Placer County
AIR POLLUTION CONTROL DISTRICT
110 Maple Street, Auburn, CA 95603 • (530) 745-2330 • Fax (530) 745-2373 • www.placer.ca.gov/apcd
Thomas J. Christofk, Air Pollution Control Officer

California Energy Commission
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California Energy Commission
Dockets Office, MS-4
1516 Ninth Street
Sacramento, CA 95814-5512

Subject: Docket No. 13-IEP-1A -- Comments on the 2013 Integrated Energy Policy Report

Dear Commission:

The Placer County Air Pollution Control District (PCAPCD) appreciates the opportunity to submit comments on the Draft "2013 Integrated Energy Policy Report" (IEPR). PCAPCD is actively involved in numerous projects to improve the ecological and economical sustainability of California Sierra Nevada forests. This includes support for existing and new bioenergy facilities. Our review is focused on Chapter 3, "Bioenergy Status and Issues." Specific comments, referenced by IEPR page, include:

- **Page 54-55:** Discussions regarding biopower potential in California need to address the scale of forest management that is fully sustainable and beneficial for the protection of California forests and forest resources. Forest fuels treatment activities need to be significantly increased strategically across the landscape (especially on public lands) to mitigate the growing trend of increasing intensity and size of catastrophic wildfires. While biomass may be a "limited resource for energy production," it has much more potential than is currently being utilized.

- **Page 56:** Emphasis is needed regarding the downward trend in the number of operating biomass facilities and the significant negative effects that each facility closure has on regional air quality, jobs, rural community vitality, and forest resource protection. Further mention needs to be made regarding the unfair and inappropriate negative impact that the price of natural gas produced electricity has on biomass electricity rates.

- **Page 57:** There must be discussion on the substantial societal benefits and values that result from forest resource management activities, that include the use of biomass wastes for energy, and the role that biomass facilities play in helping protecting forest resources -- a role that can logically be reflected in the value of the energy they produce. The range of benefits is presented in detail below, many of which are in addition to those of other renewable energy technologies.[1] This listing was generated as an outcome of a series of workshops held at Blodgett Forest Research Station, sponsored by UC Berkeley, and a report -- "The Spirit of Blodgett" -- which is enclosed with these comments.

[1]C. Mason, B. Lippke, K. Zobrist et al., "Investments in Fuel Removals to Avoid Forest Fires Results in Substantial Benefits," Journal of Forestry, January/February 2001, pp. 27-31.

- **Promotes healthy forests and defensible communities.** Provides a ready market value for woody biomass material generated as a byproduct of forest management, hazardous fuels reduction and forest restoration activities.[2] This helps encourage projects that contribute to defensible communities and healthy forest ecosystems through the generation of income to fund additional treatment activities.

- **Protects key watersheds.** A significant portion of California's in-state water resources flow from forested landscapes. Healthy forest ecosystems in these upland watersheds ensure that sustainable quantities of high quality water for both domestic and agricultural uses will continue to flow.[3,4,5,6] In addition, water to support California's significant hydropower assets originates in these watersheds. This is particularly important given the predicted effects of climate change on future water production and the ability of forest management projects to protect and enhance both quality and quantity of water from forested landscapes. Increased water yield of 9-16%[7] could result should additional forest acres be thinned within a watershed (see targeted treatment acres table on page 1 of the enclosed Blodgett paper).

- **Provides net air quality and greenhouse gas benefits.** Forest biomass material that would otherwise be disposed of by burning in the open in piles, in prescribed broadcast burns, or would have been consumed in a wildfire, can be utilized in a controlled manner to provide renewable energy (energy conversion units including boilers and gasifiers that are equipped with Best Available Control Technology), thus reducing air emissions and improving regional air quality. The air quality benefits are significant, with 95-99% reduction in particulate matter, carbon monoxide, and volatile organics, and a 60-80% reduction in nitrogen oxides when compared to open burning.[8,9,10] An additional climate change benefit results from replacing fossil fuel fired power generation with renewable bioenergy.

- **Provides economic development and employment.** Most bioenergy facilities are sited in rural areas that are currently experiencing significant economic hardship. Jobs

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[2]M. North, P. Stine, K. O'Hara, W. Zielinski, and S. Stephens, "An Ecosystem Management Strategy for Sierran Mixed-conifer Forests," USDA Forest Service, PSW General Technical Report PSW-GTR-220, 2009.
[3]D.G. Neary, K.C. Ryan and L.F. DeBano (eds.), Wildland Fire in Ecosystems: Effects of Fire on Soils and Water, Gen. Tech. Rep. RMRS- GTR- 42- vol 4. Ogden, UT, USDA Forest Service Rocky Mountain Research Station, 2005.
[4]R.R. Harris, and P.H. Cafferata, Effects of Forest Fragmentation on Water Quantity and Quality. Paper presented to the Conference on California Forest Futures, Sacramento, CA, May 23-24, 2005.
[5]J.D. Murphy, D.W. Johnson, W.W. Miller, R.F. Walker, E.F. Carrol, and R.R. Blank, "Wildfire Effects on Soil Nutrients and Leaching in a Tahoe Basin Watershed," Journal of Environmental Quality, Volume 35, 2006, pp. 479-489.
[6]Numerous studies led by Lee H. MacDonald, Colorado State University, Department of Forest, Rangeland, and Watershed Stewardship.
[7]R.C. Bales, et al., "Forests and Water in the Sierra Nevada: Sierra Nevada Watershed Ecosystem Enhancement Project" November 2011.
[8]Bruce Springsteen, Tom Christofk, Steve Eubanks, Tad Mason, Chris Clavin, and Brett Storey, "Emission Reductions from Woody Biomass Waste for Energy as an Alternative to Open Burning," Journal of the Air and Waste Management Association, Volume 61, January 2011, pp. 63-68.
[9]Greg Jones, Dan Loeffler, David Calkin, and Woodam Chung, "Forest Treatment Residues for Thermal Energy Compared With Disposal by Onsite Burning: Emissions and Energy Return," Biomass and Bioenergy, Volume 34, 2010, pp. 737-746.
[10]Carrie Lee, Pete Erickson, Michael Lazarus, and Gordon Smith, Greenhouse Gas and Air Pollutant Emissions of Alternatives for Woody Biomass Residues, prepared by the Stockholm Environment Institute for the Olympic Region Clean Air Agency, November 2010.

include plant operations and maintenance as well as fuel collection, processing and transport. Approximately five jobs are created per MW of bioenergy generation.[11]

- **Reduces waste going to landfills**. Wood waste destined for landfills can be recovered and utilized, thus extending the service life of landfills and reducing the need to develop additional landfill facilities while producing renewable energy and reducing greenhouse gases.

- **Delivers distributed, baseload generation**. Locating new, small-scale bioenergy facilities strategically across forested regions in California will mitigate the need for transmission system upgrades, as small generation facilities require relatively little transmission capacity to deliver power to load centers. This will also provide strategic 24-7 baseload generation in regions that are remote and prone to inconsistent power availability, thus minimizing the need for large diesel fired generator sets that serve as standby generation.

- **Protects transmission/distribution infrastructure.** Power distribution infrastructure in California is significant. Many of the state's generation assets utilize transmission and distribution systems located in forested regions to deliver generation to load centers. Forest management and hazard reduction projects can reduce the likelihood of wildfire damage to valuable power distribution infrastructure.

- **Utilizes renewable and sustainable feedstocks.** Bioenergy facilities are sized appropriately to utilize biomass from sources that continue to produce biomass in a long-term, sustainable way.

- **Helps California meet greenhouse gas reduction, waste reduction and renewable energy objectives.** The bioenergy market sector helps the state meet specific policy objectives as set by the California legislature and the Governor:

  - AB 32 – Greenhouse Gas Reduction.
  - AB 939 – Waste Reduction – Reduced Landfill Deposits.
  - SB 1078 – Establishes a Renewable Portfolio Standard for California.
  - Executive Order S-06-06 – Sets Bioenergy Production Targets.
  - SBX 1-2 – Increases the Renewable Portfolio Standard to 33%.
  - SB 1122 – Establishes a 250 MW set aside for bioenergy projects scaled at up to 3 MW of generation capacity.

- **Reduces wildfire suppression costs.** Forest management fuel reduction activities significantly reduce the economic costs for fighting wildfires.

We strongly support the development of a programmatic EIR for pre-commercial solid-fuel biomass facilities, especially for those that utilize biomass that would otherwise be open-burned and for smaller facilities that can participate in the various Feed-in-Tariff type programs.

[11] G. Morris, The Value of the Benefits of US Biomass Power, November, 1999, NREL Publication SR 570-27541.

- **Page 60:** The IEPR discusses that the utilities claim there is limited need for baseload renewable power. This logic is flawed in that many of the large-scale baseload power facilities in California are aging and are now targeted for closure (e.g., San Onofre Nuclear Generating Station rated at 2,150 MW capacity). Existing or proposed bioenergy facilities are available to supplement these aging facilities. In addition -- unlike solar or wind -- bioenergy facilities do not require dispatchable power generation facilities (like natural gas fired peakers) as supplemental power sources.

- **Page 61:** The discussion of opinions under the "Forest Biomass Resources" section is extremely disappointing and it not representative the utilization of biomass wastes in California. There is extensive existing research and decades of experience that supports the positive greenhouse gas impacts from the utilization of biomass wastes for energy.

  Specifically, the Center for Biological Diversity's (CBD) claim that biomass energy is detrimental to greenhouse emissions is flawed for the situation in California. As described earlier in our comments (see list of societal benefits), the utilization of forest biomass for energy production represents a benefit, not a detriment, to the resources listed. If native forests were being managed exclusively for biomass energy production, CBD's position might in some cases have merit. But such management is not the case in California and, given the economics of forest management, is unlikely to ever occur here. Many studies have been completed related to carbon sequestration and forest management.[12,13] Those relevant to California forests do not support CBD's position. We are also including a copy of a recent evaluation that refutes the applicability to California of numerous studies that claim forest biomass energy to cause greenhouse gas increases.

  The report must acknowledge that in California, forest-sourced biomass is most often a byproduct of forest management or hazard reduction projects that, if it is not utilized for energy production, is disposed of by open burning. Utilization of this biomass is not a threat to sustainability of forest ecosystems or forest resources because it is produced regardless of whether or not it will ultimately be utilized in an energy facility. When there is a viable market for biomass, its value can encourage forest management that helps reduce wildfires that threaten valuable resources like water quality and quantity, wildlife habitat, and clean air.

- **Page 62:** The statement in the first paragraph -- "Further information using the best science available is needed" -- ignores the existence of both numerous research studies and extensive experience that indicate environmental sustainability is not compromised by the mainstream forest management occurring in California.[14,15] This is particularly

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[12]Bruce Springsteen, Tom Christofk, Steve Eubanks, Tad Mason, Chris Clavin, and Brett Storey, "Emission Reductions from Woody Biomass Waste for Energy as an Alternative to Open Burning," Journal of the Air and Waste Management Association, Volume 61, January 2011, pp. 63-68.
[13]M. North, P. Stine, K. O'Hara, W. Zielinski, and S. Stephens, "An Ecosystem Management Strategy for Sierran Mixed-conifer Forests," USDA Forest Service, PSW General Technical Report PSW-GTR-220, 2009.
[14]IBID.
[15]M. Hurteau, G. Koch, B. Hungate, "Carbon Protection and Fire Risk Reduction: Towards a Full Accounting of Forest Carbon Offsets," Ecological Society of America publication, 2008

true in relation to the three questions in this paragraph asking about the maximum amount of biomass that can be removed and whether there is adequate protection from overharvesting on federal forests and California forests in general. As mentioned earlier in our comments, forest biomass collected and removed from California forests is generated as a byproduct of forest management and hazard reduction projects. Forest management on federally managed lands must meet strict environmental guidelines consistent with the National Environmental Policy Act (NEPA) and on state and private forestlands management must meet California Environmental Quality Act (CEQA) standards. Compliance with NEPA and CEQA guidelines assures that all forest management activities in California are held to very high standards and are conducted using sustainable practices.

The clear answer to both questions about overharvesting protection is "yes" based on reviews of federal policies and California's Forest Practice Regulations that are the most restrictive in the U.S.

- For the section on "Biofuels Production" there needs to be more thorough discussion and disclosure of the questionable benefit of corn-based ethanol when a full cycle analysis is done related to its energy balance and carbon benefits. Published studies indicate a marginal or even negative benefit from corn-based ethanol when there is adequate consideration of the energy necessary for its production, the reduced mileage when using ethanol, and the increased engine wear that results from using ethanol. This must be particularly true in California as corn is imported from other states given the carbon impacts associated with such transportation.

Thank you for considering these comments. Please let us know of any questions or clarifications.

Sincerely,

Tom Christofk
Air Pollution Control Officer
Placer County Air Pollution Control District

Enclosures:

"The Spirit of Blodgett"

Spatial Informatics Groups, GHG Emissions from Woody Forest Residue Biomass Energy: Literature Review Relevant to Sierra Nevada Biomass Energy Facilities, prepared for the Placer County Air Pollution Control District, June 13, 2013

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110 Maple Street, Auburn, CA 95603 • (530) 745-2330 • Fax (530) 745-2373 • www.placer.ca.gov/apcd

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THE SPIRIT OF BLODGETT

During the summer and fall of 2012 and 2013, a series of workshops focused on forest health, climate change and air quality were held at the Blodgett Forest Research Station located in the central Sierra Nevada. Sponsored by the University of California College of Natural Resources, Placer County Air Pollution Control District, CAL FIRE, and US Forest Service the findings and recommended solutions from these workshops and follow up meetings are summarized below.

Problem

California's 2013 fire season has demonstrated just how at risk our forests are to catastrophic wildfire. Many communities and millions of acres of forest ecosystems are at significant risk to catastrophic events like the Rim Fire. In response, CAL FIRE, the US Forest Service, and the Sierra Nevada Conservancy are teaming with regional partners including Fire Safe Councils, Resource Conservation Districts and local fire districts to implement strategic projects to proactively restore forest health and treat hazardous forest fuels by implementing sustainable forest management projects. In addition to protecting communities, forest resources, wildlife habitat, watersheds and recreational lands, these efforts reduce greenhouse gases, improve air quality, benefit water quality and quantity, lower firefighting costs, develop energy security, and increase local jobs and rural community vitality.

Unfortunately, these projects are quite costly with treatment expenses as high as $1,200 per acre. Public funding to support proactive forest fuels treatment is declining and will likely cause many projects to be cut back or completely curtailed. The scale of the current challenge is enormous and continues to increase due a variety of factors including (but not limited to) the dynamic nature of California forests, climate change and reduced funding allocated to hazardous fuels treatment activities. The table below summarizes the scale of the challenge:

CALIFORNIA FOREST OWNERSHIP	HIGH, VERY HIGH AND EXTREME FIRE THREAT[1] ACRES	CURRENT TREATMENT ACRES	TARGETED TREATMENT ACRES	FOREST BIOMASS TARGETED FOR REMOVAL TONS[2]
US Forest Service	8,985,800	60,000	200,000 - 500,000	4,800,000 - 12,000,000
Other Public	1,768,300	25,000	50,000 - 80,000	1,200,000 - 1,920,000
Private	7,244,400	40,000	175,000 - 300,000	4,200,000 - 7,200,000
Totals	**17,998,500**	**125,000**	**425,000 - 880,000**	**10,200,000 - 21,120,000**

The Placer County Air Pollution Control District, with the cooperation of various stakeholders, convened a series of workshops at Blodgett Forest Research Station to address this wildfire risk. The discussions identified the need for supporting forest management activities through non-traditional, market-based funding approaches that properly and fully recognize and value the significant and wide range of economic benefits that can result from proactive and sustainable forest management and fuels reduction projects.

[1]Figures are provided by CAL Fire - Fire and Resource Assessment Program.
[2]Green tons of excess forest biomass assuming 24 GT/acre.

Opportunity

An alternative, market-based opportunity to generate funding to support these projects is utilization of woody biomass generated as a byproduct of forest management and hazardous forest fuels reduction activities. In some regions of California, excess forest biomass from forest management and fuels reduction projects is utilized as feedstock for baseload renewable power generation. California has the most significant bioenergy infrastructure in the United States; however, this infrastructure is aging and some facilities have closed in recent years. There are currently 30 commercial-scale bioenergy facilities operating in the state with a generation capacity of approximately 600 megawatts (MW) of renewable power. There is a need to support this existing infrastructure (including existing bioenergy plants that are idle) while initiating development of additional, strategically located bioenergy facilities in California.

Societal Benefits

A robust and expanding California bioenergy market sector provides a number of compelling societal benefits, some of which are in addition to typical benefits of other renewable energy technologies.[3]

- **Promotes healthy forests and defensible communities.** Provides a ready market value for woody biomass material generated as a byproduct of forest management, hazardous fuels reduction and forest restoration activities.[4] This helps encourage projects that contribute to defensible communities and healthy forest ecosystems through the generation of income to fund additional treatment activities.

- **Protects key watersheds.** A significant portion of California's in-state water resources flow from forested landscapes. Healthy forest ecosystems in these upland watersheds ensure that sustainable quantities of high quality water for both domestic and agricultural uses will continue to flow.[5,6,7,8] In addition, water to support California's significant hydropower assets originates in these watersheds. This is particularly important given the predicted effects of climate change on future water production and the ability of forest management projects to protect and enhance both quality and quantity of water from forested landscapes. Increased water yield of 9-16%[9] could result should additional forest acres be thinned within a watershed (see targeted treatment acres table on page 1).

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[3] C. Mason, B. Lippke, K. Zobrist et al., "Investments in Fuel Removals to Avoid Forest Fires Results in Substantial Benefits," Journal of Forestry, January/February 2001, pp. 27-31.
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[5] D.G. Neary, K.C. Ryan and L.F. DeBano (eds.), Wildland Fire in Ecosystems: Effects of Fire on Soils and Water, Gen. Tech. Rep. RMRS-GTR-42-vol 4. Ogden, UT, USDA Forest Service Rocky Mountain Research Station, 2005.
[6] R.R. Harris, and P.H. Cafferata, Effects of Forest Fragmentation on Water Quantity and Quality. Paper presented to the Conference on California Forest Futures, Sacramento, CA, May 23-24, 2005.
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- **Provides net air quality and greenhouse gas benefits.** Forest biomass material that would otherwise be disposed of by burning in the open in piles, in prescribed broadcast burns, or would have been consumed in a wildfire, can be utilized in a controlled manner to provide renewable energy (energy conversion units including boilers and gasifiers that are equipped with Best Available Control Technology), thus reducing air emissions and improving regional air quality. The air quality benefits are significant, with 95-99% reduction in particulate matter, carbon monoxide, and volatile organics, and a 60-80% reduction in nitrogen oxides when compared to open burning.[10,11,12] An additional climate change benefit results from replacing fossil fuel fired power generation with renewable bioenergy.

- **Provides economic development and employment.** Most bioenergy facilities are sited in rural areas that are currently experiencing significant economic hardship. Jobs include plant operations and maintenance as well as fuel collection, processing and transport. Approximately five jobs are created per MW of bioenergy generation.[13]

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[13]G. Morris, The Value of the Benefits of US Biomass Power, November, 1999, NREL Publication SR 570-27541.

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- **Reduces wildfire suppression costs.** Forest management fuel reduction activities significantly reduce the economic costs for fighting wildfires.

Barriers

- Appropriated budgets for federal agency land management are far less than necessary for adequate levels of sustainable forest management and hazardous fuels reduction.

- There has been a dramatic loss of physical and human forest management infrastructure in California. This infrastructure is logistically and economically difficult to reestablish.

- Woody biomass that is a byproduct of forest management and hazard reduction projects has value for energy production or other products (like mulch) and therefore offers the potential for additional income for forest owners and managers. However, woody biomass market value as a renewable fuel has dropped in recent years (partly due to low cost fossil fuels like natural gas), so large volumes of woody biomass is currently not utilized and is instead open-burned on site.

- There is a lack of consensus among key interests as to what constitutes sustainable forest management. This often results in appeals or litigation that delay project implementation.

- Current wholesale market pricing for industrial-scale bioenergy (greater than 3 MW) does not provide the necessary financial incentive for existing bioenergy facilities to operate past current power purchase agreement termination dates.

- Many of the investor-owned-utilities are focused on least cost/best fit for renewable generation, which does not favor the relatively high cost bioenergy generation sector.

Solutions

Solution sets that provide specific and tangible results to address forest health and defensible communities are identified below, grouped as short-term, mid-term and long-term targets.

Short-Term Solutions
• AB 32 Investment Plan - State should invest in forest health projects now to realize carbon storage enhancement by 2050. • CPUC - SB 1122 implementation process - focus on fair and equitable treatment of forest bioenergy projects. Provide input on societal and ratepayer benefits (CPUC workshop planned this winter). Share Mokelumne Watershed Avoided Cost Study findings with the CPUC. • Implementation of PCAPCD Biomass to Energy Protocol through the CAPCOA Emissions Offset Exchange. • Brief key state agencies (CPUC/CEC) on the need to invest EPIC $ in research, development and deployment of emerging bioenergy technologies. • Coordinate implementation of bioenergy technology workshops to align key players (e.g., financial institutions, project developers, investors, state agencies) to the potential opportunities. Consider asking Cal EPA/BAC and/or UC Extension to sponsor these workshops. • Support upcoming bioenergy workshops planned for Chester/Eureka/Merced (sponsored by UC Extension). • Meet with Assembly members Dahle and Gordon to brief them on Wood Energy Group and BWG initiatives. Discuss possible field trip to Blodgett or other appropriate locations. • Participate in Biomass Work Group meetings to continue to help build support for sustainable forest management and bioenergy development among a broad range of interests.
Mid-Term Solutions
• Research in support of a Biomass to Biochar GHG emissions offset protocol. • Continue to pursue research related to defining the GHG benefits of sustainable forest management that reduces the negative impacts of wildfire. • State Legislative Solutions: o Cost Sharing Account for IOU's to share costs that benefit all ratepayers/society. (Consider cost shifting options - post AB 1890). Correct "unfair burden" to IOU's. Possibly team with key stakeholders (e.g., BAC, CBEA, CFA). o Least Cost/Best Fit and baseload energy. Need to solve this dynamic so existing biomass infrastructure can continue to exist.
Long-Term Solutions
• Develop a GHG protocol for benefits associated with forest management that reduces wildfire effects.

GHG Emissions from Woody Forest Residue Biomass Energy:
Literature Review Relevant to Sierra Nevada Biomass Energy Facilities

Prepared For:

Placer County Air Pollution Control District
10 Maple Street
Auburn, CA 95603

Prepared by:

Spatial Informatics Group
3248 Northampton Ct.
Pleasanton, CA 94588

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Project Lead: David Saah, Ph.D.
Managing Principal, Spatial Informatics Group
Email: dsaah@sig-gis.com
Phone: (510) 427-3571

Technical Expert: John Gunn, Ph.D.
Senior Scientist, Spatial Informatics Group and Executive Director, Spatial Informatics Group – Natural Assets Laboratory (SIG-NAL)

Technical Expert: Thomas Buchholz, Ph.D.
Senior Scientist, Spatial Informatics Group

DRAFT

Date: June 13, 2013

CONTENTS

SECTION 1: INTRODUCTION

PURPOSE AND INTENT OF WHITE PAPER

This Woody Forest Residue Biomass Energy Greenhouse Gas White Paper addresses the current scientific understanding of greenhouse gas emissions associated with developing energy facilities using woody biomass versus the use of fossil fuels. The objectives of this paper are to:

1. Summarize key issues from recent relevant literature.

2. Discuss specific relevance of literature to a scenario of distributed biomass electricity generation facilities being planned in the Sierra Nevada region.

WOODY BIOMASS GREENHOUSE GAS ACCOUNTING OVERVIEW

Many studies since 1991 have illustrated that energy generated from woody biomass can be carbon intensive (i.e., greater net GHG emissions) relative to the fossil fuel equivalent energy source for short or long periods of time. Buchholz, Gunn, and Saah conducted a literature review of 39 studies published between 1991 and 2012 that investigate the Greenhouse Gas (GHG) emissions (primarily CO_2) of forest-based bioenergy systems. The studies ranged from global to local scales and varied in temporal and analytical boundary setting. **The majority of literature reviewed concluded that biomass utilization for energy is atmospherically CO_2 ("carbon") neutral over time when compared to fossil fuel equivalent energy sources.** That is, there is an initial carbon debt to the atmosphere that is paid back as forests sequester carbon compared to fossil fuel energy sources that continue to emit greenhouse gases. This was a consistent major finding of studies published over the past 22 years[1]. Below is a discussion of some of these key papers with notes on their relevance to small-scale biomass energy generation of the type proposed for the Sierra Nevada region that would use woody feedstocks from piles of thinnings that would have otherwise been burned on site. We refer to this as the "Sierra Nevada Scenario" – where a series of distributed biomass electricity generation facilities (e.g., 2-4MW) would be developed to use forest-sourced material (hazardous fuels residuals [i.e., woody biomass material that poses a substantial fire threat to human or environmental health], forest thinning and harvest residuals [i.e., woody biomass generated from forest maintenance and restoration activities], and clean Wildland Urban Interface (WUI; generally areas within ¼-mile of urban centers where materials would otherwise be piled and burned)-sourced waste materials from defensible space clearing activities; materials that would otherwise be piled and burned. Biomass materials (fuel for the plant) would be processed (ground and screened) at the locations from which they are removed (such as U.S. Forest Service USFS fuels reduction sites) and delivered via haul truck to the project site.

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[1] See Appendix A for a citation list of these studies.

The articles discussed below, with the exception of Searchinger et al. (2009), evaluate the atmospheric GHG impacts of switching from fossil fuel energy sources to woody biomass energy in specific ecological contexts and fossil fuel substitution scenarios. Indeed, many analytical studies since 1991 (see further discussion in Section 3) have concluded that biomass energy generation using woody feedstocks from forests can produce initial increases in GHG emissions relative to the fossil fuel equivalent energy source. As described by Walker et al. (2013), a peer-reviewed publication based on the 2010 Manomet findings, the GHG impacts of wood biomass energy will be specific to the forest and technology context of the region or biomass energy projects. Key points and relevance are described for the specific citations below.

SECTION 2: REVIEW OF RELEVANT FOREST BIOMASS ENERGY LITERATURE

ISSUE 1: BIOMASS ELECTRICITY GENERATION CAN BE A GREATER EMITTER OF ATMOSHPERIC GREENHOUSE GASES THAN FOSSIL FUEL SOURCES FOR A VARYING TIME PERIOD (E.G., DECADES TO CENTURIES).

Literature that supports this statement: Mitchell et al. 2012; Schulze et al. 2012; McKechnie et al. 2011; Manomet 2010; Walker et al. 2013; and Searchinger et al. 2009.

MITCHELL, S.R., HARMON, M.E., O'CONNELL, K.E.B. 2012. CARBON DEBT AND CARBON SEQUESTRATION PARITY IN FOREST BIOENERGY PRODUCTION. GCB BIOENERGY 4(6):818-827.

Key Points/Findings: Mitchell et al. (2012) simulated ecosystems in the Pacific Northwest under several initial landscape conditions ranging from afforesting post-agricultural land to old-growth (>200 years) forests. The simulations were used to evaluate the time required to pay back carbon "debt" generated by biomass energy production (i.e., GHG emissions in excess of the fossil fuel baseline). The results showed that initial landscape condition and land-use history are fundamental in determining the amount of time required for forests to repay the carbon debt incurred from bioenergy production. Their baseline is a "do-nothing, no-harvest scenario".

Relevance to the Sierra Nevada Scenario: The simulations conducted by Mitchell et al. capture a range of forest landscape contexts, but **do not specifically evaluate a scenario where residue (i.e., tops, limbs, and small diameter material) is used from ongoing fuel reduction harvests where the baseline fate for the material would be combustion on site in piles.** Therefore, it is not appropriate to apply the results of this simulation study to the Sierra Nevada scenario.

SCHULZE, E.-D., KÖRNER, C., LAW, B. E., HABERL, H., & LUYSSAERT, S. 2012. LARGE-SCALE BIOENERGY FROM ADDITIONAL HARVEST OF FOREST BIOMASS IS NEITHER SUSTAINABLE NOR GREENHOUSE GAS NEUTRAL. GCB BIOENERGY, N/A–N/A. DOI:10.1111/J.1757-1707.2012.01169.X

Key Points/Findings: Schulze et al. (2012), in an invited editorial (i.e., no new analyses were conducted) make the argument that an increase in the appropriation of Net Primary Productivity (NPP[2]) in the form of new biomass harvested for energy, would lead to decreased biomass stocks and consequently more biogenic carbon moving into the atmosphere than is currently the case.

Relevance to the Sierra Nevada Scenario: While Schulze et al. present a valid concern about global primary energy supply targets sourced from biomass, the discussion of "additional" biomass being harvested is **not relevant to the Sierra Nevada Scenario since the residue material used in the facility is already being harvested and burned in piles at the landing areas used for thinning operations.**

MCKECHNIE, J., COLOMBO, S., CHEN, J., MABEE, W., MACLEAN, H.L., 2010. FOREST BIOENERGY OR FOREST CARBON? ASSESSING TRADE-OFFS IN GREENHOUSE GAS MITIGATION WITH WOOD-BASED FUELS. ENVIRON. SCI. TECHNOL. 45: 789–795.

Key Points/Findings: McKechnie et al. (2010) present a life cycle assessment (LCA) and forest carbon analysis to assess total GHG emissions of forest bioenergy over time. The LCA evaluates specific cases in Ontario, Canada where wood pellets would be used to generate electricity instead of coal. The LCA also evaluates ethanol production emissions. The woody feedstocks include both harvest residues and standing trees. McKechnie et al. (2010) found that GHG emissions initially exceed avoided fossil fuel-related emissions, temporarily increasing overall emissions. The length of time for this carbon debt for wood pellet electricity generation ranged from 16-38 years (shorter if using residues only, longer if standing trees were used). Ethanol emissions were greater than fossil fuel emissions for a much longer period of time (>74 years). As others have concluded, McKechnie et al. (2010) found that "forest carbon more significantly affects bioenergy emissions when biomass is sourced from standing trees compared to residues and when less GHG-intensive fuels are displaced." The baseline fate for harvest residues in McKechie et al. (2010) is decomposition on site.

Relevance to the Sierra Nevada Scenario: The baseline fate for thinning residues proposed for use in the Sierra Nevada Scenario is to be burned in piles at the thinning site as opposed to decomposition either in piles or distributed back into the forest. Therefore, the conclusions from McKechnie et al. (2010) do not address the specific case described for the Sierra Nevada.

[2] Net primary productivity (NPP) is defined as the net flux of carbon from the atmosphere into green plants per unit time. (http://daac.ornl.gov/NPP/html_docs/npp_est.html)

In fact, the authors go on to point out: **"In some jurisdictions, residues are burned during site preparation for forest regrowth. Using such residues for bioenergy would not significantly impact forest carbon stocks."** Furthermore, forest carbon stocks are being reduced through thinning even in the absence of the proposed bioenergy project.

WALKER, T., P. CARDELLICHIO, J.S. GUNN, D. SAAH, & J.M. HAGAN. 2013. CARBON ACCOUNTING FOR WOODY BIOMASS FROM MASSACHUSETTS (USA) MANAGED FORESTS: A FRAMEWORK FOR DETERMINING THE TEMPORAL IMPACTS OF WOOD BIOMASS ENERGY ON ATMOSPHERIC GREENHOUSE GAS LEVELS. JOURNAL OF SUSTAINABLE FORESTRY. 32(1-2), 130–158.

Note: Peer-reviewed publication based on the "Manomet Study": Walker, T., P. Cardellichio, J.S. Gunn, D. Saah, J.M. Hagan. 2010. Massachusetts Biomass Sustainability and Carbon Policy Study. Manomet Center for Conservation Sciences NCI-2010-03.

Key Points/Findings: Similar to McKechie et al. (2010), Walker et al. (2010) found that new harvests of standing trees and the utilization of existing harvest residues in Massachusetts forests lead to a temporary carbon debt relative to a fossil fuel equivalent energy source. Walker et al. found that the feedstock matters - and so does the type of energy being produced and energy being replaced compared to projected future baseline. The baseline scenario in Walker et al. was one where typical harvests leave residue (tops/limbs) to decompose either in the forest or at a landing site following de-limbing. Removing this residue and some additional low quality whole trees to supply new bioenergy production results in an initial "carbon debt" to the atmosphere relative to the fossil fuel and forest management baseline. They also concluded that this debt can be recovered over time through forest regrowth. Baseline and bioenergy scenarios did not include natural disturbance risks beyond density-dependent mortality.

Relevance to Sierra Nevada Scenario: The baseline described in the Manomet Study is quite different from the proposed Sierra Nevada Scenario. As with McKechnie et al. (2010), the baseline in the Manomet/Walker et al. (2010) study is to leave harvest residue in the forest to decompose naturally over time. Residues are not burned quickly after the harvest operation as is the case with the proposed scenario. The Manomet/Walker et al. (2010) study also evaluated the impact of the removal of additional whole trees beyond baseline harvest levels. This results in a reduction of forest carbon stocks from the baseline and partly drives the conclusion of excess emissions from bioenergy. **For the Sierra Nevada Scenario, baseline forest carbon stocks are already being reduced in the existing thinning operation followed by relatively immediate combustion in piles. This is a fundamental distinction that prevents the work of Walker et al. (2010) from being applied to this context in the Sierra Nevada.**

SEARCHINGER, T. D., HAMBURG, S. P., MELILLO, J., CHAMEIDES, W., HAVLIK, P., KAMMEN, D. M., LIKENS, G. E., ET AL. 2009. FIXING A CRITICAL CLIMATE ACCOUNTING ERROR. SCIENCE, 326(5952), 527-528.

Key Points/Findings: Searchinger et al. (2009) do not present any new analysis of biomass energy greenhouse gas emissions, but make the important point that "The potential of bioenergy to reduce greenhouse gas emissions inherently depends on the source of the biomass and its net land-use effects." They go on to say: "Bioenergy therefore reduces greenhouse emissions only if the growth and harvesting of the biomass for energy captures carbon above and beyond what would be sequestered anyway and thereby offsets emissions from energy use. This additional carbon may result from land management changes that increase plant uptake or from the use of biomass that would otherwise decompose rapidly." Rapid decomposition results in near term GHG emissions as well as carbon storage in the soil. Searchinger et al. (2009) were speculating about potentially carbon-beneficial scenarios and did not have data to support the statement.

Relevance to the Sierra Nevada Scenario: Searchinger et al. (2009) acknowledge that biomass energy use may result in a reduction of overall carbon emissions compared to a *business-as-usual* scenario if the feedstock used is biomass that would otherwise decompose rapidly. The overall GHG balance and length of payback time for a bioenergy system is therefore correlated to the time required to convert biogenic carbon to atmospheric carbon in a baseline scenario. In this context, burning biomass on site results in immediate conversion of biogenic carbon to atmospheric carbon. However, **Searchinger et al. do not make any statements regarding the use of material that would otherwise be burned following removal from the forest.**

ISSUE 2: FUEL REDUCTION THINNING OPERATIONS DESIGNED TO REDUCE FIRE RISK RESULT IN LONG-TERM ATMOSPHERIC GREENHOUSE GAS EMISSIONS INCREASES IF USED FOR BIOENERGY

Literature supporting this statement: Campbell et al. 2011; and Hudiberg et al. 2011

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.

Key Points/Findings: Campbell et al. (2012) use modeling results to argue that fuel reduction projects do not usually lead to an atmospheric benefit when the probability that a given area will experience fire is considered. They conclude that thinning results in high forest carbon stock loss relative to what is protected from combustion if a treated area burns. It is important to note that the study does not evaluate the use of fuel reduction thinning material for bioenergy production or wood products, but simply forest carbon stock change. We include a review of studies with findings contrary to Campbell et al. (2012) in Section 3.

Relevance to the Sierra Nevada Scenario: The Campbell et al. (2012) paper is an inappropriate comparison to make in the context of the Sierra Nevada Scenario's emissions relative to a projected future baseline because decisions related to forest management are made separate and distinct from the proposed facilities. The same amount of forest residues will be produced regardless of whether the project will be built, and the fact that some of the waste material will end up as energy instead of being burnt in the open will not change the rate at which thinnings occur. **The baseline of an un-thinned forest is not relevant to the question of the facility's contribution to the atmosphere since the thinning would have occurred whether the facility was present or not.** As the facility would not be a driver of fuel treatments, concerns on GHG implications of forest management decisions are not relevant to the question of GHG accounting.

HUDIBURG, T. W., LAW, B. E., WIRTH, C., & LUYSSAERT, S. (2011). REGIONAL CARBON DIOXIDE IMPLICATIONS OF FOREST BIOENERGY PRODUCTION. NATURE CLIMATE CHANGE, 1(11), 419–423. DOI:10.1038/NCLIMATE1264

Key Points/Findings: Hudiberg et al. (2011) conducted a comprehensive carbon accounting of net biome production (NBP) for the Washington, Oregon, and California forest sector. NBP was defined as "the annual net change of land-based forest carbon after accounting for harvest removals and fire emissions." The baseline defined by Hudiberg et al. (2011) for western US forests is relevant to the Sierra Nevada Scenario and includes current preventative thinning and harvest levels, but the scenarios that were evaluated included removals **in addition** to the current harvest level, and were performed over a 20-year period such that 5% of the landscape is treated each year. They conclude: "…even though forest sector emissions are compensated for by emission savings from bioenergy use, fewer forest fires, and wood product substitution, the end result is an increase in regional CO2 emissions compared to baseline as long as the regional sink persists."

Hudiberg et al.'s (2011) key relevant conclusion is based on a scenario that assumes additional forest thinning operations beyond the current baseline are conducted to support bioenergy production. The results are also presented on a regional basis, and as such it is difficult to downscale the conclusions to specific ecoregions or use to it determine the impact of a single facility.

Relevance to the Sierra Nevada Scenario: The important factor to consider is whether the use of forest thinning residues for bioenergy is additional to what is currently done. The scenarios described in Hudiberg et al. (2011) that result in greater emissions from bioenergy production over the baseline include an increase in thinning activity over current levels to generate feedstocks for bioenergy facilities. The proposed Sierra Nevada Scenario baseline is one where thinning already happens as a common practice and the material is stacked in piles and burned at the forest site. The Sierra Nevada Scenario would convert a feedstock to energy that is currently burned at the forest site. Therefore, the assumption that woody material derived from forest thinning operations, even if intended to reduce fire risk would result in long-term atmospheric CO_2 increases if combusted for bioenergy is not supported by Hudiberg et al. (2011) because it does not consider the context where feedstocks are derived from existing management activities and not thinnings that are "additional".

ISSUE 3: USING FOREST RESIDUALS REPRESENTS A CHANGE IN MANAGEMENT PRACTICE THAT WILL AFFECT GREENHOUSE GAS EMISSIONS

"… a change in forest management practices, for instance, by decreasing rotation length or increasing the use of forest residues also has a long-term impact on the landscape-level terrestrial stock or the stand-level C[arbon] stock time-averaged over the rotation." Citation for this statement: Pingoud et al. 2011; and related statements in Repo et al. 2010.

PINGOUD, K., EKHOLM, T., & SAVOLAINEN, I. (2011). GLOBAL WARMING POTENTIAL FACTORS AND WARMING PAYBACK TIME AS CLIMATE INDICATORS OF FOREST BIOMASS USE. MITIGATION AND ADAPTATION STRATEGIES FOR GLOBAL CHANGE, ONLINE, 1–18. DOI:10.1007/S11027-011-9331-9

Key Points/Findings: Pingoud et al. (2011) utilize a global warming potential (GWP) factor to evaluate the GHG implications of biological carbon life cycles compared to permanent fossil fuel emissions. The factor accounts for the pulse of GHGs emitted to the atmosphere when biomass is combusted relative to a lower emission per unit energy of a fossil fuel (or from decomposing harvest residues). The GWP is a radiative-forcing based metric and the authors propose that it is a more realistic warming indicator than simply considering net carbon balance.

Relevance to the Sierra Nevada Scenario: The quoted text from Pingoud et al. (2011) is from the paper's introduction and is not a conclusion from the study; and does not provide evidence to support the broad assertion that increased use of forest residuals represents a change in forest management from the baseline in all contexts. **The Sierra Nevada Scenario feedstocks are derived from thinning material that would be generated in the absence of the facility and burned in piles at the forest site. Therefore the particular quote from the Pingoud et al. (2011) paper is not applicable to the Sierra Nevada Scenario.** The paper does discuss a pulse emissions factor that would more accurately reflect the global warming potential of such an emission. However, the pulse of emissions from pile burning would have an equivalent global warming potential to the bioenergy emission (total volume emitted will vary with combustion efficiency of the pile and the facility) and as such would tend to support the conclusion that the facility does not contribute to a net increase in CO_2 emissions.

REPO, A., TUOMI, M., LISKI, J., 2011. INDIRECT CARBON DIOXIDE EMISSIONS FROM PRODUCING BIOENERGY FROM FOREST HARVEST RESIDUES. GCB BIOENERGY 3: 107–115.

Key Points/Findings: Repo et al. (2010) evaluates the use of logging (harvest) residue for bioenergy in boreal Norway spruce forest in Finland. The baseline business-as-usual context for the study assumes logging residue left in the forest to decompose (e.g., McKechnie et al., 2011 and Walker et al, 2010). The authors state that "indirect emission of using logging residues for energy production depend critically on the decomposition rate of the residues if they were left at the site." As with similar studies, the authors conclude there is a short term carbon debt to the atmosphere relative to a fossil fuel energy baseline, but over time the bioenergy system achieves net benefits relative to fossil fuels.

Relevance to the Sierra Nevada Scenario: The increased use of forest residuals in the Sierra Nevada Scenario does not represent a change in management practice that may affect overall greenhouse gas emissions. For this statement to be relevant, the presence of the biomass facility would be the (market) driver for additional harvests of residue. **In the Sierra Nevada Scenario, the well-established driver for harvests is to meet fuel reduction objectives, while the energy use is secondary. As such, conclusions from Repo et al. are not applicable to the Sierra Nevada Scenario.**

ISSUE 4: ASSUMPTIONS USED IN CALCULATING ATMOSPHERIC GREENHOUSE GAS EMISSIONS HAVE AN IMPACT ON THE OUTCOME OF THE ANALYSIS

HOLTSMARK, B. 2012. THE OUTCOME IS IN THE ASSUMPTIONS: ANALYZING THE EFFECTS ON ATMOSPHERIC CO2 LEVELS OF INCREASED USE OF BIOENERGY FROM FOREST BIOMASS. GCB BIOENERGY. ONLINE EARLY VIEW.

Key Points/Findings: Holtsmark (2012) modifies assumptions used in five published studies (including the Manomet Study and McKechnie et al., 2011 reviewed above) to evaluate the impacts on the analysis outcomes. Holtsmark (2012) looks at several assumptions, including whether a single or a set of repeated harvests were considered. Indeed, Walker et al. (2013) acknowledge that the outcome in terms of the length of the carbon debt payback period would likely be longer if harvest entries occurred at an interval more frequent than the payback period itself.

Relevance to Sierra Nevada Scenario: The frequency of harvest has no bearing on the calculations made in the evaluation of Sierra Nevada Scenario facility's emissions relative to the current baseline. In this study, as well as other studies discussed above, the carbon debt payback period partly relies on the regrowth of forests following new biomass harvests. **The important distinction between these studies and the Sierra Nevada Scenario is that fuel treatments will be carried out regardless of the presence of the biomass facility, and the frequency of forest thinning is determined by other parameters.**

ISSUE 5: LIFE CYCLE GREENHOUSE GAS EMISSIONS OF THE PILE BURNING OF THINNING RESIDUE

JONES, G., LOEFFLER, D., CALKIN, D., & CHUNG, W. 2010. FOREST TREATMENT RESIDUES FOR THERMAL ENERGY COMPARED WITH DISPOSAL BY ONSITE BURNING: EMISSIONS AND ENERGY RETURN. BIOMASS AND BIOENERGY, 34(5), 737–746. DOI:10.1016/J.BIOMBIOE.2010.01.016

Key Points/Findings: Jones et al. (2010) represents the sole paper that could be found that evaluates a scenario comparable to the Sierra Nevada Scenario. The study evaluated the life cycle greenhouse gas emissions of pile burning of thinning residue and fossil fuel energy production compared to the use of thinning residue to generate an equivalent amount of bioenergy. The authors concluded:

> “the bioenergy alternative produces substantially less total carbon dioxide emissions than do the pile-burn alternatives. Carbon dioxide emissions from the bioenergy alternative are only 55% of the pile-burn alternative using distillate oil and 62% of the pile-burn alternative using natural gas. The amount of carbon dioxide emissions from burning diesel fuel to collect, grind, and haul the biomass to the boiler facility represents only a very small percentage of the total carbon dioxide emissions in the bioenergy alternative.”

Relevance to the Sierra Nevada Scenario: The findings presented in Jones et al. are directly relevant to the Sierra Nevada Scenario. The study’s life cycle analysis includes an evaluation of the fossil fuel substitution benefits achieved from bioenergy production. This use of fossil fuel emissions in the baseline is typical of the majority of the citations reviewed above. This study demonstrates there is a bioenergy emissions benefit relative to the baseline when the feedstock is fuel reduction thinning material that would otherwise be burned in piles.

ISSUE 6: GREENSHOUSE GAS IMPLICATIONS OF FUEL REDUCTION TREATMENTS RELATIVE TO POTENTIAL FIRE-RELATED EMISSIONS

WINFORD, E.M., GAITHER JR., J.C., 2012. CARBON OUTCOMES FROM FUELS TREATMENT AND BIOENERGY PRODUCTION IN A SIERRA NEVADA FOREST. FOREST ECOLOGY AND MANAGEMENT 282, 1–9.

Key Points/Findings: This study evaluates the carbon implications of fuels treatments in a relevant context for the Sierra Nevada Scenario. Scenarios where there are frequent fires (i.e., < 31 year return interval) lead to carbon benefits from fuel reduction treatments and bioenergy production. Longer fire return intervals had greater carbon benefits in the baseline “no treatment” scenarios. The authors summarize the key drivers as:

> “Net carbon sequestration levels from fuels reduction and bioenergy production must be evaluated over long time periods and are strongly influenced by fire rotation, fire

severity, starting stand conditions, tree growth (and carbon sequestration) rates, and the efficiency of bioenergy plants. The most critical variable identified as influencing the life-cycle analysis in this study is fire rotation, the length of time that it takes for a given area to burn."

Relevance to Sierra Nevada Scenario: The study uses a baseline forest management scenario of "no treatment" to make the evaluations. This baseline scenario is again different from the Sierra Nevada Scenario where fuel reduction treatments are ongoing even in the absence of the bioenergy facility. While this is a useful study to look at the carbon benefits of thinning activities and bioenergy production as they interact with fire regimes, it is only indirectly relevant to the Sierra Nevada baseline.

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.

HURTEAU, M., & NORTH, M. 2009. FUEL TREATMENT EFFECTS ON TREE-BASED FOREST CARBON STORAGE AND EMISSIONS UNDER MODELED WILDFIRE SCENARIOS. FRONTIERS IN ECOLOGY AND THE ENVIRONMENT, 7(8), 409–414. DOI:10.1890/080049

HURTEAU, M. D., & NORTH, M. 2010. CARBON RECOVERY RATES FOLLOWING DIFFERENT WILDFIRE RISK MITIGATION TREATMENTS. FOREST ECOLOGY AND MANAGEMENT, 260(5), 930–937. DOI:10.1016/J.FORECO.2010.06.015

HUDIBURG, T. W., LAW, B. E., WIRTH, C., & LUYSSAERT, S. (2011). REGIONAL CARBON DIOXIDE IMPLICATIONS OF FOREST BIOENERGY PRODUCTION. NATURE CLIMATE CHANGE, 1(11), 419–423. DOI:10.1038/NCLIMATE1264

SAFFORD, H. D., SCHMIDT, D. A., & CARLSON, C. H. 2009. EFFECTS OF FUEL TREATMENTS ON FIRE SEVERITY IN AN AREA OF WILDLAND–URBAN INTERFACE, ANGORA FIRE, LAKE TAHOE BASIN, CALIFORNIA. FOREST ECOLOGY AND MANAGEMENT, 258(5), 773–787. DOI:10.1016/J.FORECO.2009.05.024

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 PUBLICATION NO. 143 OF THE NATIONAL FIRE AND FIRE SURROGATE PROJECT. CANADIAN JOURNAL OF FOREST RESEARCH, 39(8), 1538–1547. DOI:10.1139/X09-081

There is a lack of scientific consensus on the impacts of forest thinning operations on long-term atmospheric CO2. In addition to Campbell et al. (2012), there have been at least four recent papers that evaluate the impacts of fuel treatment (i.e., thinning and prescribed fire) on carbon storage and greenhouse gas emissions in the Sierra Nevada region in particular. Hurteau and

North (2009 and 2010), Safford et al. (2009), and Stephens et al. (2009) do not explicitly evaluate biomass energy emissions but look at forest carbon stock changes under fuel treatment scenarios designed to mitigate wildfire risk and severity.

Hurteau and North (2009 and 2010) used data from stand-scale experimental treatments in Sierran mixed conifer forests to measure changes in forest carbon stocks under various thinning and prescribed fire fuel treatments. In general, thinning trees from small size classes had little impact on tree-based C storage over a 100 year period, but did raise the average height from the ground to the base of the live crown, a key factor in reducing fire intensity[3]. Hurteau and North (2009) concluded that thinning treatments which included prescribed fire had lower wildfire emissions than did treatments that only involved thinning. They found that there is an initial carbon stock loss that results from fuel treatments, but these forests can recover carbon stocks quickly if the treatments do not remove large and fire-resistant over story trees. Based on their work, Hurteau and North conclude that "forests with "high stand-replacing wildfire potential, reducing stem density and aggregating carbon in larger, fire-resistant trees can allow for the restoration of fire as a disturbance process that maintains carbon stocks at levels within the carbon carrying capacity of the forest."

Stephens et al. (2009) provide another recent quantitative study of fuel treatments and carbon storage in the Sierran mixed conifer Blodgett Forest. As with Hurteau and North, Stephens et al. (2009) conclude that when fire frequency is high, short-term carbon loss through treatments such as thinning and prescribed burning can lead to long-term carbon benefits relative to a management regime that does not include these fuel treatments.

These studies highlight the potential for fuel treatments to have long-term carbon benefits in addition to the well-documented fire severity reduction that they are designed to achieve. Understanding the current and future fire regime for a given region is important for evaluating the potential carbon benefits. Forest ecosystems with long fire return intervals may not produce the same carbon benefits as shown for systems with high fire frequency.

SECTION 4: SUMMARY CONCLUSIONS

WOODY BIOMASS ENERGY PROJECTS AND CARBON NEUTRALITY

There is a growing understanding that biomass energy projects are not inherently "carbon neutral". However, there are contexts and scenarios where the carbon "debt" can be quite short (e.g., less than 10 years) or non-existent. Calculating the potential atmospheric GHG

[3] In support of the importance of fuel treatments reducing fire intensity, Safford et al. (2009) found fuel treatments substantially moderated fire severity and reduced tree mortality during the Angora Fire in the Lake Tahoe Basin.

impacts of switching from fossil fuel energy sources to woody biomass energy is complex and context specific. The framework described in Walker et al. (2013) documents the inputs required to evaluate the GHG impacts of a woody biomass energy project. The framework is as follows (from Walker et al. (2013)):

> "Four key inputs are required to calculate the specific shape of the debt-then-dividend curve for a given region or individual biomass facility. *First, the biomass feedstock source*: the GHG implications of feedstocks differ depending on what would have happened to the material in the absence of biomass energy generation. *Second, the form of energy generated*: energy technologies have different generation efficiencies and thus different life cycle GHG emissions profiles. *Third, the fossil fuel displaced*: coal, oil, and natural gas each have different emissions per unit of energy produced. *Fourth, the management of the forest*: forest management decisions affect recovery rates of carbon from the atmosphere. This framework has broad application for informing the development of renewable energy and climate policies. Most importantly, this debt-then-dividend framework explicitly recognizes that **GHG benefits of wood biomass energy will be specific to the forest and technology context of the region or biomass energy projects**."

The literature citations discussed above generally illustrate the impacts to atmospheric GHG emissions if **additional** material (i.e., beyond baseline removal rates) is harvested (or thinned) to support bioenergy production. The studies conclude that this results in a temporary (and sometimes permanent) reduction of forest carbon stocks and generally results in higher emissions from bioenergy relative to an equivalent fossil fuel energy source. The baseline and bioenergy scenarios described by these studies are very different than the context described in the Sierra Nevada Scenario. Use of existing fuel reduction thinning material from piles otherwise destined to be burned does not result in a decrease in forest carbon stocks from the baseline scenario because the fate of the waste materials has already been determined by others. This is a fundamental distinction between the proposed scenario and many of the studies cited by above.

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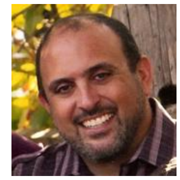
KEY CONTRIBUTORS

DR. DAVID SAAH, MANAGING PRINCIPAL



Dr. Saah has been broadly trained as an environmental scientist with expertise in a number of areas including: landscape ecology, ecosystem ecology, hydrology, geomorphology, ecosystem modeling, natural hazard modeling, remote sensing, geographic information systems (GIS) and geospatial analysis. He has used these skills to conduct research primarily at the landscape level in a variety of systems. Dr. Saah has participated in research projects throughout the United States and Internationally. His academic research uses integrated geospatial science for multi-scale mapping, monitoring and modeling of environmental spatial heterogeneity, particularly in riparian, savanna, and forest ecosystems. These efforts include quantification of change in landscape pattern, investigating the linkages between pattern and processes, and understanding the pattern-process dynamic within different environmental management regimes. To complement this, Dr. Saah's consulting research interest and experience include: developing holistic decision support systems for resource management, assessing natural hazards, and quantifying ecosystem service valuation. In addition, all of his research addresses access, availability, and accuracy of geospatial and environmental datasets, and scale in natural resource and environmental research. Dr. Saah is committed to producing high quality research projects that integrate the most current science and technology. He is dedicated to the accurate dissemination of results from these endeavors through innovative presentations, publications, and workshops.

DR. JOHN GUNN, SENIOR SCIENTIST AND EXECUTIVE DIRECTOR, SIG-NAL

Dr. Gunn became the Executive Director of the newly-launched Spatial Informatics Group – Natural Assets Laboratory (SIG-NAL) on November 1st, 2012. Prior to SIG-NAL, John was a Senior Program Leader within the Natural Capital Initiative at the Manomet Center for Conservation Sciences. John has a B.S. in wildlife management from the University of Maine, an M.F.S. from the Yale School of Forestry and Environmental Studies, and a Ph.D. in biology from the University of New Brunswick studying the landscape ecology of forest songbirds. He has a broad background in sustainable forestry, including a position developing FSC-certified forest management systems for a large private landowner in Maine and extensive work on family forest and group certification issues throughout North America. John's recent work has focused on developing the tools and science necessary to implement payments for ecosystem services programs (such as carbon sequestration and drinking water quality) involving forest landowners. John has been elected to serve as an Environmental Chamber representative on the Forest Stewardship Council (FSC) US Board of Directors through 2013.

DR. THOMAS BUCHHOLZ, SENIOR SCIENTIST

Dr. Buchholz has research and work experience in the management and economics of natural forests, timber plantations, and short rotation energy crops (e.g. willow shrub plantations) for biomass production. He earned his Ph.D. from SUNY-ESF in bioenergy sustainability assessments and his M.Sc. in sustainable forestry in Germany; he is especially knowledgeable of the US and European bioenergy research and policy communities, and industry. In the course of his doctoral and post-doctoral research and his work with the Carbon Dynamics Lab at UVM, he has developed sustainability frameworks for bioenergy systems with substantive stakeholder inputs, and tested them on case studies in the US and abroad. In 2007, Dr. Buchholz worked at forestry program of the International Institute of Applied Systems Analysis (IIASA) in Austria, investigating the application of Multi-Criteria Analysis tools for participatory sustainability assessments of bioenergy systems. Being an affiliate at the Gund Institute for Ecological Economics as well as a member of the Carbon Dynamics Laboratory at the University of Vermont, he has been the lead author of several reports on forest bioenergy and energy plantation economics across the globe. Recent work includes micro- and macroeconomic analysis of forest based bioenergy use in the Northeastern US. Dr. Buchholz's main interest is applied research working on the interface of policy and science. The motivation for his work is to directly assist stakeholders and decision makers in the natural resource field in identifying lasting forest management and bioenergy solutions.

APPENDIX A. WOODY BIOMASS ENERGY ACCOUNTING STUDIES 1991-2013

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