 Fed. Reg. 43,490 (July 20, 2011)

U.S. Environmental Protection Agency. September 2011. Accounting Framework for Biogenic CO2 Emissions from Stationary Sources. Office of Atmospheric Programs Climate Change Division. Washington, DC

U.S. Forest Service and U.S. Geological Survey. 2014. Acreage of burn severity for the California Rim Fire, 2013

U.S. Forest Service and U.S. Geological Survey. 2015. Acreage of burn severity for the California King Fire, 2014

Underwood, E.C. et al. 2010. Using topography to meet wildlife and fuels treatment objectives in fire-suppressed landscapes. Environmental Management 46: 809-819

Van Gunst, K.J. et al. 2016. Do denser forests have greater risk of tree mortality: a remote sensing analysis of density-dependent forest mortality. Forest Ecology and Management 359: 19-32

van Wagtendonk, J.W. et al. 2012. Factors associated with the severity of intersecting fires in Yosemite National Park, California, USA. Fire Ecology 8: 11-32

Veblen, T.T. et al. 1994. Disturbance regime and disturbance interactions in a Rocky Mountain subalpine forest. Journal of Ecology 82: 125–35

Westerling, A. and B. Bryant. 2008. Climate change and wildfire in California. Climate Change 87: S231– S249

Westerling, A.L. et al. 2011. Climate change and growth scenarios for California wildfire. Climatic Change 109 (Suppl 1): S445-S463

Whitlock, C. et al. 2015. Climate Change: Uncertainties, Shifting Baselines, and Fire Management. Pp. 265-289 in The Ecological Importance of Mixed Severity Fires: Nature's Phoenix. D.A. DellaSala and C.T. Hanson, eds. Elsevier, Amsterdam, Netherlands

Zielinski, W.J. et al. 2006. Using forest inventory data to assess fisher resting habitat suitability in California. Ecological Applications 16: 1010-25

Appendix A

Studies demonstrating that California's mixed conifer forests are characterized by a mixed severity fire regime

Baker 2014: A reconstruction of historical forest structure and fire across 330,000 ha of Sierra Nevada mixed-conifer forests using data from 1865-1885 indicates that historical forests experienced mixed-severity fire over 43-48% of the land area, with high-severity fire over 31-39% and low-severity fire over 13-26%. The high-severity fire rotation was estimated at 281 years in the northern and 354 years in the southern Sierra, which contributed to high levels of heterogeneity, including abundant areas and large patches (up to 9,400 ha) of early successional forest and montane chaparral, as well as old-growth forest over large land areas. The author concluded that "[p]roposals to reduce fuels and fire severity would actually reduce, not restore, historical forest heterogeneity important to wildlife and resiliency."[1]

Beaty and Taylor 2001: On the western slope of the southern Cascades in Lassen National Forest, historical fire intensity in mixed-conifer forests was predominantly moderate- and high-intensity, except in mesic canyon bottoms and lower slopes. High-intensity fire was dominant on upper slopes (85.7% of fire effects), moderate on middle slopes (23.4% of fire effects), and low on lower slopes (5.8% of fire effects) [see Table 7].[2]

Beaty and Taylor 2008: In the western Lake Tahoe basin, the pre-fire suppression fire regime was spatially variable, with mixed-conifer forests on upper slopes shaped by high-severity fire, while forests on valley bottoms and lower slopes were more influenced by frequent low or moderate severity fire, creating "structural heterogeneity at landscape scales."[3]

Bekker and Taylor 2001: On the western slope of the southern Cascades in California, in mixed-conifer forests, fire was predominantly high-intensity historically with more than 50% of forests burning at high-severity across all environmental and compositional (tree species) gradients, with most of the rest burning at moderate-severity [see Fig. 2F].[4]

Bekker and Taylor 2010: In mixed-conifer forests of the southern Cascades, reconstructed fire severity within the study area was dominated by high-severity fire effects (e.g.,"high severity fires had a dominant influence on mixed conifer stands in TLW [wilderness study area]"), including high-severity fire patches over 2,000 acres in size [Tables I and II].[5]

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[1] Baker, W.L. 2014. Historical forest structure and fire in Sierran mixed-conifer forests reconstructed from General Land Office survey data. Ecosphere 5(7): Article 79.

[2] Beaty, R.M. and A.H. Taylor. 2001. Spatial and temporal variation of fire regimes in a mixed conifer forest landscape, Southern Cascades, USA. Journal of Biogeography 28: 955–966.

[3] Beaty, R.M. and A.H. Taylor. 2008. Fire history and the structure and dynamics of a mixed conifer forest landscape in the northern Sierra Nevada, Lake Tahoe Basin, California, USA. Forest Ecology and Management 255: 707-719.

[4] Bekker, M.F. and A.H. Taylor. 2001. Gradient analysis of fire regimes in montane forests of the southern Cascade Range, Thousand Lakes Wilderness, California, USA. Plant Ecology 155: 15-28.

[5] Bekker, M.F. and A.H. Taylor. 2010. Fire disturbance, forest structure, and stand dynamics in montane forest of the southern Cascades, Thousand Lakes Wilderness, California, USA. Ecoscience 17: 59-72.

Collins and Stephens 2010: In a modern "reference" forest condition within mixed-conifer/fir forests in Yosemite National Park, 15% of the area experienced high-intensity fire over a 33-year period—a high-intensity fire rotation interval of approximately 223 years.[6]

Halofsky et al. 2011: In the Klamath-Siskiyou Mountains of northwestern California and southwestern Oregon, a mixed-severity fire regime produces structurally diverse vegetation types with intimately mixed patches of varied age. The close mingling of early- and late-seral communities results in unique vegetation and wildlife responses, including high resilience of plant and wildlife species to mixed-severity fire.[7]

Hanson and Odion 2016: An assessment of US Forest Service forest survey data from 1910 and 1911 for central and southern Sierra Nevada ponderosa pine and mixed-conifer forests indicates that these historical forests had a mixed-severity fire regime, with an average of 26% high-severity fire effects. This study's findings are contrary to those of several other reports that use a very small subset of the available data from the 1910 and 1911 surveys, demonstrating the importance of analyzing data from sufficiently large spatial scales when drawing inferences about historical conditions.[8]

Nagel and Taylor 2005: The authors found that large high-severity fire patches were a natural part of 19th century fire regimes in mixed-conifer and eastside pine forests of the Lake Tahoe Basin. Montane chaparral created by high-severity fire has declined by 62% since the 19th century due to reduced high-severity fire occurrence. The authors expressed concern about harm to biodiversity due to loss of ecologically rich montane chaparral.[9]

Odion et al. 2014: In the largest and most comprehensive analysis conducted to date regarding the historical occurrence of high-intensity fire, the authors found that ponderosa pine and mixed-conifer forests in every region of western North America had mixed-intensity fire regimes, which included substantial occurrence of high-intensity fire. The authors also found, using multiple lines of evidence, including over a hundred historical sources and fire history reconstructions, and an extensive forest age-class analysis, that we now have unnaturally low levels of high-intensity fire in these forest types in all regions, since the beginning of fire suppression policies in the early 20th century.[10]

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[6] Collins, B.M. and S.L. Stephens. 2010. Stand-replacing patches within a mixed severity fire regime: quantitative characterization using recent fires in a long-established natural fire area. Landscape Ecology 25: 927939.

[7] Halofsky, J. E., D.C. Donato, D.E. Hibbs, J.L. Campbell, M. Donaghy Cannon, J.B. Fontaine, J.R. Thompson, R.G. Anthony, B.T. Bormann, L.J. Kayes, B.E. Law, D.L. Peterson, and T.A. Spies. 2011. Mixed-severity fire regimes: lessons and hypotheses from the Klamath-Siskiyou Ecoregion. Ecosphere 2(4): art40.

[8] Hanson, C.T. and D.C. Odion. 2016. Historical fire conditions within the range of the Pacific fishers and spotted owl in the central and southern Sierra Nevada, California, USA. Natural Areas Journal 36: 8-19.

[9] Nagel, T.A. and A. H. Taylor. 2005. Fire and persistence of montane chaparral in mixed conifer forest landscapes in the northern Sierra Nevada, Lake Tahoe Basin, California,USA. J. Torrey Bot. Soc.132: 442-457.

[10] Odion, D.C., C.T. Hanson, A. Arsenault, W.L. Baker, D.A. DellaSala, R.L. Hutto, W. Klenner, M.A. Moritz, R.L. Sherriff, T.T. Veblen, and M.A. Williams. 2014. Examining historical and current mixed-

Russell et al. 1998: This study documented the occurrence of an extensive, pre-suppression, stand-replacing fire in the southern Lake Tahoe Basin. The authors concluded: “In the quest to determine the proper role of fire in the forest management scheme in the Tahoe Basin, stand-replacing fires need to be understood as part of the pre-European fire regime. In addition to periodic surface fires, stand-replacing fires have been instrumental in the formation of canopy gaps, and the maintenance of habitat heterogeneity and species diversity.”[11]

Stephenson et al. 1991: A study of fire chronologies in the giant sequoia-mixed conifer forests of the southern Sierra Nevada concluded that “the evidence presently available suggests that patchy intense fires (and perhaps predominantly intense fires) existed in presettlement times, and that these fires may have been important determiners of forest structure and composition. Thus, in more detailed descriptions of fire regimes, natural fires may be best characterized as having been patches of high intensity fire within a matrix of low intensity fire, with the frequency and relative area covered by intense fires varying over time. Rather than treating forests and the fires that burn them as homogeneous units, this view emphasizes patch dynamics.”[12]

Taylor and Skinner 1998: A study in a late-successional reserve in Douglas fir-dominated forests in the northern Klamath mountains of northern California concluded that “frequent, mixed-severity fires have been an integral process in the development of stands exhibiting structurally diverse, late-successional conditions” and that “spatial variation in [fire] severity has been important in providing diversity in landscape patterns.”[13]

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severity fire regimes in Ponderosa pine and mixed-conifer forests of western North America. Plos One 9(2): e87852. *See also* response and rebuttal: Odion D.C., C.T. Hanson, W.L. Baker, D.A. DellaSala, and M.A. Williams. 2016. Areas of agreement and disagreement regarding ponderosa pine and mixed conifer forest fire regimes: a dialogue with Stevens et al. PLoS ONE 11(5): e0154579; Stevens J.T. et al. 2016. Average stand age from forest inventory plots does not describe historical fire regimes in ponderosa pine and mixed-conifer forests of western North America. PLoS ONE 11(5): e0147688.

[11] Russell, W.H., J. McBride, and R. Rowntree. 1998. Revegetation after four stand-replacing fires in the Lake Tahoe Basin. Madroño 45: 40-46.

[12] Stephenson, N.I., D.J. Parsons, and T.W. Swetnam. 1991. Restoring natural fire to the Sequoia-mixed conifer forest: should intense fire play a role? Proceedings of the Tall Timbers Fire Ecology Conference 17: 321-337.

[13] Taylor, A.H. and C.N. Skinner. 1998. Fire history and landscape dynamics in a late successional reserve, Klamath Mountains, California. Forest Ecology and Management 111: 285-301.

Appendix B

Black Carbon Emissions and Consequent Climate Impacts of Wildfire are Inadequately Characterized

A. Data are not available to estimate black carbon from wildfires with any accuracy.

The estimation of black carbon from wildfires is notoriously difficult and fraught with uncertainty. Not only does the extent of wildfire vary widely from year to year, but also the factors influencing black carbon emissions are highly condition-dependent and time-variable. In short, there are no dependable parameters and methods for estimating wildfire black carbon emissions. California's Final Proposed Short-Lived Climate Pollutants Strategy acknowledges the uncertainties in ARB's black carbon inventory values, as summarized in the Strategy's Appendix C: "This variation [in fuel type, moisture content, oxygen levels and local weather] leads to high uncertainty in speciation assumptions, and adequate speciation profiles to account for various fire conditions are not available."[14]

Unlike other sources of black carbon, wildfire emissions are not amenable to reasonable estimation using current data and methods. ARB uses a "speciation" model to create its black carbon inventory. This means that black carbon emissions from each source are assumed to be a percentage of total PM2.5 emissions for that source, with the percentage of black carbon based on observational data. For wildfire, total PM2.5 is derived from a model that includes parameters such as the geographic extent of wildfire, fuel type and estimated moisture content, and fire phase (flaming or smoldering).[15]

Wildfire presents several challenges that undermine the accuracy of ARB's speciation approach. The first challenge is that the black carbon portion of PM2.5 can be difficult to estimate because estimates of emissions from biomass burning are highly uncertain. This is a result of the many factors that contribute to emissions, including but not limited to the mix of fuels, mass of fuel, moisture content, temperature of the fire, incline and wind direction, and duration of the fire. This results in estimates of black carbon in PM2.5 that range over two orders of magnitude, as noted by ARB.[16] Nonetheless, the ARB inventory assumes a single value for the proportion of black carbon in PM2.5 of 0.2 (20 percent).[17] Notably, this is more than double EPA's national speciation value for wildfire, which is 0.095 (9.5 percent).[18]

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[14] Cal. Air Resources Board. 2017. Appendix C: California SLCP emissions. Final Proposed SLCP Reduction Strategy (posted March 14, 2017), *available at* https://www.arb.ca.gov/cc/shortlived/shortlived.htm (visited March 16, 2017).
See Appendix C at *available at* https://www.arb.ca.gov/cc/shortlived/shortlived.htm (visited March 16, 2017).

[15] Cal. Air Resources Board. 2016. California's Black Carbon Inventory: Technical Support Document 8 (2015 Edition) (hereinafter "TSD 2015") *available at* http://www.arb.ca.gov/cc/inventory/slcp/doc/bc_inventory_tsd_20160411.pdf (visited May 25, 2016).

[16] TSD 2015 at 9.

[17] The TSD cites a number of studies that are presumed to reflect California's typical wildfire fuel mix, but at least one study by McMeeking et al. that included a similar fuel mix – and coincidentally observed

The Technical Support Document (TSD) for ARB's black carbon inventory indicates that the speciation value of 0.2 was selected as a median value from the literature, but the studies that ARB relies on for its speciation value indicate the highly variable nature of biomass black carbon emissions, even in the controlled conditions of a laboratory. Only a handful of burns are completed for each sample, and the variability between samples under the same conditions can be extremely high.[19]

Speciation values are typically derived by burning fuels in a laboratory and measuring resulting emissions, although lab conditions cannot "fully anticipate or reproduce the complex real-world fires."[20] Where downwind samples were taken from prescribed burns, the black carbon concentrations were significantly lower.[21] Moreover, Turn et al. expressly noted that their laboratory burns were in relatively windless conditions that would simulate prescribed burns, but not wildfire conditions.[22]

One of the determinants of the emission profile is combustion efficiency. A number of studies have analyzed combustion efficiency, including conditions in which it is increased or decreased. It appears that greater combustion efficiency (more carbon converted to CO_2) is associated with lower organic carbon and PM2.5 emissions, while black carbon may be slightly elevated at high combustion efficiency. There are a number of factors that contribute to combustion efficiency, many of which are difficult to predict for wildfire. Fuel type is one determinant of combustion efficiency.[23] Another influence is moisture content, which may naturally vary with conditions.[24] Generally, higher moisture burns are associated with increased PM2.5 and organic carbon emissions, reducing the relative contribution of black carbon.[25] The mass of fuel being combusted can also alter combustion efficiency,[26] which is particularly problematic when translating laboratory emission factors to large scale wildfire.

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much lower black carbon proportions – was omitted. *See* G.R. McMeeking et al., *Emissions of trace gases and aerosols during the open combustion of biomass in the laboratory*, 114 JOURNAL OF GEOPHYSICAL RESEARCH D19210 (2009)(average for Montane mix was 1.4% BC).

[18] EPA SPECIATE profile for wildfire, *available at* https://cfpub.epa.gov/si/speciate/ehpa_speciate_browse_details.cfm?ptype=PC&pnumber=91102.

[19] See L.-W.A. Chen et al., *Moisture effects on carbon and nitrogen emission from burning of wildland biomass*, 10 ATMOS. CHEM. PHYS. 1, Table 1 (2010).

[20] L.-W.A. Chen et al., *Emissions from Laboratory Combustion of Wildland Fuels: Emission Factors and Source Profiles*, 41 ENVIRON. SCI. TECHNOL. 4317, 4317 (2007); *see also* T.C. Bond et al., *Bounding the role of black carbon in the climate system: A scientific assessment*, 118 JOURNAL OF GEOPHYSICAL RESEARCH 5380, 5419 (2013).

[21] See L.R. Mazzoleni et al., *Emissions of Levoglucosan, Methoxy Phenols, and Organic Acids from Prescribed Burns, Laboratory Combustion of Wildland Fuels, and Residential Wood Combustion*, 41 ENVIRON. SCI. TECHNOL. 2115, Table 1 (2007).

[22] S.Q. Turn et al., *Elemental characterization of particulate matter emitted from biomass burning: Wind tunnel derived source profiles for herbaceous and wood fuels*, 102 JOURNAL OF GEOPHYSICAL RESEARCH, 3683, 3687 (1997).

[23] McMeeking 2009.

[24] Chen 2010.

[25] *Id.* at Table 1.

[26] McMeeking 2009.

The second challenge is that PM2.5 and black carbon emissions have different dependencies on phase of burning. Several studies have found that there is an inverse relationship between the mass of PM2.5 and black carbon emissions at different phases of the fire. During the brief duration of the flaming phase, PM2.5 is relatively low while black carbon emissions are elevated. In contrast, smoldering is associated with much higher total PM2.5, but similar or lower black carbon emissions.[27] A similar disjunction between PM2.5 mass and black carbon mass was observed by Mazzoleni et al. (2007) when examining the effect of fuel type and incline (and consequently speed of the fire).[28] Depending on how PM2.5 emissions progress in ARB's model, spurious results may occur if a high percentage of black carbon is assumed for all phases rather than just the flaming phase, when total PM2.5 is actually low.[29]

In sum, the data needed to make accurate estimates of black carbon emissions from wildfire are sorely lacking. The current speciation value selected by ARB is not adequately supportable as the basis for a state-wide mitigation policy. Not only are the speciation values themselves in question, but the time dependence and inverse trends in black carbon as opposed to PM2.5 over fire phases further complicate matters to the point that ARB's estimates of wildfire black carbon are entirely unsupportable.

B. The Plan does not adequately acknowledge that the climate impacts of the different constituents of wildfire emissions are still highly uncertain.

The Plan fails to adequately acknowledge that the climate impacts of the different constituents of wildfire emissions are still highly uncertain. In contrast to fossil fuel soot, wildfire black carbon is a much lower proportion of total aerosol emissions and it is critical to account for the climate impacts of the co-emitted particles that include, for instance, various elements, organic carbon, and nitrogen. Some of these co-emitted aerosols exert a cooling effect.[30] At one time it was assumed that all organic carbon exerted a cooling influence. It is now accepted that while black carbon is highly absorbing (hence warming), some portion of organic carbon (brown carbon) is also absorbing to a lesser degree.[31] Various studies have attempted to quantify the effects of absorption by brown carbon, and the current consensus appears to be that the direct cooling effects of non-carbon aerosols may approximately offset brown carbon forcings from biomass burning.[32] But this is an area of active investigation with a large number of remaining uncertainties.

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[27] Bond 2013 at 5419; *See also* Chen 2010; Chen 2007.

[28] Mazzoleni 2007 at 2117.

[29] Bond 2013 at 5408.

[30] Some portion of organic carbon is light scattering and cooling. In addition, some reactive nitrogen species from combustion can be cooling. R.W. Pinder et al., *Climate change impacts of US reactive nitrogen*, 109 PROC. NATL. ACAD .SCI. 7671 (2012). See Chen 2010, *supra* note 19, for a discussion of nitrogen species in biomass burning smoke.

[31] *See, e.g.,* C.E. Chung et al., *Observationally constrained estimates of carbonaceous aerosol radiative forcing*, 109 PROC. NATL. ACAD .SCI. 11624 (2012).

[32] *Id.*

It should be noted that the general conclusion that brown carbon may offset cooling impacts is largely related to agricultural burning and residential cooking and heating stoves. Thus, it is not clear what impact wildfire with its unique combustion qualities would have. A recent study that presented the most comprehensive global black carbon inventory to date noted that because the net forcing from *all* black carbon sources is slightly negative, or cooling, the "uniform elimination of all emissions from black-carbon-rich sources could lead to no change in climate warming."[33] That study indicated that the best potential targets were diesel emissions and potentially residential solid fuel.[34] With regard to wildfire, Bond and colleagues estimate that the total climate forcing for open biomass burning of forests is negative or near zero.[35] Thus, mitigation efforts related to wildfire are not guaranteed to have substantial, if any, net climate benefits.

One of the looming uncertainties related to climate impacts from black carbon relates to indirect cloud impacts. Bond and colleagues reviewed the literature on this topic and estimated that forest burning likely has a net negative climate forcing (cooling), although there is very large uncertainty. Jacobson also recently modeled climate impacts of black carbon using a model that incorporates detailed cloud interactions.[36] His results suggest a warming effect, but the results have not been replicated and he points to large uncertainties as well. Furthermore, Jacobson's recent cloud-interaction model estimates that only 7 percent of the biomass burning in his model was from natural sources such as wildfire.[37] Thus, those results may not be applicable to the specific emissions associated with wildfire. Finally, Kodros et al. recently reviewed the uncertainties in estimates of biofuel aerosol direct forcing and cloud-albedo indirect effects. Notably this study only looked at domestic biofuel combustion, and thus is not directly comparable to wildfire emissions. Nonetheless, the authors concluded that the uncertainties in effects and parameters were so large that it was not clear on a global scale whether the effects were positive (warming) or negative (cooling).[38] Furthermore, the authors pointed out that estimates of effects were highly dependent on background pollution levels for a given region.[39]

Taken together, it is clear that co-emitted aerosols can drastically alter the climate impacts of wildfire black carbon. The science is evolving rapidly, but at this point the uncertainties are too large to make any concrete predictions of overall climate impact.

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[33] Bond 2013 at 5388.

[34] *Id.*

[35] *Id.* at 5504. Although Bond et al. did not expressly include brown carbon, the method used to estimate black carbon emissions likely included brown carbon as a portion of the mass, such that brown carbon effects would be implicitly included. Bond et al. also considered cloud indirect effects in estimating total black carbon forcing.

[36] M.Z. Jacobson, *Effects of biomass burning on climate, accounting for heat and moisture fluxes, black and brown carbon, and cloud absorption effects*, 119 J. GEOPHYS. RES. 8980 (2014).

[37] *Id.* at 8984.

[38] J.K. Kodros et al., *Uncertainties in global aerosols and climate effects due to biofuel emissions,* 15 ATMOS. CHEM. PHYS. 8577, 8592 (2015).

[39] *Id.*

Appendix C

Studies demonstrating the ecological importance of complex early seral forest habitat created by high-severity fire

Bond et al. 2009: In a radio-telemetry study, California spotted owls preferentially selected high-intensity fire areas, which had not been salvage logged, for foraging, while selecting low- and moderate-intensity areas for nesting and roosting.[40]

Buchalski et al. 2013: In mixed-conifer forests of the southern Sierra Nevada, rare myotis bats were found at greater levels in unmanaged high-severity fire areas of the McNally fire than in lower fire severity areas or unburned forest.[41]

Burnett et al. 2010: Bird species richness was approximately the same between high-severity fire areas and unburned mature/old forest at 8 years post-fire in the Storrie fire, and total bird abundance was greatest in the high-severity fire areas of the Storrie fire [Figure 4]. Nest density of cavity-nesting species increased with higher proportions of high-severity fire, and was highest at 100% [Figure 8].[42]

Cocking et al. 2014: High-intensity fire areas are vitally important to maintain and restore black oaks in mixed-conifer forests.[43]

DellaSala et al. 2014: Complex early seral forests in the Sierra Nevada of California, which are produced by mixed-severity fire including large high severity patches, support diverse plant and wildlife communities that are essential to the region's ecological integrity. Fire suppression and biomass removal after fire reduce structural complexity, diversity, and resilience in the face of climate change.[44]

Donato et al. 2009: The high-severity re-burn [high-severity fire occurring 15 years after a previous high-severity fire] had the highest plant species richness and total plant cover, relative to high-severity fire alone [no re-burn] and unburned mature/old forest; and the high-severity fire re-burn area had over 1,000 seedlings/saplings per hectare of natural conifer regeneration.[45]

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[40] Bond, M.L., D.E. Lee, R.B. Siegel, and J.P. Ward, Jr. 2009. Habitat use and selection by California Spotted Owls in a postfire landscape. Journal of Wildlife Management 73: 1116-1124.

[41] Buchalski, M.R., J.B. Fontaine, P.A. Heady III, J.P. Hayes, and W.F. Frick. 2013. Bat response to differing fire severity in mixed-conifer forest, California, USA. PLoS ONE 8: e57884.

[42] Burnett, R.D., P. Taillie, and N. Seavy. 2010. Plumas Lassen Study 2009 Annual Report. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA.

[43] Cocking M.I., J.M. Varner JM, and E.E. Knapp. 2014. Long-term effects of fire severity on oak-conifer dynamics in the southern Cascades. Ecological Applications 24: 94-107.

[44] DellaSala, D., M.L. Bond, C.T. Hanson, R.L. Hutto, and D.C. Odion. 2014. Complex early seral forests of the Sierra Nevada: what are they and how can they be managed for ecological integrity? Natural Areas Journal 34: 310-324.

[45] Donato, D.C., J.B. Fontaine, W.D. Robinson, J.B. Kauffman, and B.E. Law. 2009. Vegetation response to a short interval between high-severity wildfires in a mixed-evergreen forest. Journal of Ecology 97:142-154.

Franklin et al. 2000: The authors found that stable or increasing populations of spotted owls resulted from a mix of dense old forest and complex early seral habitat, and less than approximately 25% complex early seral habitat in the home range was associated with declining populations [Fig. 10]; the authors emphasized that the complex early seral habitat was consistent with high-intensity fire effects, and inconsistent with clearcut logging.[46]

Hanson and North 2008: Black-backed woodpeckers depend upon dense, mature/old forest that has recently experienced higher-intensity fire, and has not been salvage logged.[47]

Hanson 2013: Pacific fishers use pre-fire mature/old forest that experienced moderate/high-intensity fire more than expected based upon availability, just as fishers are selecting dense, mature/old forest in its unburned state. When fishers are near fire perimeters, they strongly select the burned side of the fire edge. Both males and female fishers are using large mixed-intensity fire areas, such as the McNally fire, including several kilometers into the fire area.[48]

Hanson 2015: Pacific fisher females in the Sierra Nevada use unlogged higher severity fire areas, including very large high-severity patches. In the McNally fire area at 10 to 11 years postfire, female fishers used the large, intense fire area significantly more than unburned forest, and females were detected at multiple locations >250m into the interior of a very large (>5,000 ha), unlogged higher severity fire patch. The author concludes that these results "suggest a need to revisit current management direction, which emphasizes extensive commercial thinning and postfire logging to reduce fuels and control fire."[49]

Hutto 1995: A study in the northern Rocky Mountain region found that 15 bird species are generally more abundant in early post-fire communities than in any other major cover type occurring in the northern Rockies. Standing, fire-killed trees provided nest sites for nearly two-thirds of 31 species that were found nesting in the burned sites.[50]

Hutto 2008: Severely burned forest conditions have occurred naturally across a broad range of forest types for millennia and provide an important ecological backdrop for fire specialists like the black-backed woodpecker.[51]

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[46] Franklin, A.B., D.R. Anderson, R.J. Gutierrez, and K.P. Burnham. 2000. Climate, habitat quality, and fitness in northern spotted owl populations in northwestern California.Ecological Monographs 70: 539-590.

[47] Hanson, C. T. and M. P. North. 2008. Postfire woodpecker foraging in salvage-logged and unlogged forests of the Sierra Nevada. Condor 110: 777–782.

[48] Hanson, C.T. 2013. Pacific fisher habitat use of a heterogeneous post-fire and unburned landscape in the southern Sierra Nevada, California, USA. The Open Forest Science Journal 6: 24-30.

[49] Hanson, C.T. 2015. Uses of higher severity fire areas by female Pacific fishers on the Kern Plateau, Sierra Nevada, California, USA. Wildlife Society Bulletin 39: 497-502.

[50] Hutto, R. L. 1995. Composition of bird communities following stand-replacement fires in Northern Rocky Mountain (U.S.A.) conifer forests. Conservation Biology 9: 1041–1058.

[51] Hutto, R. L. 2008. The ecological importance of severe wildfires: Some like it hot. Ecological Applications 18: 1827–1834.

Hutto et al. 2016: This review highlights that high severity fire was historically common in western conifer forests and is ecologically essential. Many animal and plant species depend on severely burned forests for persistence. The researchers recommend a "more ecologically informed view" of severe forest fire, including changes in management and education to maintain ecologically necessary levels of severe fire and the complex early-seral forest conditions it creates.[52]

Lee and Bond 2015: California spotted owls exhibited high site occupancy in post-fire landscapes during the breeding season following the 2013 Rim Fire, even where large areas burned at high severity; the complex early seral forests created by high-severity fire appear to provide important habitat for the small mammal prey of the owl.[53]

Malison and Baxter 2010: In ponderosa pine and Douglas-fir forests of Idaho at 5-10 years post-fire, levels of aquatic insects emerging from streams were two and a half times greater in high-intensity fire areas than in unburned mature/old forest, and bats were nearly 5 times more abundant in riparian areas with high-intensity fire than in unburned mature/old forest.[54]

Ponisio et al. 2016: A study of plant–pollinator communities in mixed-conifer forest in Yosemite National Park found that pyrodiversity (the diversity of fires within a region) increases the richness of the pollinators, flowering plants, and plant-pollinator interactions, and buffers pollinator communities against the effects of drought-induced floral resource scarcity. The authors conclude that lower fire diversity is likely to negatively affect the richness of plant–pollinator communities across large spatial scales. [55]

Raphael et al. 1987: At 25 years after high-intensity fire, total bird abundance was slightly higher in snag forest than in unburned old forest in eastside mixed-conifer forest of the northern Sierra Nevada; and bird species richness was 40% higher in snag forest habitat. In earlier post- fire years, woodpeckers were more abundant in snag forest, but were similar to unburned by 25 years post-fire, while flycatchers and species associated with shrubs continued to increase to 25 years post-fire.[56]

Sestrich et al. 2011: Native bull and cutthroat trout tended to increase with higher fire intensity, particularly where debris flows occurred. Nonnative brook trout did not increase.[57]

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[52] Hutto, R.L., R.E. Keane, R.L. Sherriff, C.T. Rota, L.A. Eby, and V.A. Saab. 2016. Toward a more ecologically informed view of severe forest fires. Ecosphere 7(2):e01255.

[53] Lee, D.E. and M.L. Bond. 2015. Occupancy of California spotted owl sites following a large fire in the Sierra Nevada, California. The Condor 117: 228-236.

[54] Malison, R.L. and C.V. Baxter. 2010. The fire pulse: wildfire stimulates flux of aquatic prey to terrestrial habitats driving increases in riparian consumers. Canadian Journal of Fisheries and Aquatic Sciences 67: 570-579.

[55] Ponisio, L.C., K. Wilken, L.M. Gonigle, K. Kulhanek, L. Cook, R. Thorp, T. Griswold, and C. Kremen. 2016. Pyrodiversity begets plant-pollinator community diversity. Global Change Biology 22: 1794-1808.

[56] Raphael, M.G., M.L. Morrison, and M.P. Yoder-Williams. 1987. Breeding bird populations during twenty-five years of postfire succession in the Sierra Nevada. The Condor 89: 614-626.

[57] Sestrich, C.M., T.E. McMahon, and M.K. Young. 2011. Influence of fire on native and nonnative salmonid populations and habitat in a western Montana basin. Transactions of the American Fisheries Society 140: 136-146.

Siegel et al. 2012: Many more species occur at high burn severity sites starting several years post-fire, and these include the majority of ground and shrub nesters as well as many cavity nesters. Secondary cavity nesters, such as swallows, bluebirds, and wrens, are particularly associated with severe burns, but only after nest cavities have been created, presumably by the pioneering cavity excavating species such as the black-backed woodpecker. As a result, fires that create preferred conditions for black-backed woodpeckers in the early post-fire years will likely result in increased nesting sites for secondary cavity nesters in successive years.[58]

Swanson et al. 2010: A literature review concluding that some of the highest levels of native biodiversity found in temperate conifer forest types occur in complex early successional habitat created by stand-initiating [high severity] fire.[59]

Tingley et al. 2016: Found that, in order to maintain the full range of avian diversity in these forests, there must be a significant mix of low-, moderate-, and high-severity fire.[60]

White et al. 2016: "[S]pecies-specific modeling results predicted that some species were strongly associated with specific post-fire conditions, such as a high density of dead trees, open-canopy conditions or high levels of shrub cover that occur at particular burn severities or at a particular time following fire. These results indicate that prescribed fire or managed wildfire which burns at low to moderate severity without at least some high-severity effects is both unlikely to result in the species assemblages that are unique to post-fire areas or to provide habitat for burn specialists."[61]

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[58] Siegel, R.B., M.W. Tingley, and R.L. Wilkerson. 2012. Black-backed Woodpecker MIS surveys on Sierra Nevada national forests: 2011 Annual Report. A report in fulfillment of U.S. Forest Service Agreement No. 08-CS-11052005-201, Modification #4; U.S. Forest Service Pacific Southwest Region, Vallejo, CA.

[59] Swanson, M.E., J.F. Franklin, R.L. Beschta, C.M. Crisafulli, D.A. DellaSala, R.L. Hutto, D. Lindenmayer, and F.J. Swanson. 2010. The forgotten stage of forest succession: early- successional ecosystems on forest sites. Frontiers Ecology & Environment 9: 117-125.

[60] Tingley, M.W., V. Ruiz-Gutierrez, R.L. Wilkerson, C.A. Howell, and R.B. Siegel. 2016. Pyrodiversity promotes avian diversity over the decade following forest fire. Proceedings of the Royal Society B 283: 20161703.

[61] White, A.M., P.N. Manley, G.L. Tarbill, T.W. Richardson, R.E. Russell, H.D. Safford, and S.Z. Dobrowski. 2016. Avian community responses to post-fire forest structure: implications for fire management in mixed-conifer forests. Animal Conservation 19: 256-264.