LIFE CYCLE ANALYSIS (LCA) CALCULATOR TOOLS FOR PRODUCTION OF TRANSPORTATION FUELS FROM FOREST RESIDUE IN CALIFORNIA

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Context:

Increasingly widespread and severe wildfires are creating an ongoing ecological, climate, economic, and public health emergency in the U.S. West. States and landowners have responded with ambitious targets for forest health treatments, generating tens of millions of tons per year of woody residues that are typically left or burned in the field, impacting air quality, creating wildfire hazard, and leading to further ecosystem disruption. Diverting these residues for productive use can help increase the pace and scale of forest restoration efforts in California, reducing vulnerability to wildfire, supporting rural development, and promoting carbon storage. A 2021 report from the California Board of Forestry's Joint Institute for Wood Products Innovation[1] (JI) found that "the most promising wood product conversion option for small-diameter forest residues…are liquid and gaseous transportation fuels." In order for these products to contribute to the state's climate goals—and because key markets for biomass are structured around climate performance—comprehensive life-cycle emissions accounting is critical to the development of these industries.

Pursuant to this strategic goal, the CA Board of Forestry's Joint Institute for Wood Products Innovation (JIWPI) contracted an experienced team of LCA experts to develop a calculator quantifying the GHG impact of diverting forestry residues from current management practices to bioenergy products. This project produced calculator tools that model the life cycle GHG impact of electricity and hydrogen fuel pathways. These tools will allow biomass fuel producers to easily model the net GHG impact of utilizing these waste resources for energy production in California.

Calculator tools:

The tools produced under this project combine two cutting-edge models for bioenergy LCA. The first is the Greenhouse gas Regulated Emissions and Energy use in Technologies (GREET) model, a comprehensive LCA model developed and maintained by Argonne National Laboratory. As the premier model for fuel LCA, GREET was adapted by the California Air Resources Board (CARB) as CA-GREET and this model is used to assign carbon intensity (CI) "scores" under California's Low Carbon Fuel Standard (LCFS). CARB has released several simplified calculator tools for determining CI scores for Tier 1 fuel pathways, which allow users to enter monthly production data for mature fuel pathways. These tools use the GREET approach to combine emission factors

[1] Sanchez, D, and Gilani, H. (2021). Advancing collaborative action on forest biofuels in California. California Board of Forestry and Fire Protection. Sacramento, CA

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from the CA-GREET model with a producer's data to calculate disaggregated CI results for fuel pathway certification. However, none of the simplified calculator tools model woody biomass fuel pathways and there are currently no woody biomass-based fuel pathways certified under the LCFS. Unlike some other fuel pathways, however, fuels produced from woody biomass offer the potential to avoid emissions associated with leaving that slash material in the woods to be burned in place or left to decay and be exposed to wildfire. These spatially and temporally variable emissions must be accounted for in order to accurately characterize the life cycle carbon intensity of fuels derived from these materials. The California Biomass Residue Emissions Characterization (C-BREC) model offers a spatially-explicit Life Cycle Assessment (LCA) framework to rigorously and transparently establish the climate and air pollution impacts of mobilizing forest residues for a variety of potentially productive pathways. For these reasons, it is increasingly being used to shape energy and forest policy at the State and Federal level. Modeling with C-BREC has shown significant spatial variation in the carbon intensity of wood waste sourced from across the state's forestlands (Figure 1), driven primarily by geographic factors, such as species and size class characteristics of the residue, as well as the climatic drivers of both decay and wildfire emissions.

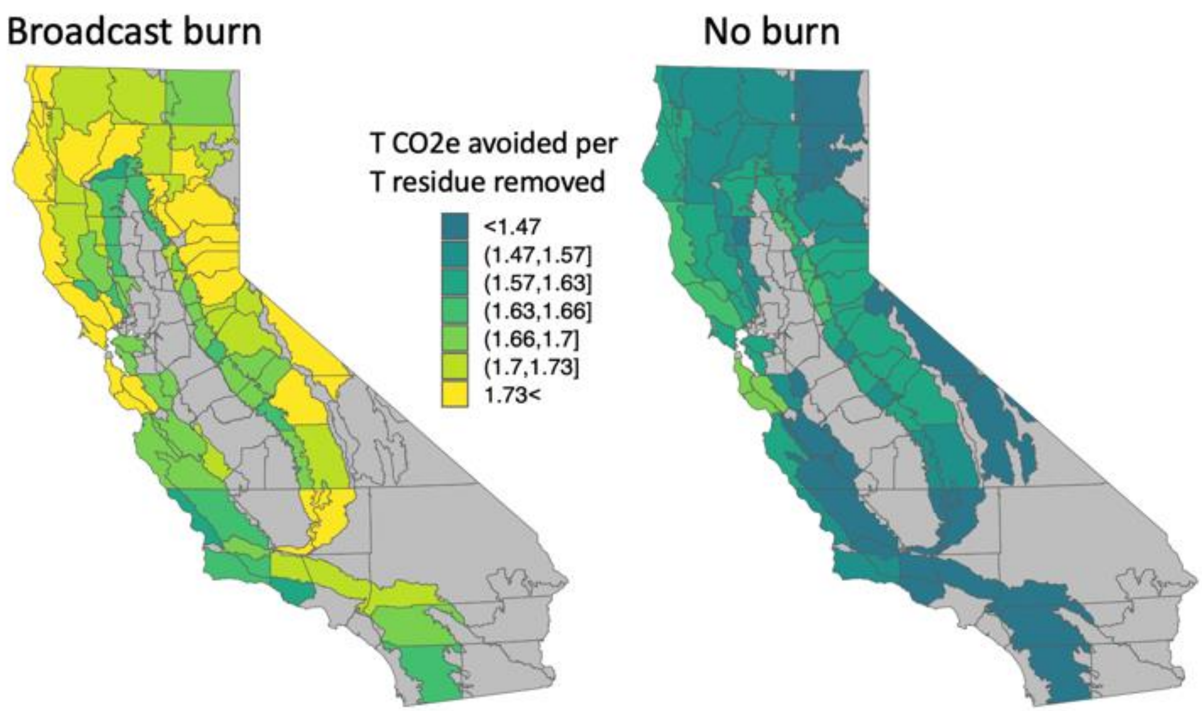

Figure 1: Example C-BREC outputs presenting avoided emissions for removal of biomass generated by moderate thinning activities (removal of 40% of total tree basal area targeting smaller diameter trees) mapped across California at the ecosection scale. These demonstrate the spatial variation of carbon intensity (within each map) as well as how avoided emissions are dependent on whether biomass would otherwise have been subject to a controlled burn (left) or left on-site (right).

In this project, simplified calculator tools were developed for renewable electricity and hydrogen fuel produced from woody biomass residues following the approach and format used in CARB's existing simplified calculator tools and counterfactual biomass emission results from the C-BREC model. Users with little or no experience with life cycle modeling can enter monthly production data, including quantities of biomass processed, biomass transport distance, production energy and chemical inputs, fuel production values (net electricity or hydrogen) and hydrogen fuel transport logistics (modes and distances), to calculate disaggregated CI results. Users also enter the quantity or share (%) of each biomass type, the California region from which it was sourced, the treatment type (commercial harvest or thinning), residue disposition (scattered or piled) and select whether the biomass would have been burned or left to decompose. The model then provides the ecosection average

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reference emissions per metric ton of biomass diverted for transport fuel production and the weighted average avoided emissions for the entire quantity of biomass converted to transport fuel. The net CI for a fuel pathway is then calculated as the sum of the life cycle fuel pathway emissions (based on the inputs throughout the fuel pathway) and the avoided reference emissions (represented as an emission credit).

The purpose of developing these calculators was to provide easy-to-use life cycle emission modeling tools that account for the reference biomass management practice and conform with the LCFS requirements and existing certified fuel pathways. Biomass fuel producers can easily estimate the CI of their fuel pathways, develop a good understanding of the avoided biomass emissions sourced from different regions and explore the impact of sourcing woody biomass from new regions in California. Ultimately, the goal of the project is to enable and accelerate the development of woody biomass-to-energy projects in California and create the tools and framework needed to certify these fuel pathways under the LCFS to unlock their credit generation potential and assist California in achieving its emission reduction and wildfire management targets. As these objectives are accomplished, the C-BREC model and the woody-biomass simplified calculators can be updated and expanded to model transport fuel produced from woody biomass sourced from other U.S. states.

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More information about the C-BREC model and related work can be found at schatzcenter.org/cbrec/ as well as our 2023 paper: Fingerman, K.R. *et al* (2023). Climate and air pollution impacts of generating biopower from forest management residues in California. *Environmental Research Letters*, *18*(3), 034038