SIERRA CLUB

September 26, 2019

Planning Team Leader
Forest Plan Revision
1323 Club Drive
Vallejo, CA 94592
r5planrevision@fs.fed.us

RE: Public Comment on Sequoia and Sierra National Forests Land Management Plans Revision #3375

Submitted via e-mail and electronic USFS comment portal at https://cara.ecosystem-management.org/Public/CommentInput?Project=3375.

Dear Planning Team Leader,

Sierra Club writes to express its concerns regarding the proposed revisions to the plans for the Sierra and Sequoia National Forests, and to identify a number of defects with the draft Revised Environmental Impact Statement ("RDEIS") for the plan revisions. To better evaluate the RDEIS, specifically with respect to its analysis of the impacts of the alternatives on carbon emissions, Sierra Club contracted expert Dr. Tara Hudiburg, whose analysis is attached to, and incorporated into, this comment letter.[1] Sierra Club also joins and incorporates by reference the comments on the RDEIS submitted by Sierra Forest Legacy et al. on September 26, 2019 to the extent that those comments are consistent with the comments provided herein. Sierra Club writes here to provide additional points and distinct positions on certain issues.

[1] *See* Attachment 1. For inclusion in the administrative record, Sierra Club has separately submitted the literature cited in this comment letter, as well as the literature cited in Dr. Hudiburg's analysis.

Sierra Club was founded in 1892 and is the nation's oldest grass-roots environmental organization. It is a national nonprofit organization of over 790,000 members, including its Tehipite and Kern-Kaweah Chapters in California. Sierra Club has over 169,000 members in California. The Sierra Club's purpose is to explore, enjoy and protect the wild places of the earth; to practice and promote the responsible use of the earth's ecosystems and resources; to educate and enlist humanity to protect and restore the quality of the natural and human environment; and use all lawful means to carry out these objectives.

I. NEPA Obligations

Under NEPA, every federal agency that takes a major federal action "significantly affecting the quality of the human environment" is required to create a detailed statement discussing: (i) the environmental impact of the proposed action; (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented; (iii) alternatives to the proposed action; (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.[2] When, as here, any significant environmental impacts might result from the proposed action, the agency must complete a meticulous environmental impact statement (EIS).[3]

NEPA imposes "action forcing procedures … requir[ing] that agencies take a *hard look* at environmental consequences." *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 350 (1989) (citations omitted) (emphasis added). The sufficiency and utility of an EIS rely heavily on the scope and depth of the analysis of environmental impacts. The EIS must include the full scope of environmental effects, including direct, indirect, and cumulative impacts.[4]

The "heart of the environmental impact statement" is a rigorous exploration of alternatives to the proposed action. 40 C.F.R. § 1502.14. BLM must "provide a full and fair discussion of significant environmental impacts" in order to "inform decisionmakers and the

[2] 42 U.S.C. § 4332(2)(C)(i)–(v).
[3] *Sierra Club v. Van Antwerp*, 661 F.3d 1147, 1153 (D.C. Cir. 2011) (citing *Sierra Club v. Peterson*, 717 F.2d 1409, 1415 (D.C. Cir. 1983)); *see also* 40 C.F.R. §§ 1508.11, 1508.27.
[4] 40 C.F.R. §1508.25(a)(c)(1)–(3). The terms "effects" and "impacts" are used synonymously in the CEQ regulations interpreting NEPA. 40 C.F.R. § 1508.8.

public of the reasonable alternative which would avoid or minimize adverse impacts." *Id*. §§ 1502.1, 1502.14; *accord California v. Block*, 690 F.2d 753, 767 (9th Cir. 1982).

II. Obligations Under MUSYA, NFMA, and the 2012 Planning Rules

The National Forest Management Act ("NFMA") directs the Secretary of Agriculture ("Secretary") to develop, maintain and revise management plans for units of the National Forest System. 16 U.S.C. § 1604(a). The plans must provide for the multiple use and sustained yield of the products and services obtained from the Forest in accordance with the Multiple–Use Sustained–Yield Act of 1960. ("MUSYA"), 16 U.S.C. §§ 528–531. *See also*, 16 U.S.C. §§ 1604(b), (d), and (e).

"In developing, maintaining, and revising plans for units of the National Forest System pursuant to this section, the Secretary shall assure that such plans— **(1)** provide for multiple use and sustained yield of the products and services obtained therefrom in accordance with the Multiple-Use Sustained-Yield Act of 1960 [16 U.S.C. 528–531], and, in particular, include coordination of outdoor recreation, range, timber, watershed, wildlife and fish, and wilderness; and **(2)** determine forest management systems, harvesting levels, and procedures in the light of all of the uses set forth in subsection (c)(1), the definition of the terms "multiple use" and "sustained yield" as provided in the Multiple-Use Sustained-Yield Act of 1960, and the availability of lands and their suitability for resource management." 16 U.S.C. §§ 1604 (e) ("required assurances").

"Multiple use" means: "The management of all the various renewable surface resources of the national forests so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; that some land will be used for less than all of the resources; and harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output." 16 U.S.C. § 531(a).

The USFS Planning Rules implementing NFMA requirements mandate that plans must take into account "system drivers, including . . . climate change" and "reasonably foreseeable risks to ecological . . . sustainability." 36 C.F.R. §§ 219.8(a)(1)(iv), 219.10(a)(7). The Rules require that USFS address "measurable changes on the plan area related to climate change" in its plan monitoring program. *Id*. at § 219.12(a)(5)(vi). Plans must also provide for "ecosystem services," which include "regulating services such as long term storage of carbon." *Id*. at §§ 219.10, 219.19.

Plans must include desired conditions ("description[s] of specific social, economic, and/or ecological characteristics of the plan area . . . toward which management of the land and resources should be directed") (DCs) and objectives ("concise, measureable, and time-specific statement[s] of a desired rate of progress toward a desired condition or conditions.").

The Rules require that plans must ensure that "[t]imber harvest [for any purpose] would be carried out in a manner consistent with the protection of soil, watershed, fish, wildlife, recreation, and aesthetic resources." *Id*. at § 219.11(d)(3).

The Rules also provide that "[n]o timber harvest for the purposes of timber production may occur on lands not suited for timber production." *Id*. at § 219.11(d)(1). Land is not suited for timber production if "[t]imber production would not be compatible with the achievement of desired conditions and objectives established" by the relevant plan. *Id*. at § 219.11(a)(1)(iii). In balancing the factors for consideration in the suitability analysis, USFS must provide justification for elevating production goals over other factors. *Citizens for Envtl. Quality v. U.S.*, 731 F. Supp. 970, 988 (D. Colo. 1989) ("if production goals are to be given greater weight in the suitability analysis, then adequate reasons must be set forth for so doing. Defendants must provide justification for allowing production goals, or any other factor required by [the NFMA] and the regulations, to weigh more heavily than other factors.").

More broadly, the Rules require the use of "the best available scientific information to inform the planning process." *Id*. at § 219.3.

III. The Revised RDEIS Does Not Provide a Legally Adequate Basis for the Selection of the Proposed Plan Due to Fatal Defects in the Analysis of Carbon Carrying Capacity

In the Revised RDEIS (hereafter "RDEIS"), USFS has conceded that the revised plans must provide for maintaining and improving the carbon carrying capacity of the forests. The RDEIS acknowledges that maintained or improved carbon carrying capacity forest-wide for the Sierra and Sequoia National Forests is a characteristic toward which management should be directed. For *all* action alternatives, the USFS has identified the following desired condition[5]:

> "The carbon carrying capacity for a given ecosystem is stable or improving, given trends in climate change, fire, insects, disease, and drought." (TERR-FW-DC 07)

RDEIS at A-14. Further, the RDEIS states that to meet the purpose and need for the action, a plan must "[i]ncrease the ability of forests to store and sequester carbon." *See* RDEIS at 38 (eliminating an alternative from detailed consideration because it purportedly would not increase the ability of forests to store and sequester carbon).

Indeed, in light of the climate crisis, it would be arbitrary and capricious, and a violation of the Forest Service's mandates under MUSYA and NFMA for it to fail to recognize that carbon storage and carbon sequestration are a critically important ecosystem service, and land use, that must be provided for in planning. The RDEIS is replete with statements acknowledging the harm that climate change will inflict on the resources of the forests themselves, in particular with regard to wildlife. *See, e.g.*, RDEIS at D-36 (Sierra marten at risk from climate change related habitat loss); D-57 (California spotted owl "unlikely" to achieve "substantial species recovery" due to threats including climate change); D-68 to D-69 ("A primary threat to Mount Pinos sooty grouse is loss of subalpine habitat from climate change"); D-118 ("Uncertainty about climate change related effects pose an additional long-term threat [to California golden trout], and temperatures are already approaching the species' upper thermal limit."); D-129 (a main threat to Kern River rainbow trout is climate change because "[d]aily maximum temperatures currently approach the upper thermal limit commonly recognized for rainbow trout … and water

[5] A "desired condition" is defined by USFS as "a description of specific social, economic, or ecological characteristics of the plan area, or a portion of the plan area, toward which management of the land and resources should be directed. This description is specific enough to allow progress toward achieving a goal, but it does not include a completion date." Desired conditions are one of the five required components for forest plans under USFS rules.

temperatures are predicted to increase."); D-149 (climate change is "main threat" to *Calasellus longus* and places it "at significant risk.").[6]

Despite recognizing that the plans must maintain or improve carbon carrying capacity, the RDEIS and supporting documents provide a fatally flawed analysis of the extent to which the alternative plans are consistent with that desired condition. The comparison of alternatives with respect to "carbon stocks, sequestration, and stability," which ultimately informs how consistent the alternatives are with regard to the desired condition of increasing carbon carrying capacity, and with providing for the "ecosystem service" of "long term carbon storage," 36 C.F.R. §§ 219.10, 219.19, is distorted by this flawed analysis, as described below.

A. The RDEIS Draws Faulty Conclusions that Inflate the Emissions Resulting from Wildfire, thereby Distorting the Carbon Benefits of Avoiding Fire

The RDEIS overstates carbon emissions from wildfires, and overstates their emissions compared to logging, thinning, and other activities. Scientific studies show that carbon emissions in California, and across the U.S., from tree harvest and thinning are much higher than the emissions from wildfire, bark beetles, or drought. Berner et al. (2017) reported that logging was the largest cause of tree mortality in California forests between 2003 and 2012, followed by wildfire and then bark beetles.[7] Furthermore, Harris et al. (2016) reported that between 2006 and 2010 logging was responsible for 60% of the carbon losses from California's forests, compared to 32% from wildfire.[8] This is because wildfire consumes only a minor percentage of forest carbon while improving availability of key nutrients and stimulating rapid forest regeneration. When trees die from drought and native bark beetles, no carbon is consumed or emitted initially, and carbon emissions from decay are small and slow; meanwhile, decaying wood keeps forest soils productive and enhances carbon sequestration capacity over time. In contrast, logging and

[6] Problematically, despite acknowledging the risks that climate change poses to the resources of the national forests, the RDEIS repeatedly asserts that threats caused by climate change are "outside the control" of the Forest Service. *See, e.g.*, RDEIS at Appendix D.
[7] Berner, Logan T. et al., Tree mortality from fires, bark beetles, and timber harvest during a hot and dry decade in the western United States (2003-2012), 12 Environmental Research Letters 065005 (2017).
[8] Harris, N.L. et al., Attribution of net carbon change by disturbance type across forest lands of the conterminous United States, 11 Carbon Balance and Management 24 (2016).

thinning results in a large net loss of forest carbon storage, and a substantial overall increase in carbon emissions that can take decades, if not a century, to recapture with regrowth.[9]

As Dr. Tara Hudiburg states: "Models used to calculate carbon emissions from wildfire are overestimating combustion (and therefore carbon emissions) in order to arrive at treatment conclusions. The carbon benefits of landscape-level thinning to avoid emissions from wildfire hinge largely on incorrect model predictions of wildfire combustion." [10] Dr. Hudiburg explains how her recent research, presented in Stenzel et al. (2019), "found that extreme over-combustion of live trees in models (>10 times) is contributing to a doubling of estimated fire emissions across the western U.S." and that this inflation of wildfire emission estimates is "even more pronounced in old-growth forests in the Sierra Nevada" because "[w]hile combustion of live trees is typically less than 5% for mature trees in the fire-prone west, researchers have been implementing up to 80% tree combustion when examining the tradeoffs of wildfire and thinning losses." [11]

Stenzel et al. (2019) demonstrates that commonly-used models for estimating wildfire emissions typically significantly over-estimate these emissions by using unrealistic biomass combustion factors and failing to accurately quantify biomass in standing dead trees. The study highlights that commonly used models overestimate the wildfire emissions from California's carbon-dense forests by three-to-four times that of actual field-based values, based on reviewing Yosemite forests as a case study: "Our results illustrate that the use of inaccurate combustion coefficients in models can double forest fire emissions estimates across the western United States. Overestimates increase to three to four times in carbon-dense forests such as the YFDP [Yosemite Forest Dynamics Plot], mostly because models incorrectly combust live trees. Treating carbon released over years to centuries as an immediate emission by equating

[9] Searchinger, T.D. et al., Fixing a critical climate accounting error, 326 Science 527 (2009); Hudiburg, T.W. et al., Regional carbon dioxide implications of forest bioenergy production, 1 Nature Climate Change 419 (2011); Campbell, J.L. et al., Can fuel-reduction treatments really increase forest carbon storage in the western US by reducing future fire emissions? 10 Frontiers in Ecology and Environment 83 (2012); Holtsmark, Bjart, The outcome is in the assumptions: Analyzing the effects on atmospheric CO_2 levels of increased use of bioenergy from forest biomass, 5 GCB Bioenergy 467 (2012); Mitchell, S.R. et al., Carbon debt and carbon sequestration parity in forest bioenergy production, 4 Global Change Biology Bioenergy 818 (2012).
[10] Attachment 1, Main Memo at 2.
[11] Attachment 1, Main Memo at 2.

combustion with mortality is simply inaccurate. Omitting snag representation in models compounds this error, because of altered decay and combustion dynamics."[12] Stenzel et al. (2019) found that the largest discrepancies between modeled and observed combustion of aboveground biomass exist for live, mature trees, which are the dominant pool of aboveground carbon. While models estimate live tree stem combustion at 30%–80% in high-severity events, post-fire observations in the western United States indicate actual combustion is nearly nonexistent for mature trees in fire-prone ecosystems. Most models also lack standing dead tree carbon pools.

Stenzel et al. (2019) highlights California as an example where the government is making land management decisions based on faulty overestimates of wildfire emissions: Contemporary CO_2 emissions to the atmosphere from fire are often significantly exaggerated because of public and policymaker misconceptions that forests commonly "burn to the ground" during fire and that mortality equals emissions. The reality is instead negligible stem combustion of live, mature trees (i.e., <5%), followed by gradual decomposition over years to centuries. Modeled estimates of fire emissions reinforce public misconceptions, as tree mortality is often mistranslated into 30%–80% of tree carbon emitted immediately and is in conflict with observations. It is important to rectify overestimates because governments are currently using mortality and emissions estimates from fire to inform land management decisions intended to mitigate climate change (California, Executive Department, 2018; …).[13]

Dr. Hudiburg also identifies serious problems with the "Westerling 2015" report that the RDEIS and supporting documents rely on.[14] Defects identified by Dr. Hudiburg that inflate the emissions associated with wildfires include:

- overestimating combustion by using only the "upper bound" emissions methods from another study;
- assuming all fires burn at the highest severity and preferentially applying to the highest biomass within each area, ignoring spatial and structural reality;

[12] Stenzel, Jeffrey E. et al., Fixing a snag in carbon emissions estimates from wildfires, Global Change Biology DOI: 10.1111/gcb.14716 (2019) at 7.
[13] Stenzel et al. (2019) at 1-2.
[14] Attachment 1, Main Memo at 2.

- unrealistically assuming permanent fuels reductions in future projections, leading to artificially large emissions reductions in restoration scenarios, when, in reality, fuel treatment lifetimes range from 1 to 2 decades;
- treating fuels as static.[15]

Further, the report does not account for the emissions due to thinning, nor does it consider the net emissions when carbon emissions from thinning are balanced against putative avoidance of emissions from wildfires.[16] Nor does it account for the respective timing of the carbon emissions from thinning verses the purportedly avoided emissions from wildfires, which is important because, as Dr. Hudiburg explains, “thinned biomass is immediately utilized or burned, releasing the carbon to the atmosphere faster than if the biomass is killed in future fire and allowed to decompose slowly onsite over decades to centuries.”[17]

In sum, in relying on flawed models and analyses that overestimate the carbon emissions resulting from wildfires, and failing to adequately consider empirical studies demonstrating that actual emissions are far lower than modeled, the RDEIS inflates the carbon emissions associated with wildfire, and thereby inflates the long term carbon reduction benefits of actions to prevent fire. This flaw violates NEPA by distorting the comparison of alternatives and failing to take a hard look at the true impact of the plans. Moreover, due to this flaw, the Forest Service’s analysis of the extent to which the plans provide for the “ecosystem service” of “long term storage of carbon,” 36 C.F.R. §§ 219.10, 219.19, is distorted, and findings based upon that distorted analysis would be arbitrary and capricious. This flaw also violates the NFMA requirement to base decisions on the best available scientific evidence.

---

[15] *See* Attachment 1, Main Memo at 2; Attachment 1, Supplemental Material: Flaws, misrepresentation of study conclusions and data, and apparent contradictions at 3.

[16] *See* Attachment 1, Main Memo at 2.

[17] *See* Attachment 1, Main Memo at 2.

B. The RDEIS Fails to Consider Impacts in Light of the Timing of Carbon Emissions, the Impact of that Timing on Climate Change, and the Uncertainty Associated with Purported Emissions Reductions from Mechanical Thinning

In failing to assess the changes in carbon emissions between alternatives with respect to how their timing will affect climate change, the RDEIS improperly dismisses the importance of existing forest carbon stocks, with no guarantee of longer-term benefits. The RDEIS focuses entirely on the expected longer-term stability of carbon stored in future "restored" forests while minimizing the importance of short-term carbon storage loss from proposed vegetation treatments as well as logging and other activities. Carbon stock losses and emissions from thinning activities are not quantified and are dismissed as short-term. But increased vegetation treatment operations will reduce forest carbon stocks in the short term without guaranteeing increased carbon sequestration in the future. Vegetation reduction projects will definitely increase carbon emissions in the near-term, and USFS has failed to evaluate rationally whether the purported emissions reductions from wildfire avoidance will occur on a time scale that provides a net benefit with respect to climate change compared to the harm of the near term emissions increases. Further, the USFS has failed to adequately assess whether the putative future emission reductions from thinning will occur at all.

As Dr. Hudiburg states: "Mechanical thinning always increases carbon dioxide emissions to the atmosphere in the short-term (< 20 years;) *and* can increase emissions in the long-term (>50 years)."[18] Dr. Hudiburg explains that thinning "can require up to 10 times the treatment area compared to the fire area that would actually occur" and that even though "some of the removed carbon will be re-sequestered by the remaining trees, … this is a process that occurs over **decades to centuries**, especially when mid-to- large-diameter trees are removed as suggested by this plan."[19] "Thinning also results in large short and long-term emissions due to the decomposition of the killed material that is left on site (e.g. all root mass, stumps, debris), on-site slash combustion (fire), and emissions from wood product chain waste and decomposition. Most wood product carbon (especially from thinning operations) is returned to the atmosphere within 1-2 years."[20] Further, "thinning removes live trees that were actively sequestering carbon through their leaf area. At stand and landscape levels, thinning that decreases overstory tree

[18] Attachment 1, Main Memo at 1 (emphasis added).
[19] Attachment 1, Main Memo at 1.
[20] Attachment 1, Main Memo at 1.

density results in immediate reductions in the amount of carbon that can be sequestered by intact ecosystems for years to decades."[21] Thus, there are immediate, near term, and long term carbon emissions resulting from thinning such that evaluating the carbon impacts rationally requires considering the carbon flux resulting from thinning, and the timing of changes in net carbon emissions resulting from thinning.

Further, as discussed in detail in the following section, the purported benefits from avoiding wildfires are uncertain to occur. Therefore USFS is trading certain increases in net carbon emissions for uncertain future reductions, without evaluating or considering that factor.

As highlighted by the IPCC's Special Report on Global Warming of 1.5°C,[22] global GHG emissions must be cut approximately in half over the next decade to avoid catastrophic harms from climate change. These targets require increasingly steep reductions in emissions over the coming decade. Yet this is precisely the time period during which the carbon emitted from the proposed "restoration" treatments contemplated in the mechanical thinning alternatives will increase atmospheric CO_2 levels without any guarantee of reduced emissions in the longer term.

The October 2018 IPCC report underscored the need for urgent emissions reductions on an unprecedented scale.[23] To avoid exceeding 1.5°C of warming, global net CO_2 emissions reductions would need to decline by 45% relative to 2010 levels by 2030, and reach net zero by 2050.[24] To keep warming below 2°C, emissions would have to decline by 20% relative to 2010 levels by 2030, and reach zero by 2075.[25] According to the report, "[b]y the end of 2017, anthropogenic CO_2 emissions since the preindustrial period are estimated to have reduced the total carbon budget for 1.5°C by approximately 2200±320 $GtCO_2$." [26] Further, "[t[he associated remaining budget is being depleted by current emissions of 42± 3 $GTCO_2$ per year."[27] Estimates of the remaining carbon budget to remain under 1.5°C depend on the measure of temperature

[21] Attachment 1, Main Memo at 2.
[22] Intergovernmental Panel on Climate Change (IPCC), Special Report on Global Warming of 1.5 °C (SR15) (October 2018), *available at* https://www.ipcc.ch/sr15/download/.
[23] *See* IPCC, Global Warming of 1.5 °C (Oct. 2018), *available at* http://www.ipcc.ch/report/sr15/.
[24] IPCC, Global Warming of 1.5 °C: Summary for Policy Makers (Oct. 2018), at SPM-15, *available at* http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf.
[25] *Id*.
[26] *Id*. at SPM-16.
[27] *Id*.

effects considered and the probability of success.[28] For a 50% chance of successfully staying under 1.5°C, estimates range from 580 to 770 $GTCO_2$.[29] For a 66% chance, estimates range from 420 to 570 $GTCO_2$.[30]

The report explains that "limiting global warming to 1.5°C …would require rapid and far-reaching transitions," including in energy, "unprecedented in terms of scale."[31] With high confidence, the report finds that, "In 1.5°C pathways with no or limited overshoot, renewables are projected to supply 70–85% (interquartile range) of electricity in 2050."[32] It also acknowledges that current Paris Agreement ambitions will fail to limit warming to 1.5°C, even if additional aggressive emissions goals are pursued *after* 2030: "Estimates of the global emissions outcome of current nationally stated mitigation ambitions as submitted under the Paris Agreement would lead to global greenhouse gas emissions in 2030 of 52–58 $GtCO_2$eq yr-1 (*medium confidence).* Pathways reflecting these ambitions would not limit global warming to 1.5°C, even if supplemented by very challenging increases in the scale and ambition of emissions reductions after 2030 (*high confidence*)."[33] With high confidence, the report finds that, "Pathways that limit global warming to 1.5°C with no or limited overshoot show clear emission reductions by 2030 … All but one show a decline in global greenhouse gas emissions to below 35 $GtCO_2$eq yr-1 in 2030, and half of available pathways fall within the 25–30 $GtCO_2$eq yr-1 range (interquartile range), a 40–50% reduction from 2010 levels."[34] Alarmingly, the report also finds, "Pathways reflecting current nationally stated mitigation ambition until 2030 are broadly

[28] *Id*. at SPM-16.
[29] *Id*.
[30] *Id*. The report also notes the sources of uncertainty in the budget estimates: "Uncertainties in the climate response to CO_2 and non-CO_2 emissions contribute ±400 $GtCO_2$ and the level of historic warming contributes ±250 $GtCO_2$ (*medium confidence*). Potential additional carbon release from future permafrost thawing and methane release from wetlands would reduce budgets by up to 100 $GtCO_2$ over the course of this century and more thereafter (*medium confidence*). In addition, the level of non-CO_2 mitigation in the future could alter the remaining carbon budget by 250 $GtCO_2$ in either direction (*medium confidence*)." 2018 IPCC Report at SPM-16.
[31] *Id*. at SPM-21.
[32] *Id*.
[33] *Id*. at SPM-24.
[34] *Id*.

consistent with cost-effective pathways that result in a global warming of about 3°C by 2100, with warming continuing afterwards (*medium confidence*).”[35]

As Dr. Hudiburg explains, the RDEIS and supporting documents fail to provide consideration of the effects of the proposed treatments on the overall landscape-level carbon balance: “Whole-ecosystem carbon balance is ignored: No process-based models or data are used to evaluate the net effects of the proposed treatments on landscape carbon storage and sequestration.” [36] Instead of quantitatively evaluating changes in net carbon emissions over time resulting from the proposed treatments, and under each alternative, “The Carbon Supplemental report assumptions about carbon balance impacts of the proposed treatments are based on *qualitative* extrapolations from select literature rather than formal quantitative modeling.”[37] The limited quantitative estimates that the Carbon Supplemental report does present are not an adequate basis for evaluating and comparing the full carbon impacts of the proposed alternatives for a number of reasons detailed by Dr. Hudiburg.[38]

The obvious importance of maintaining and improving carbon carrying capacity as an ecosystem service is to address climate change, and contribute to reductions consistent with avoiding extreme impacts scenarios that will otherwise occur. Thus, the failure to evaluate the carbon emissions from the alternatives in a manner that takes into account the timing of changes in the net emissions with regard to avoiding the worst impacts of climate change is arbitrary and capricious, violates NEPA by distorting the comparison of alternatives and failing to take a hard look at the impact. Further, due to this flaw, the Forest Service’s analysis of the extent to which the plans provide for the “ecosystem service” of “long term storage of carbon,” 36 C.F.R. §§ 219.10, 219.19, is distorted, and findings based upon that distorted analysis would be arbitrary

[35] *Id*.

[36] *See* Attachment 1, Supplemental Material: Flaws, misrepresentation of study conclusions and data, and apparent contradictions, at 1–2.

[37] *See* Attachment 1, Supplemental Material: Flaws, misrepresentation of study conclusions and data, and apparent contradictions, at 1–2 (emphasis added).

[38] *See* Attachment 1, Supplemental Material: Flaws, misrepresentation of study conclusions and data, and apparent contradictions, at 2 (points 2(b) through 2(d)); *id*. at 3 (point 3(a)) (explaining why the “Westerling 2015” relied upon by USFS “inhibits a meaningful estimation of ecosystem carbon impacts of potential treatments” as it does not account for “treatment losses” and therefore does not present “net emissions”).

and capricious. This flaw also violates the NFMA requirement to base decisions on the best available scientific evidence.

C. The RDEIS Relies on Faulty Assumptions about Mechanical Thinning Reducing Wildfire

The RDEIS focuses exclusively on improving long-term carbon stability through active "restoration" measures purported to improve forest resilience and reduce future high-severity wildfires. The assumption that vegetation treatment will reduce the incidence and severity of wildfires is flawed. While scientific evidence suggests that anthropogenic climate change is contributing to a longer fire season and more acres burned in California, scientific studies have not found significant trends in fire severity in California's forests in terms of proportion, area, and/or patch size, including recent studies by Picotte et al. 2016 (California forest and woodland) and Keyser and Westerling 2017 (California forests).[39] Most recently, Keyser and Westerling (2017) tested trends for high severity fire occurrence for western United States forests, for each state and each month. The study found no significant trend in high severity fire occurrence during 1984-2014, except for Colorado. The study also found no significant increase in high severity fire occurrence by month during May through October, and no correlation between fraction of high severity fire and total fire size. Furthermore, 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.[40]

Thus, by relying on an inflated estimate of how much high severity fire will occur in the future, the RDEIS inflates the carbon emissions associated with such fires, and inflates the future carbon reductions associated with avoiding them.

[39] Picotte, J.J. et al., 1984-2010 trends in fire burn severity and area for the coterminous US, 25 International Journal of Wildland Fire 413 (2016); Keyser, A. and A.L. Westerling, Climate drives interannual variability in probability of high severity fire occurrence in the western United States, 12 Environmental Research Letters 065003 (2017).

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

Moreover, as Dr. Hudiburg states: "Mechanical thinning rarely reduces the risk of wildfire, has never been shown to reduce the risk of drought mortality and rarely reduces risk of insect-related mortality. The [R]DEIS calls for large-diameter (> 20 inches DBH) mechanical thinning to reduce both fire severity and carbon emissions from wildfire. However, the use of thinning to reduce burn severity and tree mortality in subsequent (post-treatment) wildfires is highly contested, and may in some circumstances increase burn severity and tree mortality."[41] Dr. Hudiburg provides a detailed explanation of how mechanical thinning fails to remove, *and actually increases*, surface fuels, and summarizes available studies to explain why the purported impact of mechanical thinning on reducing wildfire risk is overstated.[42]

Further, the RDEIS fails to adequately address whether the proposed plans under alternatives B and D impose requirements to ensure that the idealized purported carbon benefits from mechanical thinning would be realized. Specifically, the studies relied upon by the Forest Service make assumptions about what kind of mechanical thinning operations will be conducted. The conclusions of those studies regarding the effectiveness of the thinning operations in reducing wildfires therefore turn on satisfying those assumptions. It is irrational to assume that those assumptions will be met in actual thinning operations conducted under alternatives B and D in the absence of adequate and specific provisions in the plans to ensure that actual conditions are consistent with those assumed in the relied upon studies. As Dr. Hudiburg explains, "Large tree removal strategies recommended in [R]DEIS v.1 directly contradict the low biomass-removal strategy highlighted in the Carbon Supplemental [report]…. The proposed relaxation of large tree diameter cutoffs and emphasis on stand structural heterogeneity at the cost of large tree biomass in the [R]DEIS v1 is in direct conflict with thinning aimed towards minimum carbon loss (proposed in the Carbon Supplemental) and with leaving large, fire-tolerant trees and modifying stand structure for high resistance to fire (i.e. removal of ground and ladder fuels."[43]

Consequently, the assertions and assumptions in the RDEIS that mechanical thinning will avoid the carbon emissions associated with more frequent high severity fires are flawed.

---

[41] Attachment 1, Main Memo at 3.
[42] Attachment 1, Main Memo at 3.
[43] Attachment 1, Supplemental Material: Flaws, misrepresentation of study conclusions and data, and apparent contradictions at 1 (internal citation omitted).

These flaws violate NEPA by distorting the comparison of alternatives and failing to take a hard look at the true impact of the plans. Moreover, due to these flaws, the Forest Service's analysis of the extent to which the plans provide for the "ecosystem service" of "long term storage of carbon," 36 C.F.R. §§ 219.10, 219.19, is distorted, and findings based upon that distorted analysis would be arbitrary and capricious. These flaws also violate the NFMA requirement to base decisions on the best available scientific evidence.

D. The RDEIS Fails to Evaluate the Carbon Emissions from Timber Harvesting in Comparing Alternatives with Regard to Impacts on Carbon Carrying Capacity

Only "forest restoration" actions and their relationship to forest stressors (e.g., uncharacteristically large wildfires, tree mortality from crowding, draught, insects) are considered in the sections of the RDEIS comparing alternatives based on impacts on carbon carrying capacity. The RDEIS does not appear to calculate or account for greenhouse gas emissions, changes in carbon storage, or sequestering capacity related to timber harvesting for any of the alternatives.

In logging operations, 28% of the carbon in felled trees is emitted from the burning of logging "slash" debris (branches from felled trees), and 53% of the remaining tree carbon is then lost almost immediately to the atmosphere through the milling and manufacturing process. [44] This means that about *two-thirds* of the carbon stored in the trees that are logged is emitted into the atmosphere. Logging not only removes the carbon stored in trees from forest ecosystems, but it also compacts and damages soils, removes vital nutrients that are stored in trees, and disturbs the carbon contained in soils.[45] All of these impacts from logging combine to

[44] Harmon, M.E., et al. 1996. Modeling carbon stores in OR and WA forest products: 1900-1992. Climatic Change 33: 21- 50.
[45] Elliot, W.J., et al. 1996. The effects of forest management on erosion and soil productivity. Symposium on Soil Quality and Erosion Interaction. July 7, 1996, Keystone, CO; Helmisaari, H.S., et al. 2011. Logging residue removal after thinning in Nordic boreal forests: Long-term impact on tree growth. Forest Ecology and Management 261: 1919-27; Achat, D.L., et al. 2015. Forest soil carbon is threatened by intensive biomass harvesting. Scientific Reports 5: Article 15991.

significantly reduce forest productivity (the rate at which trees and plants will grow), which substantially reduces the capacity of our forest ecosystems to absorb, sequester, and store CO_2 over time.

The fuel required for felling, loading, and hauling of felled trees to the sawmill or biomass facility also add carbon to the atmosphere, yet those carbon emissions are not considered.[46]

E. The Artificially Inflated Carbon Benefits Resulting from the Flawed Analysis Described Above Undermine the Comparison of Alternatives with Regard to the Impacts of Wilderness Designation

The RDEIS portrays high-severity wildfires as inevitable in untreated areas and wholly negative for the ecosystem and carbon sequestration. This is used as part of the rationale not to recommend hundreds of thousands of acres of wilderness-quality lands as new wilderness. The RDEIS in its Analytical Conclusions section concludes that Alternative D, with the most thinning and logging, would provide the best carbon sequestration outcomes. Alternative C, with the most recommended new wilderness and least logging, is portrayed as having the worst carbon sequestration outcomes—except for the No-Action Alternative. This conclusion relies on a series of flawed assumptions as described above. Consequently, the comparison of the impacts of alternatives with regard to the impacts of wilderness designation is also flawed.

F. The Timber Suitability Determination Fails to Address the Need to Improve the Carbon Carrying Capacity of the Forests to Address Climate Change

i. The Timber Suitability Determination Fails to Account for Desired Condition TERR-FW-DC 07, Pertaining to Carbon Carrying Capacity

The RDEIS concludes that the only "land categories [that] have objectives or desired conditions that are not compatible with timber production and are not suitable" are:

- Recommended wilderness areas included in each alternative.
- The corridor (approximately one quarter-mile on each side) surrounding wild river segments of eligible wild and scenic rivers.

---

[46] The impacts of PM2.5 fine particulate matter from those same sources should also be considered in the analysis of air and soil pollution.

- Areas identified as valuable California spotted owl habitat are as follows: Alternatives A, B, and D recognized California spotted owl protected activity centers, while alternatives C and E recognized the California spotted owl home range core area. Home range core area is used as a proxy for high-value forested habitat in California spotted owl territories, and does include protected activity centers. The row is labeled protected activity centers in the tables, but note that this applies to home range core areas for alternatives C and E.
- Riparian conservation areas (RCA), including RCA for perennial, intermittent, and ephemeral streams, plus special aquatic features for Alternatives B, C, and E. RCA for perennial and intermittent streams, plus special aquatic features for Alternative D.
- Backcountry Management Areas for Alternative E.

RDEIS at F-3. The RDEIS does not provide a rational explanation of how timber production is compatible with the forest-wide desired condition that: "The carbon carrying capacity for a given ecosystem is stable or improving, given trends in climate change, fire, insects, disease, and drought." (TERR-FW-DC 07). As discussed above, logging affects both carbon storage and forest productivity (the rate at which trees and plants will grow), which substantially reduces the capacity of the forest ecosystems to absorb, sequester, and store CO_2 over time, thereby diminishing carbon carrying capacity.

The RDEIS also fails to consider this factor in relation to the mechanical thinning that it asserts will reduce long-term emissions by avoiding wildfires. Specifically, the RDEIS fails to consider whether the near term drastic decreases in carbon storage and sequestration that will be caused by mechanical thinning must be offset by avoiding timber production to ensure that the desired condition of maintaining or improving carbon carrying capacity is satisfied.

ii. The Timber Suitability Determination and Proposed Plan More Generally Fails to Account for the Need to Reduce Emissions to Preserve Other Uses

Given the severe impacts of climate change on the lands and resources in the Sierra and Sequoia National Forests that the RDEIS acknowledges, timber production, and the resulting near term carbon emissions from timber production, is not compatible with the uses of those lands for resources such as fish and wildlife, and related desired conditions and objectives. 36 C.F.R. § 219.11(a)(1)(iii). In the proposed plan and RDEIS, USFS has also failed to address how timber harvest could be carried out in a manner consistent with the urgent need to reduce carbon emissions, and therefore with "in a manner consistent with the protection of soil, watershed, fish, [and] wildlife…resources." 36 C.F.R. § 219.11(d)(3).

IV. Failing to Optimize Carbon Carrying Capacity to Avoid Catastrophic Climate Change Impacts is an Abuse of Discretion, and Arbitrary and Capricious

In exercising its discretion to balance uses under MUSYA, and plan for those uses under NFMA, the Forest Service cannot rationally ignore the urgent need to manage the forests in a manner that not only maintains or improves carbon carrying capacity, but optimizes the carbon carrying capacity of the forests in a manner consistent with making the near term reductions in carbon emissions that the October 2018 IPCC report identifies as critical. Forest protection in the U.S. is a vital part of achieving those reductions. More logging occurs in U.S. forests than in any other nation in the world, making the U.S. the largest global problem in terms of carbon emissions from logging.[47] Greenhouse gas emissions from the U.S. constitute about one-quarter of the global total, and much of this is the result of fossil fuel extraction from federal public lands, including 41% of all coal extraction that occurs in the U.S.[48] Increased forest protection could account for approximately *half* of the climate change mitigation needed to keep global temperature rise to 1.5 degrees Celsius or less.[49]

As Dr. Hudiburg explains: "Carbon sequestration in forests is always increased by reducing harvest, by increasing rotation intervals, afforestation, and reforestation of degraded forest lands….There are a multitude of studies that outline the potential for forests to maintain their current rates of sequestration and how to increase them. **By far the most effective methods**

[47] Hansen, M.C., et al. 2013. High-resolution global maps of 21st-century forest cover change. Science 342: 850-53; Prestemon, J.P., et al. 2015. The global position of the U.S. forest products industry. U.S. Forest Service, e-Gen. Tech. Rpt. SRS-204.

[48] *See, e.g.*, 81 Fed. Reg. 17,720, 17,224 (Mar. 30, 2016); Stockholm Environment Institute, *How would phasing out U.S. federal leases for fossil fuel extraction affect CO_2 emissions and 2°C goals?* (May 2016), https://www.sei-international.org/mediamanager/documents/Publications/Climate/SEI-WP-2016-02-US-fossilfuel-leases.pdf.

[49] Erb, K.H., et al. 2018. Unexpectedly large impact of forest management and grazing on global vegetation biomass. Nature 553: 73-76. Griscom, B.W., et al. 2017. Proceedings of the National Academy of Sciences, Vol. 114, pp. 11645-50.

are reduction in harvest and deforestation. In other words, leave live biomass on the landscape for longer periods of time and carbon stocks will increase."[50]

The purpose and need that the USFS 2012 planning rules were promulgated to address specifically included: "Contribut[ing] to ecological, social, and economic sustainability by ensuring that all plans *will be responsive* and can adapt *to issues such as the challenges of climate change*; the need for forest restoration and conservation, watershed protection, and species conservation; and the sustainable use of public lands to support vibrant communities." 77 Fed. Reg. at 21,164 (emphasis added). Notably, that purpose and need was specified distinctly from the purpose and need to emphasize restoration to make the lands resilient to climate change. *See id*.

The Forest Service has in the past articulated its position regarding how to balance carbon reduction benefits with other land uses as follows: "Taking any tradeoffs into account, the Forest Service will work with partners *to sustain or increase carbon sequestration and storage* in forest and grassland ecosystems and to generate forest products that reduce and replace fossil fuel use. The Forest Service will balance its mitigation efforts with all other benefits that Americans get from healthy, resilient forests and grasslands, such as wildlife habitat, wood fiber, water quantity and quality, and opportunities for outdoor recreation." National Roadmap for Responding to Climate Change, FS-957b (February 2011), at 20 (emphasis added).

The emergency need for reductions described in the 2018 IPCC report makes clear that the value of the forests for climate mitigation (i.e. reducing carbon emissions) is even higher than realized at the time the National Roadmap was developed. In balancing the value of using forest lands to maximize carbon storage and sequestration to mitigate climate change, the Forest Service cannot rationally discount the extreme urgency identified by the 2018 IPCC report, nor the role of land conservation in achieving the reductions necessary by 2030.

Further, to the extent that the Service is balancing the value of mitigation via increased carbon storage and sequestration against purely economic benefits (such as benefits from the sale of logged or salvaged timber), the Service should be conducting an explicit cost-benefit analysis to ensure that there are in fact net economic benefits when the impacts of not avoiding carbon emissions are taken into account. In other words, the Service should monetize the value of avoided emissions that are being forsaken for the economic activity.

---

[50] Attachment 1, Main Memo at 4.

Due to the failure of the RDEIS to provide an assessment specifically of how the timing, extent, and certainty of changes in net carbon emissions under each alternative compare against the urgent need for reductions by 2030, it does not provide an adequate basis for the Service to assert that it is rationally balancing the benefits of climate mitigation efforts with other benefits, let alone optimizing climate mitigation efforts.

V. Other Issues

A. Strategic Fuel Breaks

Incorporating strategic fuel breaks into potential wilderness and roadless areas, even by "cherry stemming," could fragment those areas, and lead to degradation, and therefore is inappropriate. Strategic fuel breaks should not be planned in potential wilderness and roadless areas.

B. Fuel Management Zones

Sierra Club continues to assert the points raised in its 2016 comments on the DEIS that forest plan WUI size is not supported by science, and that science supports treating the home ignition zone and the 200 feet immediately surrounding homes to protect communities. Thus, Sierra Club rejects the proposed Fuel Management Zones presented in the RDEIS. Sierra Club does not support adoption of any alternative that would incorporate, or have the effect of incorporating, the proposed Fuel Management Zones as part of the revised plans.

C. Inadequate Basis for Treatment Levels in Vegetation Management Direction

Thee RDEIS selects arbitrary treatment thresholds (15%, 30%, and 60%) to anticipate the effects of the various alternatives. Instead of identifying potentially appropriate treatment levels based on mapped data of current fuel loads and fire behavior, and then analyzing the impacts associated with those levels, the RDEIS and plan consider instead treatment levels that do not bear a relationship to actual forest conditions. Without knowledge of the current conditions, and how far they are from the desired conditions, it is not possible to meaningfully compare the impacts of alternatives on moving from current to desired conditions. As one of the management goals is to restore natural fire regimes and characteristic vegetation structure and compositions, establishing current conditions regarding fire is needed to determine how to achieve that goal. The failure to collect the necessary data to establish and describe baseline conditions, and conduct a meaningful analysis of impacts in light of those conditions violates NEPA. *See* 40 C.F.R. §§ 1502.15, 1502.22; *see also Half Moon Bay Fisherman's Marketing Ass'n v. Carlucci*, 857 F.2d 505, 510 (9th Cir. 1988).

D. Forestwide Components for Terrestrial Ecosystems

As explained in detail above, the Forest Service's analysis of the need for and impacts of mechanical thinning are deeply flawed. In the Plan, Objective TERR-FW-OBJ-01 currently says, "Restore forest structure and composition on 7,500 to 12,000 acres of the montane, upper montane, and portions of the foothill landscape, using primarily mechanical treatment, within 15 years following plan approval." Standard TERR-FW-STD sets a 30" diameter limit for conifer removal with exceptions for larger ones. A limitation to remove conifer trees 30 inches and sometimes greater is not appropriate or adequately protective to ensure that the harmful impacts of mechanical thinning are avoided, nor is it appropriate or sufficient to ensure that carbon concerns are addressed appropriately. Nor would a limitation to remove surface and ladder fuels "generally less than 16" dbh" be adequately protective to meet those ends.

With regard to TERR-FW-OBJ-01 and related plan components, we recommend the following changes:

> Revise Objective TERR-FW-OBJ-01 to say, "Prioritize wildland fire use (allowing more mixed-intensity wildland fires from lightning strikes to occur, particularly in more remote forests."
>
> Associated Guideline: "Wildland fire use will be the priority for management, especially in more remote forests. Where vegetation management does occur for fire management purposes, such activities shall involve removal of surface and ladder fuels less than 10 inches in diameter."

In connection with this point, we note that the notion that dense, long-unburned forests must be "thinned" through logging operations prior to reintroducing fire is simply not scientifically supported, and is directly contradicted by a wealth of scientific data.[51]

---

[51] *See* Keifer, M.B., 1998. Fuel load and tree density changes following prescribed fire in the giant sequoia-mixed conifer forest: the first 14 years of fire effects monitoring. In: Proceedings

E. Old Forests

The logging of mature trees is not appropriate. We recommend revising guideline TERR-OLD-GLD-01 to include an express statement that large trees should not be removed.

F. Burned Forests and Complex Early Seral Forests

To address concerns about burned forests and complex early seral forests, USFS should include a guideline in the forest plans stating: "The salvage of dead and dying trees should not occur, except in narrow circumstances where public life and property are at risk." This change is necessary to prevent unnecessary tree removal taken under the guise of being "strategic to future fire suppression" where there is no *present* demonstrable need to remove the dead or dying trees to protect life or property. Further, economic recovery should not be a goal of decisions about whether to salvage or leave in place dead and dying trees post-disturbance. USFS should include

---

of the Tall Timbers Fire Ecology Conf., vol. 20. pp. 306–309; Stephens, S.L., Finney, M.A., 2002. Prescribed fire mortality of Sierra Nevada mixed conifer tree species: effects of crown damage and forest floor combustion. For. Ecol. Manage. 162, 261–271; Fulé, P.Z., Cocke, A.E., Heinlein, T.A., Covington, W.W., 2004. Effects of an intense prescribed forest fire: is it ecological restoration? Restoration Ecology 12, 220–230; Schwilk, D.W., Knapp, E.E., Ferrenberg, S.M., Keeley, J.E., Caprio, A.C., 2006. Tree mor- tality from fire and bark beetles following early and late season prescribed fires in a Sierra Nevada mixed-conifer forest. Forest Ecology and Management 232, 36–45; van Mantgem, P.J., J.C.B. Nesmith, M. Keifer, and M. Brooks. 2013. Tree mortality patterns following prescribed fire for *Pinus* and *Abies* across the southwestern United States. Forest Ecology and Management 289: 463-469; van Mantgem, P.J., A.C. Caprio, N.L. Stephenson, and A.J. Das. 2016. Does prescribed fire promote resistance to drought in low elevation forests of the Sierra Nevada, California, USA? Fire Ecology 12: 13-25; van Mantgem, P.J., N.L. Stephenson, J.J. Battles, E.K. Knapp, and J.E. Keeley. 2011. Long-term effects of prescribed fire on mixed conifer forest structure in the Sierra Nevada, California. Forest Ecology and Management 261: 989−994.

language in the plans to clarify that: "Post-disturbance restoration projects should be designed such that recovery of economic value is not among the purposes of projects."

G. Backcountry Management Areas

The use of Backcountry Management Areas is not an appropriate substitute for recommending lands as Wilderness, and should not be a strategy for avoiding recommending Wilderness designation.

H. Protections for California Spotted Owl and Other Species

No logging should occur in Protected Activity Centers (PACs) for California Spotted Owl. Nor should logging occur in Home Range Core Areas surrounding PACs. Logging should also be excluded from the habitats of Pacific fisher, Northern goshawks, yellow legged frogs and great gray owls. These areas are not suitable for timber production, and should be excluded from it.

VI. Conclusion

For the reasons articulated in this letter, the Forest Service has failed to provide an adequate analysis of alternative plans, and has failed to ensure that its choice of plan will rationally address the realities of climate change, and otherwise adequately protect and sustain forest species and resources.

If you have any questions about this comment letter, please contact Sierra Club attorney Karimah Schoenhut at the phone number or e-mail address listed below.

Sincerely,

Karimah Schoenhut
Staff Attorney
Sierra Club
Environmental Law Program
50 F St NW, Eighth Floor
Washington, DC 20001
202-548-4584
karimah.schoenhut@sierraclub.org

ATTACHMENT 1 – Expert Report of Dr. Tara Hudiburg

TCI
Terrestrial Carbon Institute LLC
511 E C St.
Moscow, ID 83842

September 25, 2019

RE: California National Forest Management Plans

To Whom It May Concern:

Please find enclosed a review of the documents: Sierra, Inyo, and Sequoia National Forest Carbon Supplemental Report and the Revised Draft Environmental Impact Statement for Revision of the Sequoia and Sierra National Forests Land Management Plans (DEIS).

My company (TCI) and I are exceptionally qualified to perform this review. I have a PhD in Forest Science from Oregon State University and I am an associate professor (with tenure) in the Department of Forest, Rangeland, and Fire Sciences at the University of Idaho. I am a National Science Foundation Early Career Award recipient and I was recently awarded the Presidential Early Career Award in Science and Engineering (PECASE). The PECASE is the highest honor bestowed by the United States Government to outstanding scientists and engineers who are beginning research careers and who show exceptional promise for leadership in science and technology. I was awarded the PECASE specifically for my novel research on understanding the impacts of climate, fire, and management practices on forest carbon cycling.

Our review finds the document are lacking in the best available science and in many cases conflict with carbon sequestration goals. The intent to allow for mid-to-large diameter tree removal (unrestricted) will most assuredly increase carbon emissions to the atmosphere. Wildfire fuels reduction and forest restoration should focus on surface (forest floor) and ladder fuel removal (suppressed small-diameter trees and saplings).

Sincerely,

Tara W. Hudiburg, PhD
Director, Terrestrial Carbon Institute
Email: tara.hudiburg@gmail.com; Cell: 360.204.1019

September 25, 2019

RE: Sierra, Inyo, and Sequoia National Forest Carbon Stability and the Revised Draft Environmental Impact Statement for Revision of the Sequoia and Sierra National Forests Land Management Plans (DEIS)

Authors: Tara Hudiburg, PhD; Jeffrey Stenzel, MS; Kristina Bartiwitz, MS

Summary:

1. **Mechanical thinning does not reduce carbon dioxide emissions to the atmosphere, it increases them.**

2. **Models used to calculate carbon emissions from wildfire are overestimating combustion (and therefore carbon emissions) in order to arrive at treatment conclusions.**

3. **Mechanical thinning rarely reduces the risk of wildfire, has never been shown to reduce the risk of drought mortality and rarely reduces risk of insect-related mortality.**

4. **Carbon sequestration in forests is always increased by reducing harvest, by increasing rotation intervals, afforestation, and reforestation of degraded forest lands.**

(1) Mechanical thinning does not reduce emissions to the atmosphere, it increases them

Mechanical thinning always increases carbon dioxide emissions to the atmosphere in the short-term (< 20 years;[1-5]) and can increase emissions in the long-term (>50 years, [2,4,6]).

Thinning is inherently an inefficient method for increasing carbon sequestration because the amount of carbon removed at landscape scales (not stand scales) is always greater than the amount that can be saved through avoided emissions [7,8]. Studies show that thinning for fuel reduction can require up to 10 times the treatment area compared to the fire area that would actually occur [8]. It is true that some of the removed carbon will be re-sequestered by the remaining trees, but this is a process that occurs over **decades to centuries**, especially when mid-to-large-diameter trees[1] are removed as suggested by this plan (DEIS v1).

[1] Mid-to-large-diameter trees have a diameter-at-breast height (DBH) greater than 12 inches (the diameter cutoff for merchantable wood). Large-diameter trees are greater than 20 inches DBH and are best for producing structural wood products.

Thinning also results in large short and long-term emissions due to the decomposition of the killed material that is left on site (e.g. all root mass, stumps, debris), on-site slash combustion (fire), and emissions from wood product chain waste and decomposition. Most wood product carbon (especially from thinning operations) is returned to the atmosphere within 1-2 years ([9-11]).

Finally, **thinning removes live trees** that were actively sequestering carbon through their leaf area. At stand and landscape levels, **thinning that decreases overstory tree density results in immediate reductions in the amount of carbon** that can be sequestered by intact ecosystems for years to decades.

Only by ignoring non-wildfire carbon fluxes does thinning appear to result in carbon emission reductions. The reductions are entirely dependent on the predicted fire emissions definitely occurring and that the predicted emissions are more than the included thinning emissions.

(2) Models used to calculate carbon emissions from wildfire are overestimating combustion (and therefore carbon emissions) in order to arrive at treatment conclusions.

The carbon benefits of landscape-level thinning to avoid emissions from wildfire hinge largely on incorrect model predictions of wildfire combustion. In a recent analysis of fire model shortcomings (Stenzel et al. 2019) we found that extreme over-combustion of live trees in models (>10 times) is contributing to a doubling of estimated fire emissions across the western U.S. These estimates are even more pronounced in old-growth forests in the Sierra Nevada. While combustion of live trees is typically less than 5% for mature trees in the fire-prone west [12-15], researchers have been implementing up to 80% tree combustion when examining the tradeoffs of wildfire and thinning losses[16-20].

The fire emissions modeling performed specifically for the management plans ("Final Report: Changing fire, fuels and climate in the Sierra Nevada"; referred to as Westerling 2015 in the plan documents) similarly generates unrealistic carbon savings. **The report is also not peer-reviewed.** The report does not consider any treatment losses associated with restoration, including significant emissions from prescribed fire or thinning. The report overestimates combustion by using only the “upper bound” emissions methods from another study [21]. All fire is assumed to burn at the highest severity and is preferentially applied to the highest biomass within each area, ignoring spatial and structural reality. Furthermore, the report unrealistically assumes permanent fuels reductions in future projections, leading to artificially large emissions reductions in restoration scenarios; in reality, fuel treatment lifetimes range from 1 to 2 decades[7]. Finally, fuels are static, allowing no negative feedback between fire and fuels (meaning a reduction of fuels after fire does not reduce the risk of fire or the amount that can burn in the next fire). Ultimately, because the statistical modeling employed is not based on biological processes (i.e. “mechanistic”), it cannot distinguish the consequences of treatments on fire emissions over decades. **Simultaneously, it says nothing about the net emissions associated with fire and treatment needed to inform carbon management.**

Overall, when modeled combustion is overestimated and is greater than thinning losses as a result, it is trivial to show that thinning will avoid emissions [22]. Even if thinning and fire mortality are equal, **thinning assuredly releases carbon** and at a much faster rate than potential fire. This is because thinned biomass is immediately utilized or burned, releasing the carbon to the atmosphere faster than if the biomass is killed in future fire and allowed to decompose slowly onsite over decades to centuries [7,23].

(3) Mechanical thinning rarely reduces the risk of wildfire, has never been shown to reduce the risk of drought mortality and rarely reduces risk of insect-related mortality.

The DEIS calls for large-diameter (> 20 inches DBH) mechanical thinning to reduce both fire severity and carbon emissions from wildfire. **However, the use of thinning to reduce burn severity and tree mortality in subsequent (post-treatment) wildfires is highly contested, and may in some circumstances increase burn severity and tree mortality.** Fire severity and level of tree mortality is highly context-specific and depends upon forest type, fire weather, and fuel aridity.

Surface and ladder fuels are those that are most likely to burn and cause fire spread; treatment of surface fuels can reduce fire severity [24]. Mechanical thinning removes mid-to-large diameter trees (> 12 inches DBH) which are not part of the main fuel pools that lead to increased fire spread and severity. **Mechanical thinning does not remove surface fuels** and increases the amount surface fuel due to slash, which may lead to more crown scorch and tree mortality [25]. In other words, not only does mechanical thinning not remove surface fuels, in many cases it increases this pool while decreasing the number of large trees on a landscape that are the largest aboveground carbon pool.

Case studies on specific fires showing the impacts of pre-fire treatments on fire severity and tree mortality do not show clear-cut trends; some case studies shown lower fire severity in treated areas while some studies show higher fire severity in treated areas. Fire severity was higher in forests that had been thinned and logged prior to the 2002 Biscuit Fire in southern OR [25,26]. Thinned plots in MT and WA also experienced increased fire severity due to increased slash (surface fuel) availability post-treatment [27]. Decreasing surface fuels has been shown to be the most effective to reduce potential for crown fire and tree mortality [28], here these authors encouraged retaining large trees to increase overall forest resilience to fire. The efficacy of thinning may depend on the removal of slash following treatment (through prescribed burning), as well as the very unlikely occurrence of wildfire within the timeframe of treatment effectiveness (i.e. before fuels grow back)[29]. Extreme fire weather and dryness of fuels may also override any fire severity and spread reductions that fuel treatments may achieve [30-32].

A western US-wide study showed that increased forest protection (i.e. less management and treatment of forests) had lower severity wildfire than areas with lower forest protection (i.e. higher amounts of forest treatment) [29]. Finally, intensively managed forests (plantations) in southern OR burned more severely than older, less managed forested areas [33]. Much of this is forest-type specific and depends on fire weather at time of fire. Zald and Dunn 2018 also found that intensive forestry had a greater impact on fire severity than fuels buildup from fire suppression.

Finally, lands with restoration treatments have not significantly influenced tree mortality during the recent widespread drought in California [34]. Thinning has had varied impact on post-treatment beetle outbreaks, with studies showing both increased and decreased mortality in outbreaks with treatment. which again, is forest-type dependent and contingent on other factors such as tree stress from wildfire and on-going drought [35].

The DEIS report does not address ladder and surface fuel removal and instead focuses on live tree removal which is contrary to the best available science for increasing carbon sequestration.

<u>(4) Carbon sequestration in forests is always increased by reducing harvest, by increasing rotation intervals, afforestation, and reforestation of degraded forest lands.</u>

The United Nations Sustainable Development Goal 15 calls for protection of *Life on Land* including forests [36]. The 2018 IPCC 1.5 degree special report [37] mandated that we must not only achieve zero emissions but that we also must achieve negative emissions. Forests are suggested as way to achieve negative emissions through increased sequestration.

There are a multitude of studies [38-40] that outline the potential for forests to maintain their current rates of sequestration and how to increase them. **By far the most effective methods are reduction in harvest and deforestation**. In other words, leave live biomass on the landscape for longer periods of time and carbon stocks will increase.

Intensifying management as the DEIS plan outlines **will not improve forest resiliency** because the methods of intervention (roads, machinery, humans, etc) will likely cause more damage in the process of trying to restore ecosystems to an assumed historical structure than save trees from mortality (see number 3 above). However, climate change will affect forest carbon sink potential and some forests will become carbon sources in California as mortality and decomposition exceed growth [41]. Because there is very little that restoration practices can accomplish to prevent this (again see number 3 above), we argue that **leaving forests alone is the best practice.**

These reports and society are not treating the symptom. Small-diameter thinning is a zero-sum game at best for carbon storage. Reversing climate change impacts by reducing fossil fuel and biogenic emissions (treating the actual problem) will actually increase forest carbon uptake and resiliency.

References

1 Hudiburg, T. W., Law, B. E., Wirth, C. & Luyssaert, S. Regional carbon dioxide implications of forest bioenergy production. *Nature Climate Change* **1**, 419-423, doi:10.1038/nclimate1264 (2011).
2 Hudiburg, T. W., Luyssaert, S., Thornton, P. E. & Law, B. E. Interactive Effects of Environmental Change and Management Strategies on Regional Forest Carbon Emissions. *Environmental Science & Technology* **47**, 13132-13140, doi:10.1021/es402903u (2013).
3 Mitchell, S. R., Harmon, M. E. & O'Connel, K. E. B. Forest fuel reduction alters fire severity and long-term carbon storage in three Pacific Northwest ecosystems. *Ecological Applications* **19** (2009).
4 Mitchell, S. R., Harmon, M. E. & O'Connell, K. E. B. Carbon debt and carbon sequestration parity in forest bioenergy production. *GCB Bioenergy*, n/a-n/a (2012).
5 McKechnie, J., Colombo, S., Chen, J., Mabee, W. & MacLean, H. L. Forest Bioenergy or Forest Carbon? Assessing Trade-Offs in Greenhouse Gas Mitigation with Wood-Based Fuels. *Environmental Science & Technology* **45**, 789-795 (2011).
6 Law, B. E., Hudiburg, T. W. & Luyssaert, S. Thinning effects on forest productivity: consequences of preserving old forests and mitigating impacts of fire and drought. *Plant Ecology & Diversity* **6**, 73-85, doi:10.1080/17550874.2012.679013 (2013).
7 Campbell, J. L., Harmon, M. E. & Mitchell, S. R. 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, doi:10.1890/110057 (2012).
8 Campbell, J. L. & Ager, A. A. Forest wildfire, fuel reduction treatments, and landscape carbon stocks: A sensitivity analysis. *Journal of Environmental Management* **121**, 124-132, doi:10.1016/j.jenvman.2013.02.009 (2013).
9 Hudiburg, T. W., Law, B. E., Moomaw, W. R., Harmon, M. E. & Stenzel, J. E. Meeting regional GHG reduction targets requires accounting for all forest sector emissions. *Environmental Research Letters* **14**, 095005 (2019).
10 Stockmann, K. D. *et al.* Estimates of carbon stored in harvested wood products from the United States forest service northern region, 1906-2010. *Carbon Balance and Management* **7**, 1, doi:10.1186/1750-0680-7-1 (2012).
11 Smyth, C., Rampley, G., Lemprière, T. C., Schwab, O. & Kurz, W. A. Estimating product and energy substitution benefits in national-scale mitigation analyses for Canada. *Gcb Bioenergy* **9**, 1071-1084 (2017).
12 Campbell, J., Donato, D., Azuma, D. & Law, B. Pyrogenic carbon emission from a large wildfire in Oregon, United States. *Journal of Geophysical Research: Biogeosciences* **112**, G04014, doi:10.1029/2007JG000451 (2007).
13 Ghimire, B., Williams, C. A., Collatz, G. J. & Vanderhoof, M. Fire-induced carbon emissions and regrowth uptake in western U.S. forests: Documenting variation across forest types, fire severity, and climate regions. *Journal of Geophysical Research: Biogeosciences* **117**, doi:doi:10.1029/2011JG001935 (2012).

14 Harris, L. B., Scholl, A. E., Young, A. B., Estes, B. L. & Taylor, A. H. Spatial and temporal dynamics of 20th century carbon storage and emissions after wildfire in an old-growth forest landscape. *Forest Ecology and Management* **449**, 117461 (2019).

15 Meigs, G., Donato, D., Campbell, J., Martin, J. & Law, B. Forest fire impacts on carbon uptake, storage, and emission: the role of burn severity in the Eastern Cascades, Oregon. *Ecosystems* **12**, 1246-1267 (2009).

16 Gonzalez, P., Battles, J. J., Collins, B. M., Robards, T. & Saah, D. S. Aboveground live carbon stock changes of California wildland ecosystems, 2001–2010. *Forest Ecology and Management* **348**, 68-77 (2015).

17 Wiedinmyer, C. & Hurteau, M. D. Prescribed fire as a means of reducing forest carbon emissions in the western United States. *Environmental Science & Technology* **44**, 1926-1932 (2010).

18 Liang, S., Hurteau, M. D. & Westerling, A. L. Large-scale restoration increases carbon stability under projected climate and wildfire regimes. *Frontiers in Ecology and the Environment* **16**, 207-212, doi:10.1002/fee.1791 (2018).

19 Liang, S., Hurteau, M. D. & Westerling, A. L. Response of Sierra Nevada forests to projected climate–wildfire interactions. *Global change biology* **23**, 2016-2030 (2017).

20 McCauley, L. A. *et al.* Large-scale forest restoration stabilizes carbon under climate change in Southwest United States. *Ecological Applications*, e01979 (2019).

21 Hurteau, M. D., Westerling, A. L., Wiedinmyer, C. & Bryant, B. P. Projected effects of climate and development on California wildfire emissions through 2100. *Environmental science & technology* **48**, 2298-2304 (2014).

22 Stenzel, J. E. *et al.* Fixing a snag in carbon emissions estimates from wildfires. *Global Change Biology* **0**, doi:10.1111/gcb.14716 (2019).

23 Law, B. E. & Harmon, M. E. Forest sector carbon management, measurement and verification, and discussion of policy related to climate change. *Carbon Management* **2**, 73-84, doi:doi:10.4155/cmt.10.40 (2011).

24 Agee, J. K. & Skinner, C. N. Basic principles of forest fuel reduction treatments. *Forest Ecology and Management* **211**, 83-96, doi:10.1016/j.foreco.2005.01.034 (2005).

25 Raymond, C. L. & Peterson, D. L. Fuel treatments alter the effects of wildfire in a mixed-evergreen forest, Oregon, USA. *Canadian Journal of Forest Research* **35**, 2981-2995 (2005).

26 Thompson, J. R., Spies, T. A. & Ganio, L. M. Reburn severity in managed and unmanaged vegetation in a large wildfire. *Proceedings of the National Academy of Sciences* **104**, 10743-10748 (2007).

27 Wimberly, M. C., Cochrane, M. A., Baer, A. D. & Pabst, K. Assessing fuel treatment effectiveness using satellite imagery and spatial statistics. *Ecological Applications* **19**, 1377-1384 (2009).

28 Stephens, S. L. *et al.* Fire treatment effects on vegetation structure, fuels, and potential fire severity in western US forests. *Ecological Applications* **19**, 305-320 (2009).

29 Bradley, C. M., Hanson, C. T. & DellaSala, D. A. Does increased forest protection correspond to higher fire severity in frequent-fire forests of the western United States? *Ecosphere* **7**, e01492 (2016).

30 Bessie, W. & Johnson, E. The relative importance of fuels and weather on fire behavior in subalpine forests. *Ecology* **76**, 747-762 (1995).

31 Hély, C., Flannigan, M., Bergeron, Y. & McRae, D. Role of vegetation and weather on fire behavior in the Canadian mixedwood boreal forest using two fire behavior prediction systems. *Canadian journal of forest research* **31**, 430-441 (2001).

32 Schoennagel, T., Veblen, T. T. & Romme, W. H. The interaction of fire, fuels, and climate across Rocky Mountain forests. *BioScience* **54**, 661-676 (2004).

33 Zald, H. S. & Dunn, C. J. Severe fire weather and intensive forest management increase fire severity in a multi-ownership landscape. *Ecological applications* **28**, 1068-1080 (2018).
34 Lydersen, J. M., Collins, B. M. & Hunsaker, C. T. Implementation constraints limit benefits of restoration treatments in mixed-conifer forests. *International Journal of Wildland Fire* **28**, 495-511 (2019).
35 Fettig, C. J. *et al.* The effectiveness of vegetation management practices for prevention and control of bark beetle infestations in coniferous forests of the western and southern United States. *Forest ecology and management* **238**, 24-53 (2007).
36 UN. *Sustainable Development Goals Report 2017*. (Unite Nations, 2017).
37 IPCC. Summary for Policymakers. In: Global warming of 1.5°C. . (World Meteorological Organization, Geneva, Switzerland, 2018).
38 Law, B. E. *et al.* Land use strategies to mitigate climate change in carbon dense temperate forests. *Proceedings of the National Academy of Sciences*, 201720064 (2018).
39 Canadell, J. G. & Schulze, E. D. Global potential of biospheric carbon management for climate mitigation. **5**, 5282, doi:10.1038/ncomms6282 (2014).
40 Canadell, J. G. & Raupach, M. R. Managing Forests for Climate Change Mitigation. *Science* **320**, 1456-1457, doi:10.1126/science.1155458 (2008).
41 Buotte, P. C. *et al.* Near-future forest vulnerability to drought and fire varies across the western United States. *Global change biology* **25**, 290-303 (2019).

Supplemental Material: Flaws, misrepresentation of study conclusions and data, and apparent contradictions

Summary of methods problems:

1) **Best practices are being ignored:** Large tree removal strategies recommended in DEIS v.1 directly contradict the low biomass-removal strategy highlighted in the Carbon Supplemental Plan.
2) **Whole-ecosystem carbon balance is ignored:** No process-based models or data are used to evaluate the net effects of the proposed treatments on landscape carbon storage and sequestration.
3) **Emissions benefits are exaggerated:** The primary modeling analysis used exaggerates emissions benefits of landscape treatment by ignoring carbon costs of treatments and by using only the highest combustion factors (upper bounds) from previous studies.

Details:

1. **Best practices for carbon sequestration are being ignored**: The proposed relaxation of large tree diameter cutoffs and emphasis on stand structural heterogeneity *at the cost of large tree biomass* in the DEIS v1 is in direct conflict with thinning aimed towards minimum carbon loss (proposed in the Carbon Supplemental) and with leaving large, fire-tolerant trees and modifying stand structure for high resistance to fire (i.e. removal of ground and ladder fuels)(Agee & Skinner, 2005). From a carbon storage point of view, the least harm is done by minimizing live biomass removals (i.e. tree biomass killed through treatment) to achieve fire risk reduction (or other non-carbon management goals)(Campbell, Harmon, & Mitchell, 2012; Hurteau, Robards, et al., 2014). Examples:
    a. (Carbon Supplemental, p 4) "Forest restoration treatments that retain large trees and promote ecological resilience to stressors (e.g., reduction of surface and ladder fuels) are most likely to maximize carbon sequestration and maintain stable carbon stocks over the long term." VERSUS
    b. (Revised Draft Environmental Impact Statement, p 242) "Forest management in mature and old forests can often involve mechanical thinning that may be constrained by diameter limits ("diameter caps"). Such limits prohibit the cutting of large trees above a defined diameter threshold. Although the literature on diameter limits is limited, the available studies suggest that there are clear tradeoffs in achieving multiple forest restoration objectives."

2. **Whole-ecosystem carbon balance is ignored**: No formal scientific analysis (i.e. quantitative and replicable) is made regarding the effects of the proposed treatments on the overall landscape-level carbon balance. Therefore net carbon emissions (including all gains and losses) are not being quantified. Emphasis is placed on calculating fire emissions only, without a complete analysis of the effects of treatments on ecosystem carbon and without the spatially explicit prescriptions for achieving fuel load goals.
    a. The Carbon Supplemental report assumptions about carbon balance impacts of the proposed treatments are based on qualitative extrapolations from select literature rather than formal quantitative modeling for the >1 million acres of proposed treatment

area. This seems irresponsible: (Carbon Supplemental, p 3) *Analysis and Data: Carbon Sequestration*: "A qualitative analysis of carbon sequestration was conducted based upon scientific literature."

b. Quantitative modeling of ecosystem carbon impacts was precluded by a lack of actual treatment prescriptions. Rather, fire emissions calculations in the revision plan are based on 'fuel load conversion outcomes', whose accomplishment is not associated with specific treatments. Also, treatment is reported by area, not by impact magnitude on carbon pools. Examples:
    i. (Carbon Supplemental, p 3) *Analysis and Data: Carbon Stability*: "Future trends in fire, vegetation stability, and smoke emissions were based on general, documented assumptions because the plan is at the programmatic level and specific locations of restoration treatments are not identified."
    ii. (Fire-Climate Supplemental Report, p 1) "The restoration treatments were not modeled in a specific, prescriptive manner but as a broad level pattern to inform impacts at a programmatic level."
    iii. (Final Report: Changing fire, fuels and climate in the Sierra Nevada, pg 16) "Scenarios in every case **equated fuels restoration with converting a fraction of the total area of fuels** in FRCC 2 and FRCC 3 combined to FRCC 1."

c. Primary literature cited for back-of-the-envelope estimates presented in the Carbon Supplemental (e.g. Table 4) is limited to stand scale, location-specific studies that do not reflect landscape-scale realities such as low treatment efficiency (area treated to area burned by wildfire within the treatment lifetime) nor do they include observed responses of treatments to actual wildfire occurrence (Malcolm, Matthew, & James, 2009; North & Hurteau, 2011; Stephens, Moghaddas, Hartsough, Moghaddas, & Clinton, 2009; Wiechmann, Hurteau, North, Koch, & Jerabkova, 2015) .

d. Informal calculations in the Carbon Supplemental assume increased ecosystem productivity (bottom row, Table 4) in all treated area (treatment undefined) based on net biome productivity values from a single, stand-level study (Wiechmann et al., 2015)which is contrary to the findings of most research. While biomass removal can enhance surviving individual tree growth rates, the enhancement of stand or landscape-level carbon sequestration is generally inhibited by a decrease in the total number of live, productive trees as well as damage to productive trees through prescribed fire and mechanical damage (Law, Hudiburg, & Luyssaert, 2013).

Table 4. Estimate of total carbon emissions for each alternative measured in Gigatons (Gg). Emissions are based on estimates of mechanical and prescribed fire treatment acres provided in Table 4 of the FEIS for the Inyo, Sequoia, and Sierra National Forests. Carbon emissions are based on mechanical and prescribed fire treatment estimates from North et al. (2010), Hurteau and North (2009), North and Hurteau (2011), and Stephens et al. (2009). Carbon emissions estimates that include changes in net biome productivity over time are based on Wiechmann et al. (2015).

	Alternative A	Alternative B	Alternative C	Alternative D
Estimated Carbon Emissions (Gg)	322	566	310	989
Estimated Carbon Emissions with Net Ecosystem Productivity (Gg)	157	261	132	449

3. Estimated emissions benefits are misleading:

a. The lack of an ecosystem perspective in the wildfire analysis (Final Report: Changing fire, fuels and climate in the Sierra Nevada) inhibits a meaningful estimation of ecosystem carbon impacts of potential treatments. The report modified Hurteau et al. 2014 methods to include conversion of fuels from higher to lower states and therefore to higher and lower emissions in a fire. This does not translate to **net emissions** because the analysis does not simulate the treatment losses needed for fuels to move from a higher to lower state. No mention or calculation of the carbon associated with live trees is considered in the fire report nor in other cited analyses (Hurteau, Westerling, Wiedinmyer, & Bryant, 2014)despite the central role of tree removals in the revision plan. **Developing thinning management plans around studies that did not specifically implement thinning as a strategy for achieving reduced emissions is wrong and a misuse of study data.**

b. The fire emissions analysis extracts only the most drastic “high combustion, high biomass” scenario from Hurteau et al. 2014. This scenario assumes, per grid cell, that fire occurs at high severity and that it preferentially burns the highest fuel biomass area within the cell. This means that that the dominant factor driving cell fire location is overall biomass stored. This does not incorporate the known structural considerations that determine how biomass structure relates to fire spread (e.g. ground fuels, ladder fuels), nor does it acknowledge the inherent spatial constraints of each fire (e.g. topography, adjacency).

c. The wildfire analysis assumes static fuels, meaning that the benefits of fuel treatments are artificially permanent. In reality, fuel treatments last 1-2 decades due continual production of biomass by ecosystems (Campbell 2012). Static fuels also mean that reductions in fuel from modeled fire do not reduce the risk of fire or emissions in the future, which conflicts with fuels-reductions premise of the revision plan.

References:

Agee, J. K., & Skinner, C. N. (2005). Basic principles of forest fuel reduction treatments, *211*, 83–96. https://doi.org/10.1016/j.foreco.2005.01.034

Campbell, J. L., Harmon, M. E., & Mitchell, S. R. (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*(2), 83–90. https://doi.org/10.1890/110057

Hurteau, M. D., Robards, T. A., Stevens, D., Saah, D., North, M., & Koch, G. W. (2014). Modeling climate and fuel reduction impacts on mixed-conifer forest carbon stocks in the Sierra Nevada, California. *Forest Ecology and Management*, *315*, 30–42. https://doi.org/10.1016/j.foreco.2013.12.012

Hurteau, M. D., Westerling, A. L., Wiedinmyer, C., & Bryant, B. P. (2014). Projected effects of climate and development on California wildfire emissions through 2100. *Environmental Science and Technology*, *48*(4), 2298–2304. https://doi.org/10.1021/es4050133

Law, B. E., Hudiburg, T. W., & Luyssaert, S. (2013). Thinning effects on forest productivity: consequences of preserving old forests and mitigating impacts of fire and drought. *Plant Ecology & Diversity*, *6*(1), 73–85.

Malcolm, N., Matthew, H., & James, I. (2009). Fire suppression and fuels treatment effects on mixed-conifer carbon stocks and emissions. *Ecological Applications*, *19*(6), 1385–1396. https://doi.org/10.1890/08-1173.1

North, M. P., & Hurteau, M. D. (2011). High-severity wildfire effects on carbon stocks and emissions in fuels treated and untreated forest. *Forest Ecology and Management*, *261*(6), 1115–1120. https://doi.org/10.1016/j.foreco.2010.12.039

Stephens, S. L., Moghaddas, J. J., Hartsough, B. R., Moghaddas, E. E. Y., & Clinton, N. E. (2009). Fuel treatment effects on stand-level carbon pools, treatment-related emissions, and fire risk in a Sierra Nevada mixed-conifer forest. *Canadian Journal of Forest Research*, *39*(8), 1538–1547. https://doi.org/10.1139/X09-081

Wiechmann, M. L., Hurteau, M. D., North, M. P., Koch, G. W., & Jerabkova, L. (2015). The carbon balance of reducing wildfire risk and restoring process: an analysis of 10-year post-treatment carbon dynamics in a mixed-conifer forest. *Climatic Change*, *132*(4), 709–719. https://doi.org/10.1007/s10584-015-1450-y

September 2019

Curriculum vitae

Tara W. Hudiburg

Associate Professor
Department of Forest, Rangeland, and Fire Sciences
University of Idaho, Moscow, ID 83843
Tel: 360-204-1019, Email: thudiburg@uidaho.edu, Web: iteamlab.weebly.com

EDUCATION

Ph.D. Forest Ecology (2012), Oregon State University, Corvallis, OR USA
Dissertation: *Analysis of Regional Forest Carbon Balance under Changing Climate, Disturbance, and Management for Bioenergy*
Committee: Dr. Beverly Law (chair), Dr. Peter Thornton, Dr. Richard Waring, Dr. Dominique Bachelet

M.S. Forest Science (2008), Oregon State University, Corvallis, OR USA
Thesis: *Climate, Management, and Forest Type Influences on Carbon Dynamics of US Forests*
Committee: Dr. Beverly Law (chair), Dr. Peter Thornton, Dr. David Turner, Dr. Warren Cohen

B.S. Biology (1998) Pacific Lutheran University, Tacoma, WA USA
Thesis: *Water Relations and Gas Exchange Rates of Red Alder and Big Leaf Maple*

APPOINTMENTS

2019 – Present	Associate Professor, Department of Forest, Rangeland, and Fire Sciences, University of Idaho, Moscow, ID
2014 – 2019	Assistant Professor, Department of Forest, Rangeland, and Fire Sciences, University of Idaho, Moscow, ID
2014 – Present	Affiliate faculty, Environmental Sciences Program, University of Idaho, Moscow, ID
2014 – Present	Affiliate faculty, Ecology and Conservation Biology Program, University of Idaho, Moscow, ID
2012 – 2014	Postdoctoral Research Associate, Department of Plant Biology, Energy Biosciences Institute, University of Illinois Urbana-Champaign, Urbana, IL

HONORS AND AWARDS

2019	Presidential Early Career Award for Scientists and Engineers (PECASE)
2016	NSF Early CAREER Award
2016	Outstanding Faculty Research Award, College of Natural Resources, University of Idaho
2011, 2009	North American Carbon Program student travel award
2010	Microsoft Graduate Internship/Fellowship, San Francisco, CA
2010	DOE Global Change Graduate Fellowship
2009, 2006	Oregon State University, College of Forestry Graduate Fellowship
2009, 2007	Oregon State University Henry and Mildred Fowells Fellowship
2008, 2005	Visiting Graduate Student Scholar at National Center for Atmospheric Research
1997	MJ Murdock Undergraduate Research Grant recipient

PUBLICATIONS (* indicates mentored student or post-doc author)

(Google Scholar: *h*-index =16, Citations = ~1080)

Hudiburg, T., B.E. Law, J. Stenzel*, M. Harmon, and W. Moomaw. Meeting regional GHG reduction

targets requires accounting for all forest sector emissions. *Environmental Research Letters* 14(9), 095005 (2019). (https://doi.org/10.1088/1748-9326/ab28bb)

Walsh, E.* and **T. Hudiburg**. An integration framework for linking avifauna niche and forest landscape models. *PLOS ONE* (2019). (https://doi.org/10.1371/journal.pone.0217299)

Stenzel, J*, K. Bartowitz*, A. Smith, J. Lutz, C. Kolden, M. Swanson, A. Larson, B. Law and **T. Hudiburg**. Fixing a snag in estimating carbon emissions from wildfire. *Global Change Biology* (2019). (https://doi.org/10.1111/gcb.14716)

Buotte, P., S. Levis, B. Law, **T. Hudiburg**, D. Rupp, P. Mote, and J. Kent*. Near-future forest vulnerability to drought and fire varies across the western US. *Global Change Biology* 25.1, 290-303 (2019). (https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.14490)

Walsh, E.*, K. Vierling, E. Strand, K. Bartowitz*, and **T. Hudiburg**. Climate change, woodpeckers, and forests: Current trends and future modeling needs. *Ecology and Evolution (*2018), 00:1–15 (https://doi.org/10.1002/ece3.4876)

Gomez-Casanovas, N., N.J. DeLucia, **T. Hudiburg**, C.J. Bernacchi, & E.H. DeLucia. Conversion of grazed pastures to energy cane as a biofuel feedstock alters the emission of GHGs from soils in Southeastern United States. *Biomass and Bioenergy*, 108, 312-322 (2018). (https://www.sciencedirect.com/science/article/pii/S0961953417303951)

Law, B., **T. Hudiburg,** P. Buotte, L. Berner, J. Kent, and M. Harmon. Forest land use strategies to mitigate climate change in a carbon dense temperate region. *Proceedings National Academy of Sciences*, 115 (14) 3663-3668 (2018). *(*http://www.pnas.org/content/115/14/3663*)*

Hudiburg, T., P. Higuera, and J. Hicke. Fire-regime variability impacts forest carbon dynamics for centuries to millennia. *Biogeosciences* 14 (17), 3873-3882 (2017). (https://www.biogeosciences.net/14/3873/2017/)

Khanna, M., W. Wang, **T. Hudiburg**, and E. H. DeLucia. Regulating indirect land use change due to biofuels: is it worth it? *Nature Communications* 8, 15513 (2017). (http://www.nature.com/articles/ncomms15513)

Carvalho, J.*, **T. Hudiburg**, H. Franco, and E. Delucia. Contribution of above- and belowground bioenergy crop residues to soil carbon. *Global Change Biology-Bioenergy* 9 (8), 1333-1343 (2017). (http://dx.doi.org/10.1111/gcbb.12411)

Berner, L.*, B. Law, and **T. Hudiburg**. Water availability limits tree productivity, carbon stocks, and carbon residence time in mature forests across the western United States. *Biogeosciences* 14 (2), 14 (2), 365-378 (2017). (https://www.biogeosciences.net/14/365/2017/)

Black, C.*, S. Davis, **T. Hudiburg**, C. Bernacchi, and E. DeLucia. Elevated CO_2 and temperature increase soil C losses from a soy-maize ecosystem. *Global Change Biology* 23 (1), 435-445 (2016) (http://dx.doi.org/10.1111/gcb.13378)

Hudiburg, T., W. Wang, M. Khanna, S. Long, W. Parton, P. Dwivedi, M. Hartmann, and E. DeLucia. Impacts of a 32-billion-gallon bioenergy landscape on land and fossil fuel use in the US. *Nature Energy* 1, 15005 (2016). (http://www.nature.com/articles/nenergy20155)

Gomez-Casanovas, N., **T. Hudiburg**, E. DeLucia, W. Parton, and C. Bernacchi. Current and future impacts of atmospheric nitrogen deposition on grassland GHG balance. *Global Change Biology* 22, 1348-1360 (2016). (http://onlinelibrary.wiley.com/doi/10.1111/gcb.13187/pdf)

P. Dwivedi, W. Wang, **T. Hudiburg**, M. Khanna, S. Long, E. DeLucia and W. Parton. Life-Cycle Carbon Intensity and Production Cost of Cellulosic Ethanol. *Environmental Science and Technology* 49 (4), 2512–2522 (2015). (http://pubs.acs.org/doi/abs/10.1021/es5052588)

Hudiburg, T., S. Davis, W. Parton, and E. DeLucia. Bioenergy crop greenhouse gas mitigation potential under a range of management practices. *Global Change Biology-Bioenergy* 7 (2), 366-374 (2015). (http://onlinelibrary.wiley.com/doi/10.1111/gcbb.12152/epdf)

DeLucia, E., N. Gomez-Casanovas, J. Greenberg, **T. Hudiburg**, I. Kantola, S. Long, A. Miller, D. Ort, and W. Parton. Theoretical limit to plant productivity. *Environmental Science & Technology* 48 (16), 9471-9477 (2014). (http://pubs.acs.org/doi/abs/10.1021/es502348e)

Hudiburg, T., B. Law, S. Luyssaert, and P. Thornton. Interactive effects of environmental change and management strategies on regional forest carbon emissions. *Environmental Science and Technology*

47 (22), 13132–13140 (2013). (http://pubs.acs.org/doi/abs/10.1021/es402903u)

Hudiburg, T., B. Law, P. Thornton. Evaluation and improvement of the Community Land Model (CLM 4.0) in Oregon forests. *Biogeosciences* 10, 453-470 (2013). (http://www.biogeosciences.net/10/453/2013/bg-10-453-2013.pdf)

Anderson-Teixeira, K., A. Miller, J. Mohan, **T. Hudiburg**, B. Duval, and E. DeLucia. Dynamics of forest recovery under a changing climate. *Global Change Biology* 19 (7), 2001-2021 (2013). (http://onlinelibrary.wiley.com/doi/10.1111/gcb.12194/epdf

Law, B., **T. Hudiburg**, and S. Luyssaert. Thinning effects on forest productivity: consequences of preserving old forests and mitigating impacts of fire and drought. *Plant Ecology and Diversity* 6 (1), 73-85 (2013). (http://www.tandfonline.com/doi/abs/10.1080/17550874.2012.679013)

Hudiburg, T., B. Law, C. Wirth, and S. Luyssaert. Regional carbon dioxide implications of forest bioenergy production. *Nature Climate Change* 1, 419–423 (2011). (http://www.nature.com/nclimate/journal/v1/n8/full/nclimate1264.html)

Turner, D., Goeckede, M., Law, B., Ritts, W., Cohen, W., Yang, Z., **Hudiburg, T.**, Kennedy, R., Duane, M., Multiple constraint analysis of regional land–surface carbon flux. *Tellus B* 63, 207-221. (2011) (http://onlinelibrary.wiley.com/doi/10.1111/j.1600-0889.2011.00525.x/epdf)

Duane, M., W. Cohen, J. Campbell, **T. Hudiburg**, D. Turner, D. Weyermann. Implications of alternative field-sampling designs on Landsat-based mapping of stand age and carbon stocks in Oregon forests. *Forest Science* 56(4): 405-416. (2010) (http://terraweb.forestry.oregonstate.edu/pubs/duane_2010.pdf)

Hudiburg, T., B. Law, D. Turner, J. Campbell, D. Donato, and M. Duane. Carbon dynamics of Oregon and northern California forests and potential land-based carbon storage. *Ecological Applications* (19) 163–180 (2009). (http://www.esajournals.org/doi/pdf/10.1890/07-2006.1).

Turner, D, W. Ritts, B. Law, W. Cohen, Z. Yang, **T. Hudiburg**, J. Campbell, M. Duane. Scaling net ecosystem production and net biome production over a heterogeneous region in the western United States. *Biogeosciences* 4, 597-612 (2007). (http://www.biogeosciences.net/4/597/2007/)

RESEARCH FUNDING ($2,150,000 AWARDED AS PI OR CO-PI)

Active (Total ~$1,800,000)

BIA Tribal Resilience Planning Grant, "Dataset Development and Modeling for Resilient Decision-Making for Extreme Events, Harmful Environmental Trends, and Land Cover Impacts to Nez Perce Tribe Salmon, Wetlands, Forests, and Prairies", UI Award $80,858, 2019-2020, S. Krantz (Nez Perce – PI), **T. Hudiburg** (Co-PI).

DOE Bioenergy Research Center, "Center for Advanced Bioenergy and Bioproducts Innovation", UI Award $760,000, 2017-2022, E. DeLucia (PI), **T. Hudiburg** (Co-PI), et al.

NSF DEB Ecosystem Sciences, "Collaborative Research: Causes and consequences of fire-regime variability in Rocky Mountain forests", UI Award $241,818, 2017-2021, P. Higuera (U. Montana-PI), **T. Hudiburg** (U. Idaho-PI), B. Shuman (U. Wyoming-PI), K. McLaughlin (K. State-PI).

NSF CAREER DEB Ecosystem Sciences, "CAREER: Forest-atmosphere interactions in an era of fire and drought", $664,235, 2016-2021, **T. Hudiburg** (PI).

Completed (Total ~$350,000)

USDA-NIFA Sun Grant, "Achieving Conservation and Renewable Energy Goals with the Conservation Reserve Program", UI Award $19,000, 2017-2018, M. Khanna (PI), **T. Hudiburg** (Co-PI), E. DeLucia (Co-PI).

USDA-NIFA AFRI, "EaSM2: Forest dieoff, climate change, and human intervention in Western North America", UI Award $141,598 (2014-2018), P. Mote (PI), B. Law (Co-PI), J. Hicke (Co-PI), **T. Hudiburg** (Senior Investigator), et al.

NASA ISGC Seed Grant, "Exploratory analysis of drought impacts on forest ecosystem respiration", UI Award $40,000, 2015-2016, J. Law (PI), **T. Hudiburg** (Co-PI).

DOE Global Change Graduate Fellowship, 2009 - 2012, $150,000, **T. Hudiburg** (PI).

TEACHING ACCOMPLISHMENTS

FOR 221: *General Ecology*, (2015 - present). Development of active learning components and instruction of the U. Idaho introductory ecology course with annual enrollments >100 students from four colleges across the university.
FOR 529: *Ecosystem Analysis and Modeling,* (2015 - present). Development and instruction of a new graduate course in Terrestrial Ecosystem Analysis and Modeling
ISEM 301: *Climate Change and You,* (2017 - present). Development and instruction of a new undergraduate seminar course emphasizing the regional impacts of climate change and how we can mitigate climate change.
FOR 504: *Earth System Modeling,* (2017- present). Graduate seminar covering theory and current literature in earth system modeling.

INVITED LECTURES AND SEMINARS

Seminar, U. Idaho Vice-Provost for Research seminar series (May 2019)
Seminar, Palouse Clearwater Environmental Institute, December 2018, Moscow ID.
Lecture, Washington State University, Fall 2018, "Organisms and global change"
Seminar, University of Wisconsin, December 2017, "Fire, Drought, Beetles, and Humans: Quantifying the Impacts of Disturbance on the Forest Carbon Cycle"
Speaker, National Academy of Sciences, Terrestrial Carbon Panel, September 2017, "Forest Carbon Sequestration Strategies"
Speaker, Washington Environmental Council, Carbon Friendly Forestry, September 2017, "Oregon's Forest Carbon Balance: Potential Bioenergy Implications"
Seminar, Malcolm Renfrew Interdisciplinary Symposium, University of Idaho, April 2017, "Fire, Drought, Beetles, and Humans: Quantifying the Impacts of Forest Disturbance on the Carbon Cycle
Lecture, Washington State University, Fall 2016, "Organisms and global change"
Lecture, Washington State University, Fall 2015, "Organisms and global change"
Seminar, "Ecosystem Measurements and Modeling from Minutes to Millennia", Washington State University Center for Environmental Research, Education, and Outreach. September, 2015
Seminar, "Automated tree (hugging) measurements to improve model prediction of forest carbon uptake. Palouse Ecology and Evolution Symposium", April 29th, 2015.
Lecture, University of Idaho, Spring 2015, Environmental Science and Policy
Seminar, "21st century forest carbon dynamics", West Virginia University, Dept. of Biology, March 2014
Seminar, "Bioenergy Landscapes of the Future", Olympia Science Café, Olympia, WA, March 2014
Seminar, "Effects of climate, disturbance, and forest management on regional carbon storage and emissions under current and proposed policy plans", March 2012. Microsoft Research Conservation and Ecology Group, Cambridge University, Cambridge, UK

WORKSHOPS AND WORKING GROUPS

2019	AmeriFlux annual meeting committee member
2018, 2017	Workshop/Course Leader, 4-day NSF Forest-Climate Interactions High School Teacher Workshop/Course, McCall, ID
2017	Invited participant, NSF NOVUS IV RCN Workshop, Hubbard Brook, New Hampshire
2017	Invited participant, Wood Product Substitution Working Group, Pierre and Marie Curie University, Paris, France
2015, 2013	Participant, 20th Annual CESM meeting
2014	Invited participant, NSF NOVUS II RCN Workshop "Scaling biogeochemical interactions with disturbance events, multiple disturbance agents, and disturbance regimes", Estes Park, CO

2013 North Central Regional Sun Grant Center Annual Meeting participant, Chicago, IL
2012 National Sun Grant Meeting participant, New Orleans, LA
2012 Strategies to promote integrated experiment-model approaches to terrestrial ecosystem study (DOE, Washington DC)
2011 AGU Fall Meeting Communicating Science Skills Workshop

CONFERENCE PRESENTATIONS

First-author presentations and posters

Hudiburg, T.W., B. Law, and W. Moomaw. (2018). B33E-2704 Advanced ecosystem accounting for state to country-level forest sector net emissions that account for biogenic, pyrogenic, and anthropogenic emissions. AGU 2018 Fall Meeting, Washington D.C.

Hudiburg, T. (2018) Forest growth and mortality: carbon cycle impacts and mitigation opportunities. USDA Agricultural Congressional Research Exhibition, Washington D.C.

Hudiburg, T., J. Stenzel, B. McNellis, and D. Berardi. (2016) B53A-0516 Measuring and modeling carbon balance in mountainous Northern Rocky mixed conifer forests. 2016 AGU Fall Meeting, San Francisco, CA.

Hudiburg, T., N. Gomez-Casanovas, E.H. DeLucia, and C. Bernacchi. (2014) BG21H-0162 Current and Future Impacts of Atmospheric Nitrogen Deposition on Grassland GHG Balance. 2015 AGU Fall Meeting, San Francisco, CA.

Hudiburg, T., W. Wang, M. Khanna, S. Long, W. Parton, M. Hartmann, P. Dwivedi, and E.H. DeLucia. (2014) Environmental impact of bioenergy landscapes in the United States. 20th World Congress of Soil Science. June 8 – 13th, 2014. Jeju, South Korea

Hudiburg, T., P. Dwivedi, W. Wang, M. Khanna, W. Parton, M. Hartmann, S. Long and E.H. DeLucia. (2013) GC43A-1033 Integrated regional modeling assessment of the environmental and economic potential of perennial grass bioenergy feedstocks. 2013 AGU Fall Meeting, San Francisco, CA.

Hudiburg, T. and E.H. DeLucia. (2013) Bioenergy landscapes of the future. Energy Biosciences Retreat. July 15 – 18. Champaign, IL. (Invited)

Hudiburg, T., S. Davis, W.J. Parton, K. Anderson-Teixeira, C. Smith, E. DeLucia. (2013) Reducing uncertainty of bioenergy crop carbon sequestration strategies using observations from field sites across the central and eastern United States and the DayCent biogeochemical model. 4th NACP Investigators Meeting. Feb. 4-7, Albuquerque, NM.

Hudiburg, T., B. Law, S. Luyssaert, and P. Thornton. (2012) B32-C Forest carbon response to management scenarios intended to mitigate GHG emissions and reduce fire impacts in the US West Coast region. 2012 AGU, Fall Meeting, San Francisco, CA. (Invited)

Hudiburg, T., B. Law, and P. Thornton. (2012) B53B Interactive effects of changing climate, increasing atmospheric CO2, nitrogen deposition and disturbance on carbon and nitrogen dynamics in Oregon forests. 2012 AGU Fall Meeting, San Francisco, CA.

Hudiburg, T., B. Law, C. Wirth, S. Luyssaert, and P. Thornton. (2011) GC21E-04 Short and Long-Term Impacts of Forest Bioenergy Production on Atmospheric Carbon Dioxide Emissions. Eos Trans. 2011 AGU Fall Meet. Suppl., San Francisco, CA.

Hudiburg, T., B. Law, C. Wirth, and S. Luyssaert. (2011) Life-cycle analysis of US West Coast forests following thinning for combined fire prevention and bioenergy production. North American Carbon Program Meeting, New Orleans, LA.

Hudiburg, T., B. Law, J. Martin. (2009) B52C-06 An evaluation of the impact of forest biomass harvest for biofuels on carbon storage in the US west coast states under different management scenarios. Eos Trans. 2009 AGU 90(52), Fall Meet. Suppl., San Francisco, CA.

Hudiburg, T., P. Thornton, B. Law. (2009) Interactive effects of disturbance, rising CO2 concentrations, nitrogen deposition and climate on carbon cycle dynamics of US West-Coast forests. North American Carbon Program Science Meeting, February 17-21, San Diego, CA.

Hudiburg, T., B.E. Law, D. Turner, J.L. Campbell, D. Donato and M. Duane. (2008) B31D-0311 Disturbance, Climate, and Management Impacts on US West-Coast Forest Carbon Budgets. *Eos*

*Trans.*AGU 89(53), Fall Meet. Suppl., San Francisco, CA.

Hudiburg, T., M. Duane, D. Turner, Y. Zhiqiang, J. Campbell, W. Cohen and B. Law. (2006) Parameterization and validation of Biome-BGC model estimates of carbon stores and fluxes across Oregon and Northern California using FIA plot data. Program of the 8th Annual Forest Inventory and Analysis Symposium, Monterey, California.

Student/poster/collaborator posters and presentations (limited to last 5 years):
**indicates mentored student or postdoc*

E. Walsh* and T. Hudiburg. (2018) GC11G-0989 A Framework for Forest Landscape and Habitat Suitability Model Integration to Evaluate Forest Ecosystem Response to Climate Change. 2018 AGU Fall Meeting, Washington D.C.

D. Berardi*, T. Hudiburg, W. Yang, A.C. von Haden, E. DeLucia. (2018) B33E-2713 Corn Belt Bioenergy Crops: Perennial Grass Potential for Additional Greenhouse Gas Abatement Compared to Corn Given Increased Frequency of Seasonal Flooding Events. 2018 AGU Fall Meeting, Washington D.C.

K. Bartowitz*, T. Hudiburg, P. Higuera. (2018) GC51E-0830 Carbon Consequences of Fire-regime Variability in Rocky Mountain Subalpine Forests Over Millennia. 2018 AGU Fall Meeting, Washington D.C.

C. Moore, D. Berardi, E. Blanc-Bates, T. Hudiburg. (2018) B51J-2081 The carbon, water and energy costs of converting perennial switchgrass back to annual maize-soybean rotation. 2018 AGU Fall Meeting, Washington D.C.

L. Chen, E. Blanc-Bates, M. Khanna, T. Hudiburg, et al. (2018) GC53F-1010 Achieving Conservation and Renewable Energy Goals with the CRP. 2018 AGU Fall Meeting, Washington D.C.

S.M. Parker*, J. Stenzel, and T. Hudiburg (2018) ED13E-0797 High resolution measurements of forest productivity in the Northern Rockies: Examining the mechanics of forest response to thinning and drought. 2018 AGU Fall Meeting, Washington D.C.

P. E. Higuera, T. Hudiburg, K. Bartowitz, et al. (2018) GC43D-01 A Framework for Understanding, Testing, and Anticipating the Ecosystem Consequences of Wildfire Activity over Space and Time. 2018 AGU Fall Meeting, Washington D.C.

J. Kent*., and T. Hudiburg. (2018) B33E-2704 Modeling Energy Sorghum Emissions for the Rainfed United States. 2018 AGU Fall Meeting, Washington D.C.

J. Stenzel*, T. Hudiburg, D. Berardi, B. McNellis, and E. Walsh. (2017) GC24G-08 Integrated model-experimental framework to assess carbon cycle components in disturbed mountainous terrain. 2017 AGU Fall Meeting, New Orleans, LA.

P. Buotte, B. Law, and T. Hudiburg. (2017; invited) B51B-1800 Forecasting Vulnerability to Drought-related Mortality in Western US Forests. 2017 AGU Fall Meeting, New Orleans, LA.

D. Berardi*, N. Gomez-Casanovas and T. Hudiburg. (2017) B23H-08 Reducing uncertainty in the DayCent model of heterotrophic respiration with a more mechanistic representation of microbial processes. 2017 AGU Fall Meeting, New Orleans, LA.

E. Walsh* and T. Hudiburg. (2017) B53D-1977 The Big Burn: C Emissions from the Northern Rockies 1910 Fires. 2017 AGU Fall Meeting, New Orleans, LA.

E. Blanc-Bates*, T. Hudiburg, M. Khanna, and E. DeLucia. (2017) B53D-1985 Environmental impact of converting Conservation Reserve Program land to perennial bioenergy crops in Illinois. 2017 AGU Fall Meeting, New Orleans, LA.

B. McNellis* and T. Hudiburg. (2017) B53D-1979 Improving Predictions of Tree Drought Mortality in the Community Land Model Using Hydraulic Physiology Theory and its Effects on Carbon Metabolism. 2017 AGU Fall Meeting, New Orleans, LA.

B. McNellis* and T. Hudiburg. (2017) Predicting forest mortality and landscape change under novel climates using an analytical approach to drought response physiology and probabilistic scaling. Spring Western Sectional Meeting #1128, American Mathematical Society, Pullman, WA.

E. Walsh* and T. Hudiburg. (2017) Future Carbon Dynamics of the Northern Rockies Ecoregion due to

Climate Impacts and Fire Effects. Spring Western Sectional Meeting #1128, American Mathematical Society, Pullman, WA.
E. Walsh*, K. Vierling, and T. Hudiburg. (2016) Future Carbon Dynamics of the Northern Rockies Ecoregion due to Climate Impacts and Fire Effects., 2016 AGU Fall Meeting, San Francisco, CA.
J. Stenzel*, D. Berardi, and T. Hudiburg. (2016) Automated Monitoring of Carbon Fluxes in a Northern Rocky Mountain Forest Indicates Above-Average Net Primary Productivity During the 2015 Western U.S. Drought., 2016 AGU Fall Meeting, San Francisco, CA.
K. Beale*, G. Becker*, D. Berardi, and T. Hudiburg. (2015) Belowground Carbon Allocation in a Mixed Conifer Forest in the Northern Rockies. Idaho Conference of Undergraduate Research. July, Boise, ID. (Undergraduate student authors)
E. Walsh* and T. Hudiburg. (2015) Linking climate impacts with avian cavity nester viability: predicting long term habitat suitability across multiple ecological scales. Northwest Climate Conference. November, Coeur D'Alene, ID.
J. Stenzel*, D. Berardi, and T. Hudiburg. (2015) Biogeochemical impacts of drought on Idaho forest ecosystems: can we resolve species level differences with high resolution measurements? Northwest Climate Conference. November, Coeur D'Alene, ID.

MENTORING

Postdoctoral Researchers: Eric Walsh (2019 – present); Jeffrey Kent (2017 – present)

Graduate Students (PhD): Eric Walsh (major advisor, 2014- 2018); Jeffrey Stenzel (major professor, 2017 - present); Danielle Berardi (major professor, 2018 – present); Kristina Bartowitz (major professor, 2017 – present); Adrienne Marshall (major professor, 2017 - present); Katherine Baker (co-major professor, 2015 – present); Nuria Lopez (committee member, 2016 – present)

Graduate Students (MS): Brandon McNellis (major professor, 2016 - 2019); Megan Miller (committee member, graduated Spring 2018); John Raines (major professor, graduated Spring 2018); Danielle Berardi (major professor, graduated Fall 2017); Jeffrey Stenzel (major professor, graduated Fall 2016); Matthew Fisk (committee member, graduated Spring 2016)

Undergraduate Students: Seth Parker (research advisor; 2017 – present); Heather Crawford (research advisor, 2018 – present); Gabrielle Becker (research advisor, Summer 2015); Kaylissa Beale (Lewis and Clark State College, research advisor, Summer 2015); Alexis Litty (research advisor, 2015); Jesus Gonzalez (research advisor, 2015); Ecology and Conservation Biology Undergraduate Thesis advisor (1-2 students per year, 2014-present)

SERVICE AND OUTREACH

Professional and Community Service

Guest Editor, (2019) Special Issue in *Forests*: “Management Strategies for Greenhouse Gas Emissions Mitigation”
Volunteer, Moscow Charter School, Climate Cats club (2018)
Reviewer, National Academies of Sciences, Engineering, and Medicine report “A Research Agenda for Carbon Dioxide Removal and Reliable Sequestration”, (2018)
Organized a 2-day symposia for Rep. Bob Inglis (R-SC) to meet with students, faculty and give a keynote address “Solving Climate Change with Conservative Principles”, Moscow, ID, (Fall 2017, Fall 2018)
Idaho Master Forest Stewards Meeting, ~30 forest stewards, gave lecture (outside) on “Mitigating Climate Change - How Forests Store Carbon”, Pitkin Nursery, Moscow, ID (Fall 2017)
Review Editor, USDA State of Carbon Cycle Science Report 2 (SOCCR2), 2017-2018
Session Chair and Convener, Biogeosciences, AGU Fall Meeting, San Francisco, CA. (2015, 2016, 2017)

Session Convener, Northwest Climate Conferences, Couer D'Alene, ID, "Ecological Impacts" (2015)
Invited Panel Participant, Earth Science Women's Network workshop "Getting on the Tenure Track and Succeeding", AGU Fall Meeting, San Francisco, CA. (2014)
Volunteer Judge, AGU Fall Meeting Outstanding Student Presentation Award (2012 - 2016)
Peer Reviewer for: Nature Climate Change, Global Change Biology, GCB- Bioenergy, Carbon Management, Remote Sensing and Environment, Environmental Science and Technology, Forest Ecology and Management, Carbon Balance and Management, Journal of Geophysical Research-Biogeosciences, Ecological Applications, PLOS ONE, Biogeosciences
Panel Reviews: NSF CAREER (2018), NSF DEB Ecosystems (2016), NASA ROSES C Cycle Science (2016, 2017), USDA NIFA BNRE (2017), Joint Fire Science Program (2016), NSF PREEVENTS Fire Panel (2017), Purdue Postdoctoral Fellowship (2017, 2018)
Editorial Advisory board, Global Change Biology - Bioenergy (2014 – present)
USGS Western Region Carbon Report, external reviewer (2012)

University service

Dean of College of Natural Resources, search committee member (2018)
Vice Provost for Faculty, search committee member (2018)
FRFS Department Head, search committee member (2016)
University Curriculum Committee, College of Natural Resources delegate (2016 - present; elected)
Speaker, UI Experimental Forest Field Day, Moscow, ID (2015)
Ecology Curriculum Committee, member (2015 - present)
Forestry Curriculum Committee, member (2014 - present)