Quantifying avoided wildfire emissions from significant wildfires

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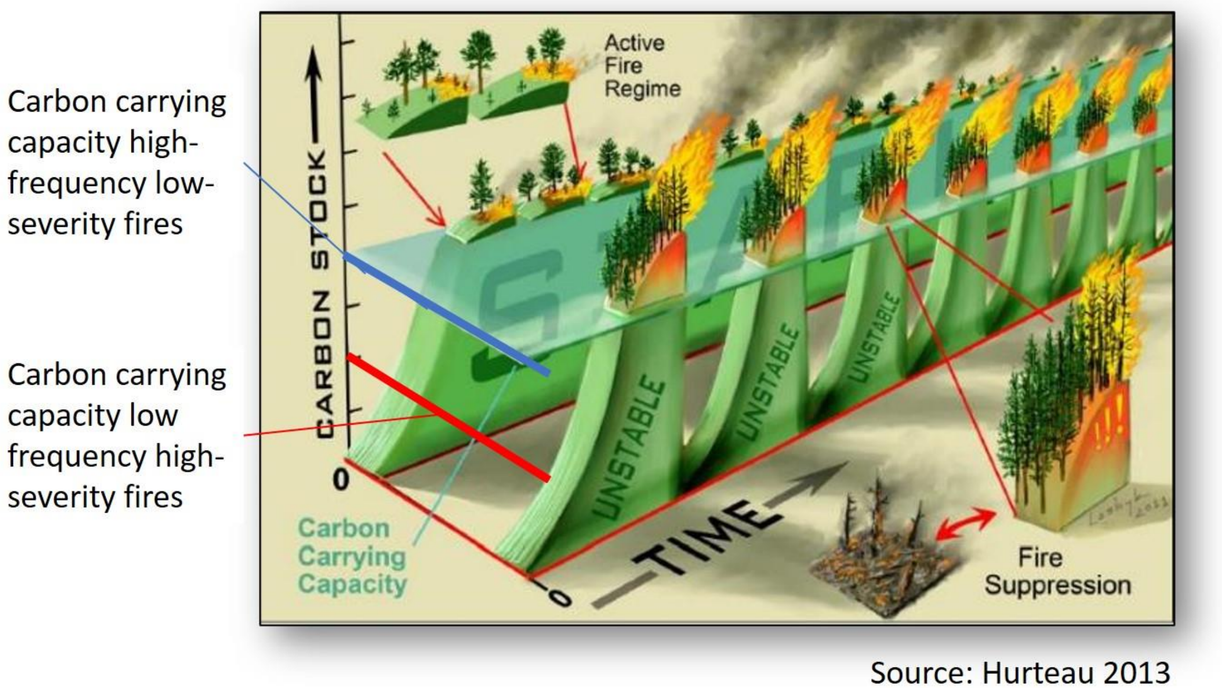
1 Forest restoration treatments

The western U.S. has millions of acres of forestlands at risk of large and uncharacteristically severe wildfire. This is due to a variety of factors, including decades of fire suppression as well as climate change.



Source: Hurteau 2013

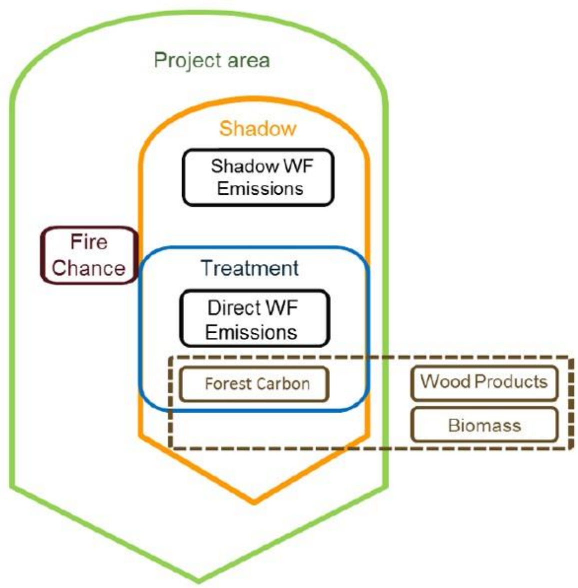
Fuel treatments such as mechanical thinnings or prescribed burns in fire-adapted forests can reduce wildfire severity and size and stabilize forest carbon in the western US; resulting in avoided wildfire emissions (AWE) of greenhouse gases (GHG). Accounting for GHG emission benefits of fuel treatments is challenging; hence, scientific consensus and broad stakeholder buy-in from public agencies, non-governmental organizations and the private sector is key. Using most recent forest vegetation and weather datasets as well as forest growth and wildfire behavior models, we present an avoided wildfire GHG emission accounting framework developed in collaboration with by key stakeholders in the western US as well as recent case studies. This probability-based GHG emission accounting framework can not only provide tools to quantify GHG benefits of fuel treatments, but can specifically be employed to help fund fuel treatments through carbon offset credits. The probability-based nature of this GHG emission accounting approach has further application value for risk accounting to forest carbon stocks from other stochastic events (e.g. drought, insect outbreaks) as well as forest-based carbon offset protocols in general.

2 Concept: Quantifying avoided wildfire emissions (AWE)

The Avoided Wildfire Emissions Methodology (AWE Methodology) quantifies greenhouse gas (GHG) emissions from implementing fuel treatments in forests that are at risk for wildfire from fire-suppression and past harvesting history.

Box 1: Avoided wildfire emissions accounting steps.

To quantify fuel treatment impacts on reducing emissions from wildfires, all relevant carbon pools -- forest carbon, wood products, and biomass -- are accounted for across the entire project area. This requires an ecologically relevant integration of wildfire probability (fire chance), wildfire behavior, and forest carbon accounting. Treatments to reduce high severity fires will impact fire behavior within their direct footprint, and indirectly beyond their direct footprint ("treatment shadow effect"). Emission savings from delayed reforestation are also considered in this methodology.



Fuel treatments modify fire behavior such that severity and individual fire size are reduced compared to the baseline of no fuel treatment activity (Fulé et al., 2003; Liang et al., 2018; Moghaddas et al., 2010; Moghaddas & Craggs, 2007; Peterson et al., 2005; Safford et al., 2009, 2009; Stephens et al., 2012; Stephens, Moghaddas, Edminster, et al., 2009; Stephens, Moghaddas, Hartsough, et al., 2009). While identifying climate benefits of fuel treatments can be challenging (Campbell et al., 2012; Mitchell et al., 2009), this methodology seeks to identify ecological conditions and fuel treatment approaches that verifiably provide climate benefits.

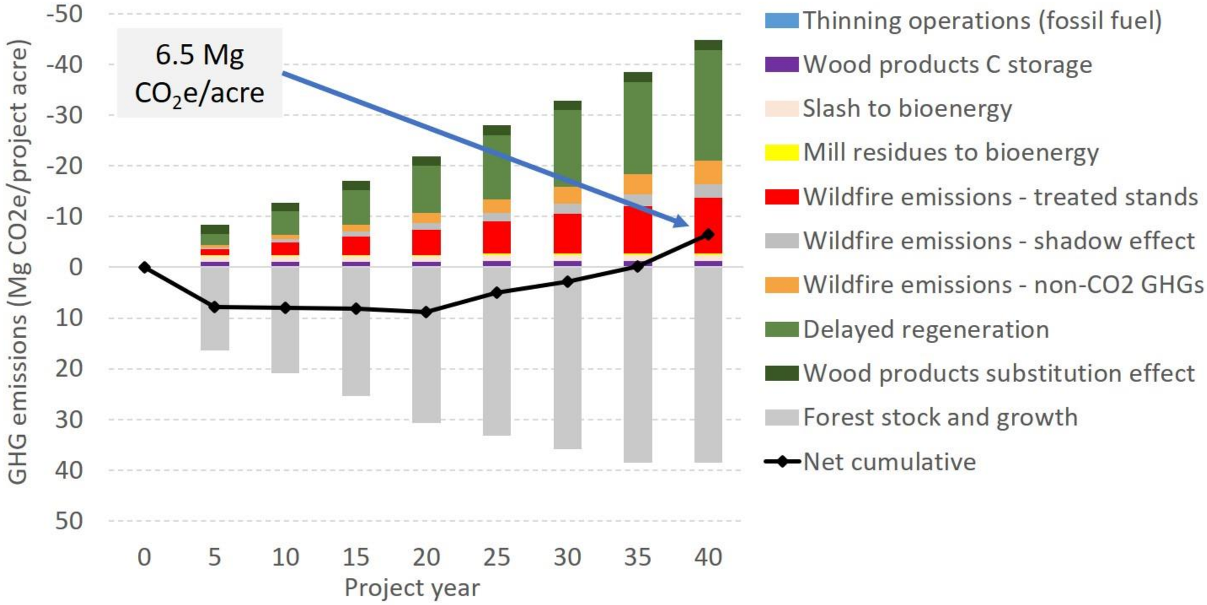
Fuel treatments provide GHG emissions reductions through considering:

- Forest carbon. Increase in stored carbon on the designated landscape (project area) over time, particularly in larger, more fire-resistant trees (Hurteau & North, 2010; Stephens, Moghaddas, Hartsough, et al., 2009). This results from reducing individual wildfire size and severity on both the directly treated areas as well as untreated areas through fuel limitation (Collins et al., 2008). Treating even a small portion of the landscape can result in a decrease in probability of areas outside those treated areas being burned severely, referred to as the "treatment shadow effect" (Finney et al., 2007; Moghaddas et al., 2010). The thinned forest may also grow at an enhanced rate compared with the untreated forest due to a reduction in competition for water, nutrients, and light.

- Wood products and renewable energy. Utilization of fuel treatment byproducts as: (1) long-lived wood products that sequester carbon and displace fossil fuel intensive alternatives to wood products, such as concrete and steel2; and (2) renewable energy3 production that displaces fossil fuel energy alternatives (Buchholz et al., 2016).
- Fossil fuel emissions required for harvesting and processing of wood. This also requires accounting for fossil fuel emissions associated with harvest and processing of wood products.
- Preservation of forest. High intensity fires in forests, particularly uncharacteristically severe active and passive crown fires, can cause high levels of tree mortality and soil impacts that result in delayed reforestation and at least a temporary vegetation type change from forest to grassland or shrub types lasting from several decades to permanent change (Collins & Roller, 2013; Coppoletta et al., 2016; Roccaforte et al., 2012; Rother & Veblen, 2016; van Wagtendonk et al., 2012; Welch et al., 2016). Fuel treatments can reduce the amount of forest that is redirected compared to the baseline, through moderating fire size and severity. This protocol provides a methodology to quantify delayed reforestation related GHG emissions.

3 Eldorado case study (Sierra Nevada Mountains, USA)

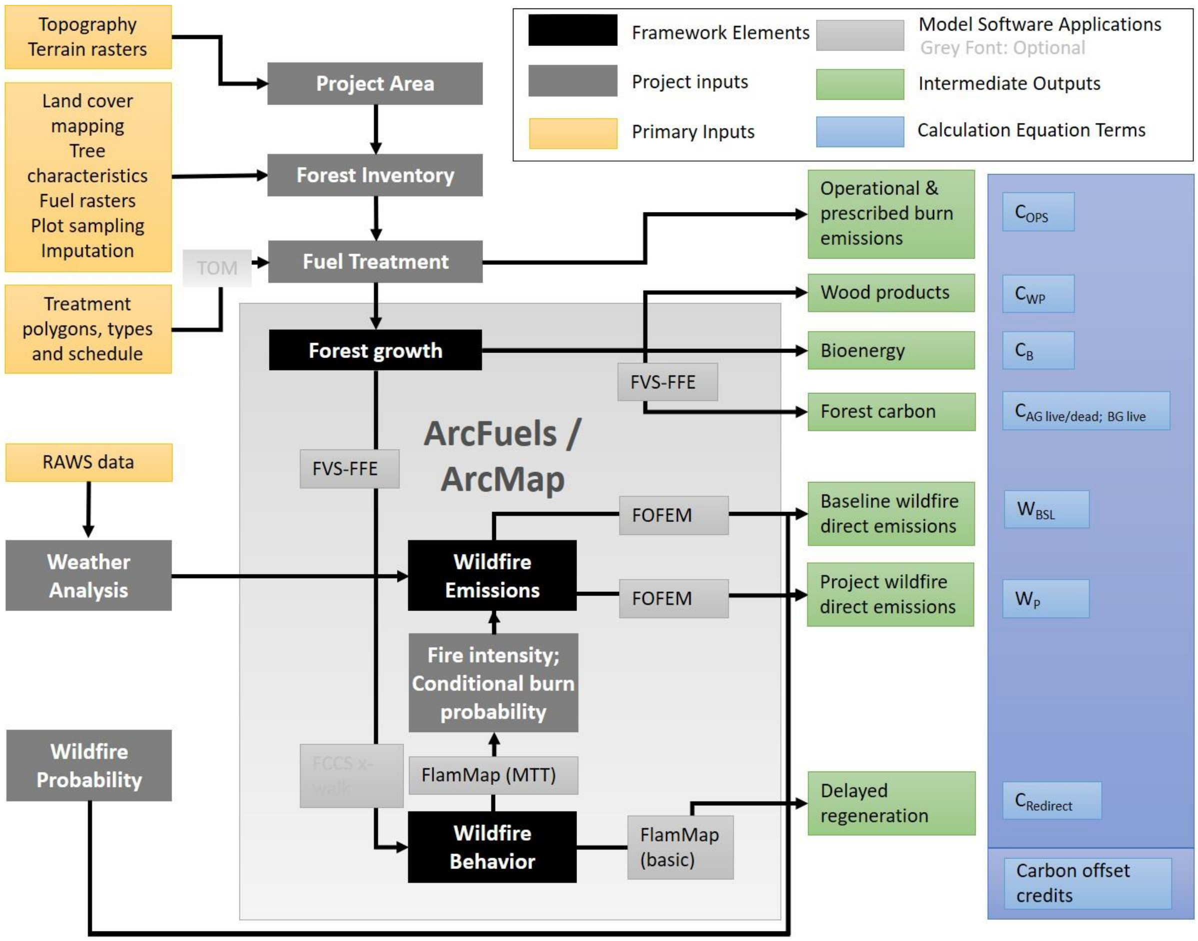
The sample project covers about 215,986 forested acres in the north-central Sierra Nevada mountains .The larger area consist of about 650,000 forested acres, with over one third burnt over the last 100 years. This region is characterized by high productivity, a watershed at high risk for wildfire, relatively short fire return intervals, and a mix of industrial timberland, non-industrial private timberland, and public forests (mostly the Eldorado National Forest).
Besides the availability of on-the-ground inventory data for key factors when assessing avoided wildfire emissions, this project area was chosen to provide a challenging case study area for an avoided wildfire emissions project in several respects: a high crown-fire risk; the ownership mix challenges; the type (mechanical treatments vs. prescribed burns) and the placement (only in the national forest) of fuel treatments; abundant wildlife habitat restrictions (spotted owl); and a topography that limits options to implement mechanical fuel treatments. Therefore, the project's net GHG benefits presented here are likely conservative. Projects located in areas where, for instance, large-scale prescribed burns can be implemented regularly (e.g. Liang et al., 2018) will yield substantially larger GHG emission benefits.



The initial C stock reduction on the project area due to fuel treatments (Figure above, grey columns) is eventually offset by GHG emission savings mostly associated with avoided delayed reforestation, reduced C emissions from treated and untreated (shadow effect) stands, as well as reduced non-CO2 GHG emissions. Due to its outsized effect on overall credit contributions and novelty, we highlight the calculation procedures for avoided wildfire C emissions on treated and non-treated stands as well from avoided delayed reforestation. The total accumulated ERTs over the 40-year project term equal 6.5 Mg Co2e/acre before accounting for leakage, uncertainty, and buffer pool contributions.

4 Methods: Quantifying avoided wildfire emissions

The AWE methodology quantifies the GHG benefits from fuel treatments (fuel reduction thinning, prescribed fire) that restore forest to desired ecological conditions and fire regimes (North 2012). Fuel treatments reduce wildfire size and severity in forests that are at risk for wildfire from a fire-suppression and harvesting history.



The methodology involves the following steps, for both the baseline and project scenarios:

1. Project area. Define the geographic boundary of the project. Quantify the forest condition - including tree stands, tree list, species, height, and diameter, and surface fuels - in the project area existing at the start of the project through site characterization measurements.

2. Management scenario development. Define the details of the fuel treatment - including fuel reduction harvesting levels, procedures, location, timing, and fate of residuals.

3. Forest carbon. Project the growth of the forested land over the project term (40 years) at five-year intervals.

4. Forest removals life cycle assessment. Determine sequestration in wood products, and avoided/displaced fossil fuels from wood products and bioenergy.2,3

5. Fire ignition probability. Determine the project area's expected fire return interval. Use the fire return interval to determine statistical fire probability over the project term.

6. Weather data. Define weather conditions under which to simulate fire over the project term.

7. Wildfire emissions. Determine emissions from wildfire that burns the entire project area, at five-year intervals over the project term. Amortize the emissions by the statistical fire probability (fire return interval).

8. Delayed reforestation. Quantify the area and emissions associated with project land temporarily or permanently over the project term converted from forestland to grass or shrubland following high severity fire.

9. Aggregated emissions accounting. Determine the difference between the baseline and project scenario GHG emissions, for each five-year interval period over the project term.

These assessment steps are followed by two post-implementation steps:

10. Fuel treatment project measurements. Over the project term, measure and document all applicable operational parameters, including fossil fuel engine usage, tree and brush removal rates, wood products generation, bioenergy 3, prescribed fire, and open pile burning. Use these to refine/adjust the aggregate emissions.

11. Project site inventory. At ten-year intervals, perform site measurements to characterize on-the-ground carbon. Use these to refine/adjust the aggregate emissions.

5 Bringing Carbon Offset Credits to the market

Fuel treatments are hampered by both access to and timing of funding options. Frequently, payout of grants are delayed or rely on evidence of implemented fuel treatments. IN the carbon offset context, credits are frequently issued only once climate benefits can be verified. This approach puts climate beneficial projects at a disadvantage that provide high climate benefits but only once a certain activity has been implemented. A new platform at the Climate Action Reserve (CAR) called Climate Forward intends to bridge this gap by issuing credits once an initial activity has been implemented and future climate benefits are reasonably secured. We are actively working with Climate Forward towards endorsement of the AWE methodology in the near future to enable carbon offset credits issued for the voluntary offset market or mandated climate mitigation activities.

6 Abstract

The western U.S. has millions of acres of forestlands at risk of large and uncharacteristically severe wildfire. This is due to a variety of factors, including decades of fire suppression as well as climate change.

Fuel treatments such as mechanical thinnings, prescribed burns, and combinations of thinning and burning in fire-adapted forests can reduce wildfire severity and potentially stabilize sequestered forest carbon in coniferous, fire adapted forests of the western US; resulting in

avoided wildfire emissions (AWE) of greenhouse gases (GHG). Accounting for GHG emission benefits of fuel treatments is challenging; hence, scientific consensus and broad stakeholder buy-in from public agencies, non-governmental organizations, and the private sector is key. Using most recent forest vegetation and weather datasets as well as forest growth and wildfire behavior models, we present an avoided wildfire GHG emission accounting framework developed in collaboration with key stakeholders in the western US as well as recent case studies. This probability-based GHG emission accounting framework can not only provide tools to quantify GHG benefits of fuel treatments, but can specifically be employed to help fund fuel treatments through carbon offset credits. The probability-based nature of this GHG emission accounting approach has further application value for risk accounting to forest carbon stocks from other stochastic events (e.g. drought, insect outbreaks) as well as forest-based carbon offset protocols in general.