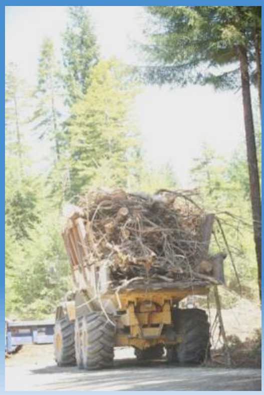
Climate and air quality impacts of utilizing forest management residues in California

Research Brief



The challenge:

California faces crisis conditions on its forested landscapes. A century of fire suppression and neglected forest health in combination with conditions exacerbated by climate change have created an ongoing ecological, economic, and public health emergency. Between commercial harvest on California's working forestlands and the increasing number of acres the state treats each year for fire risk reduction and carbon sequestration, California forests generate millions of tons of woody residues annually that are typically left or burned in the field, with impacts for air quality, climate, wildfire, and forest ecosystems. State policymakers have sought to create market for woody biomass in the hope that they could support sustainable forest management activities while also supporting climate and air pollution goals. However, open questions surrounding the climate and air pollution performance of utilization pathways for woody biomass have made it difficult to determine how best to manage the risks and opportunities posed by forest residues.

Our team has investigated many of the environmental, economic, and policy aspects of using forest-derived woody biomass residue in the state of California. Our early research focused on the climate performance of electricity generation from these residues, showing it to be highly variable (Figure 1), differing across forest treatments, supply chains, and geographic characteristics. Utilization of woody residues from forest treatments can and should be targeted to create climate and air quality benefits, and emerging tools can aid in structuring policy to deliver that outcome.

What we've learned so far:

The California Biomass Residue Emissions Characterization (C-BREC) model offers a spatially-explicit Life Cycle Assessment framework to rigorously and transparently establish the climate and air pollution impacts of diverting California's forest residues to a variety of potential uses. C-BREC characterizes the variable emissions from different biomass supply chains as well as the counterfactual emissions from prescribed burn, wildfire, and decay avoided by residue mobilization.

The C-BREC model provides novel approaches to this issue and builds upon prior analyses by:

- Enabling quantification and mapping of criteria pollutant emissions (CO_2, CH_4, N_2O, volatile organic compounds (VOCs), NO_x, SO_2, PM_{10}, $PM_{2.5}$, and black carbon) and avoided emissions associated with bioenergy generation
- Quantifying emissions from decay, prescribed burns, and subsequent wildfires in a spatially disaggregated fashion, which is critical to assessing the impact of biomass utilization on a concrete, case-specific basis

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- Enabling time-explicit analysis to calculate the relative climate impact of the pulse of emissions from burning residuals today compared to the time series of emissions associated with leaving them in the field

Modeling with C-BREC shows significant variation in the climate and air quality performance of biomass electricity derived from residues of forest management in California. The following are key findings related to climate impact:

1) The life cycle emissions of biopower from woody residues range widely—from comparable with solar PV to comparable with natural gas.
2) Using residues that would otherwise have been burned if not mobilized creates a lower net carbon intensity than no-burn scenarios, especially when using time-explicit analysis to characterize the climate forcing impact of delayed emissions.
3) Between 8 and 31% of the stable carbon content of biochar produced from forest residues in a typical region of California may not represent net carbon removal because there is sequestration present in the alternate fate of the same biomass.
4) There is significant spatial variation in the carbon intensity of woody biomass sourced from across the state's forestlands, 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 (see Figure 1).

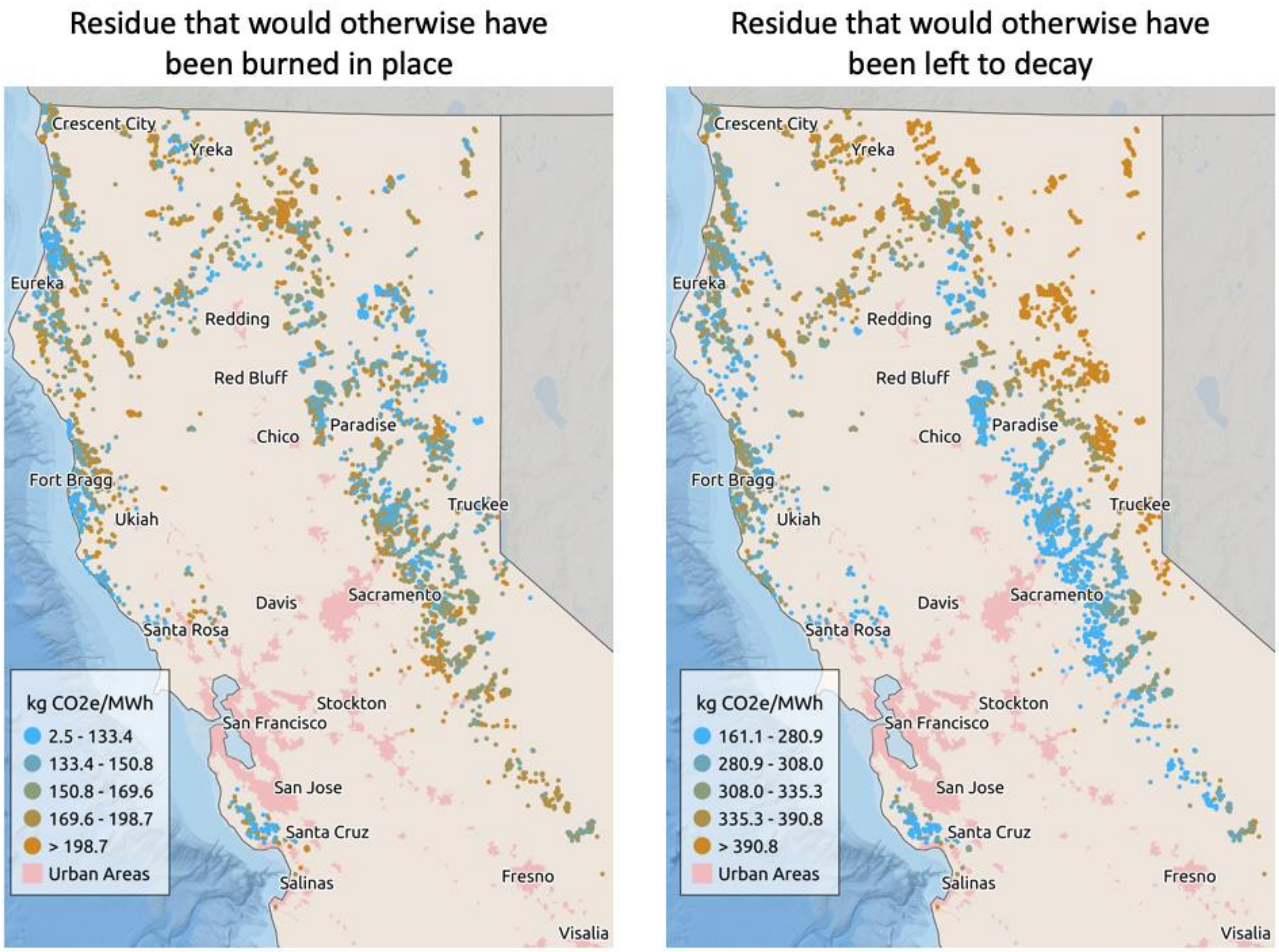

Figure 1: Example C-BREC output comparing the carbon intensity (kg CO_2e/MWh) of two scenarios mapped across a section of California. These demonstrate the spatial variation of carbon intensities (within each map) as well as how the net carbon intensity is influenced by the counterfactual burn scenario (across the two maps).

Next steps:

The C-BREC model offers the most rigorous and transparent accounting of the life-cycle impact of forest residue utilization systems to date, and its results reveal significant variation in climate and air pollution impacts across supply chains, feedstock types, and geographies in California. This model enables us to perform project-level analysis for policies aiming to reduce GHG emissions from forestlands and energy systems and is already beginning to be used to structure incentives accordingly. The model results to date offer key insights into the climate and air quality performance of biomass utilization in California. They have also helped to prioritize next steps to enable this information to shape forest products industries going forward. C-BREC is well-positioned to perform future analyses that contribute to this effort, including:

a) *Expanding the spatial reach of C-BREC:* We are poised to expand C-BREC's coverage of forest treatment and residue removal activities to cover the forested landscapes of the US West, increasing its ability to drive policy and decision-making beyond the California context.

b) *Pushing forward C-BREC's LCA methodologies:* Ongoing research efforts include updating residue characterization to projected 2025 and 2030 forest state, updating treatment of fire behavior, and further investigation and communication around the importance of time accounting for woody biomass LCA.

c) *Expansion of C-BREC to other use cases for woody biomass* such as liquid fuels, biochar, Biomass with Carbon Removal and Storage (BiCRS), or durable wood products could move towards harmonization of impact assessments and inform policy and industry decision-making. In particular, current efforts to establish a carbon intensity for liquid fuels from woody residues under the Low Carbon Fuel Standard, as well as compliance-grade carbon offsets for BiCRS would both be strengthened by the analytical rigor enabled by modeling with C-BREC.

d) *Air emissions health burden:* Mobilization of residues typically reduces the total criteria pollutant load emitted per ton of residue, but it also aggregates this emission to a point source which may be closer to human populations. This is an important area for future research that will be enabled by the C-BREC Model.

e) *Remote sensing to establish baseline residue fate:* The counterfactual fate of residue – whether burned in the field or left to decay – is the primary driver of the climate, air quality, and ecological impact of residue utilization, and is not tracked in any organized fashion. We propose to answer this "burning question" by combining high-resolution aerial photography and satellite infrared hot-spot detection with geospatial information on forest treatment activities through the use of modern machine learning methods.

f) *Integration of C-BREC with forest treatment economic and forest carbon modeling tools* could evaluate the landscape-level climate implications of different land management scenarios and to provide a more detailed and complete analysis of the carbon effects of both forest/land management strategies and biomass utilization.

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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