Modeled Forest Inventory Data Suggest Climate Benefits From Fuels Management

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As part of a recent synthesis addressing fuel management in dry, mixed-conifer forests (Jain et al. 2012), we analyzed more than 5,000 Forest Inventory and Analysis (FIA) plots, a probability sample that represents 33 million acres of these forests throughout Washington, Oregon, Idaho, Montana, Utah, and extreme northern California. We relied on the BioSum analysis framework (Daugherty and Fried 2007, Barbour et al. 2008) that integrates several models to evaluate the economics of treating fuels by using 13 different mechanical fuel treatments per plot. We are extending this analysis to explore the carbon dynamics associated with these fuel treatments and to share a conceptual model and preliminary results.

The BioSum framework uses FIA data consisting of high-quality field measurements as the foundation and the Fire and Fuels Extension of the Forest Vegetation Simulator (FFE-FVS) to model silvicultural prescriptions and generate indexes relevant to fire hazard. The Fuel Reduction Cost Simulator (Fight et al. 2006) was used to estimate on-site treatment costs, and a geospatially explicit travel times calculator was used to estimate haul costs. Covering the full study area required 14 different FFE-FVS variants.

We considered three aspects of fire hazard: crown fire potential (as indicated by FFE predictions of torching index and probability of torching [ptorch]); intensity and firefighter safety during initial attack (based on FFE-predicted surface flame height); and wood value, residual stand viability, and carbon emissions risk implications (based on FFE-calculated mortality volume). Our hazard score for each plot was computed as the sum of the number of aspects by which it was rated hazardous on a scale of 0 to 4 (receiving one point for each of four criteria: ptorch >20 percent, torching index <20 mph [miles per hour], surface flame height >4 feet, and mortality volume [as a percentage of prefire live tree volume] > 30 percent). We modeled a variety of treatments aimed at achieving greater crown spacing; removal of ladder fuels; removal of late-seral species to favor retention of fire adapted, early-seral species; and blended approaches. We deemed treatments that reduced hazard score from the no-treatment case as effective and processed and aggregated "cut-lists" produced by FVS to generate estimates of expected yields and value of merchantable and energy wood, as well as both on-site treatment costs and the costs of delivering material from the forest to suitable processing facilities.

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By our hazard score calculation, most forested acreage in dry mixed-conifer forests is currently hazardous with respect to at least one hazard criterion (figure 1). Between one-tenth (in Utah) and one-third (in northern California and on the Klamath) of hazardous acreage could be effectively treated (achieving a reduction in hazard score) by using 1 or more of the 13 treatments modeled. These opportunities were about equally split between acreage where treatments would pay for themselves and return some net revenue

> The prospect of climate benefits depends critically on the likelihood of fire encountering the treated area during the effective lifespan of the treatment.

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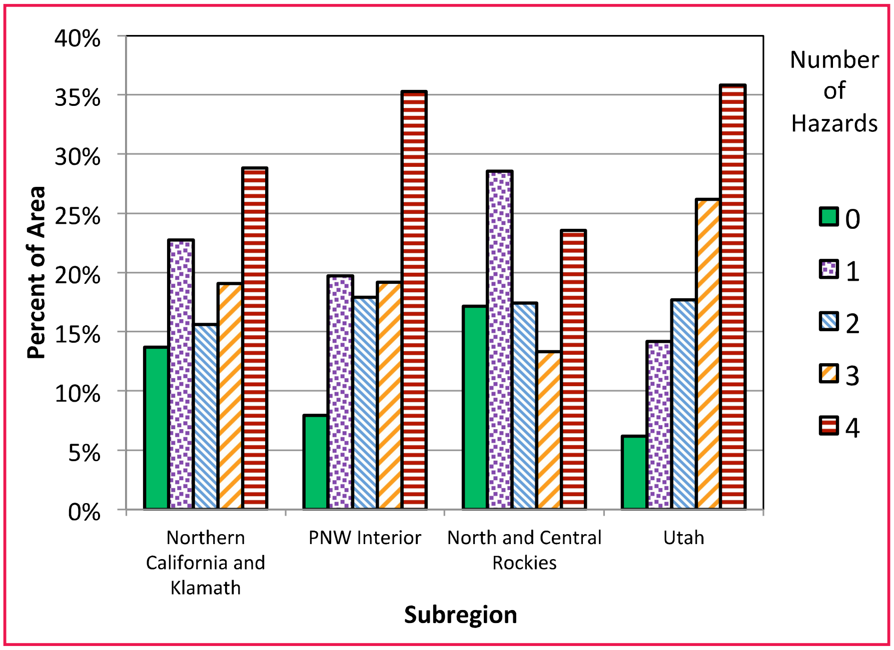

Figure 1.— *Percentage of area within each subregion by hazard score (number of ways rated hazardous).*

Some recent studies have suggested that fuel treatments compromise the climate benefits of forests by reducing carbon sequestration and by generating greater net greenhouse gas emissions than would occur with a hands-off or caretaker approach to forest management. On close evaluation, such conclusions typically turn out to be driven by: (1) not including some or all of the out-of-forest climate benefits linked to forest products and biomass-generated energy, (2) using outdated information concerning the magnitude of those benefits (for example, citing studies that overstate mill waste and unutilized harvest residues relative to contemporary norms), (3) not fully accounting for mortality in unmanaged stands, or (4) evaluating study areas in which wildfires are comparatively rare.

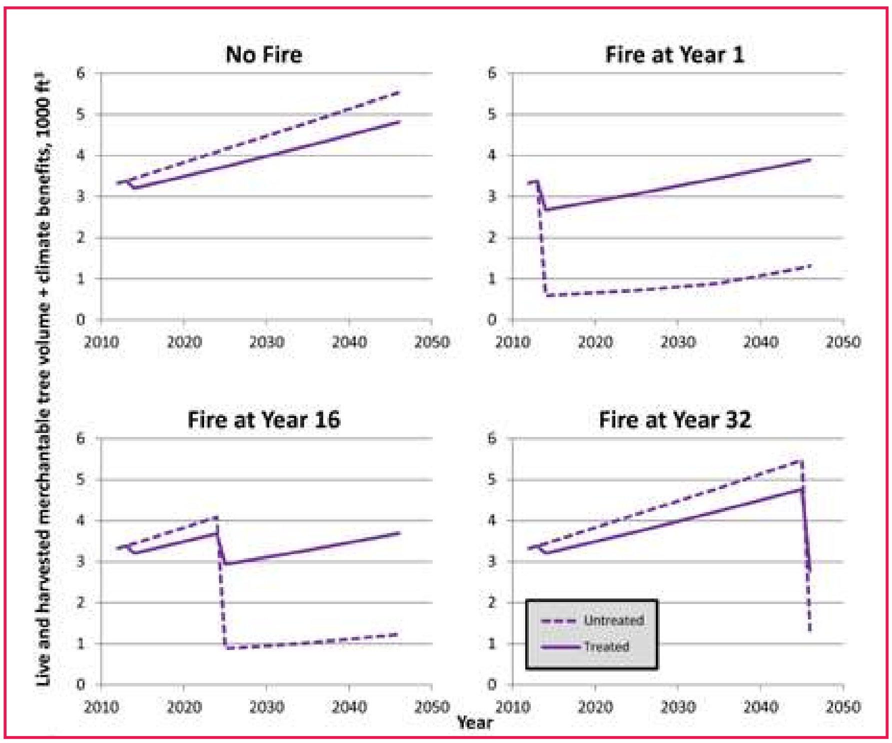

Figure 2.— *Trajectories of mean, per acre, merchantable volume (no treatment case), and merchantable volume plus products effects (best treatment case) for 4 fire scenarios, based on 132 plots in Douglas-fir and true fir forests representing 1.2 million acres.*

To bring systematic FIA data representing all forested lands to bear on this question, we extended the BioSum analysis summarized in the *Fuel Synthesis Guide* by using FVS to project effectively treated plots forward for 32 years under four alternative fire scenarios: no fire and fire under severe, but not extreme, weather conditions at 1, 16, and 32 years following treatment.

Each scenario results in a trajectory of in-forest carbon and out-of-forest carbon and greenhouse gas implications that we summarize for the Douglas-fir and true fir forest type group (figure 2). We focused on live tree boles in part because of the difficulty in obtaining accurate estimates of other carbon pools and also because of the availability of comparatively accurate volume estimation models. These models account for the largest share of forest carbon that changes over the life of a stand and generates substantial out-of-forest climate impacts that are often underestimated.

We used a multiplier of 1.23 (Stewart and Nakamura 2013) to account for the climate implications of woody carbon moved from the forest to storage in products and landfills, the substitution of wood for materials such as metal and concrete that are responsible for substantial fossil energy emissions (Malmsheimer et al. 2011), and the substitution of woody biomass-generated energy for fossil fuel energy.

Without fire or treatment, average climate benefits are always greater over the 32-year projection period, owing to maintenance of higher forest carbon stocks. If fire occurs, climate benefits are greater in treated forests by the end of the projection period, regardless of fire timing.

Given that fire has long been an integral part of these forests, it is all but certain that a fire will occur at any particular location in the forest at some time in the future. There is, however, an uncertainty as to when fire will encounter that location. Therefore, we incorporated the probability of fire occurrence for a given mean fire return interval and used this to weight the combination of future carbon trajectories depicted in figure 2 for the no-treatment and best- treatment cases (figure 3).

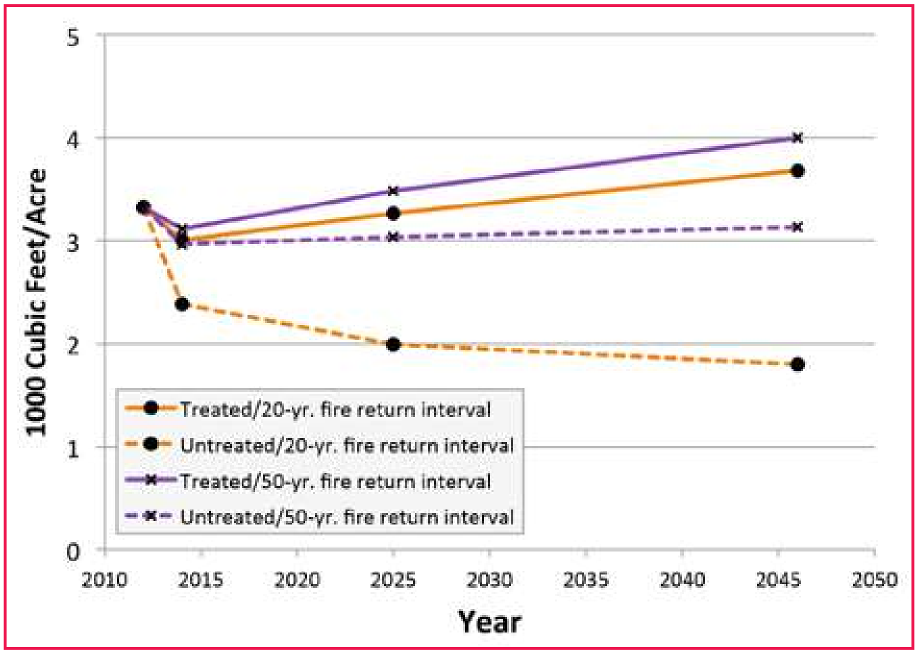

Figure 3.— *Mean merchantable volume of live and harvested trees in Douglas-fir and true fir stand of the dry mixed-conifer region, including climate effects of harvested wood expressed as volume, by whether treated and fire return interval.*

For fire return intervals of 20 and 50 years, implementing the best treatment produces greater climate benefits than no treatment, considering in-forest carbon and out-of-forest product effects. Of course, climate benefits represent only one of many drivers of decisions about forest management. The evidence, however, that fuels management may not be incompatible with producing climate benefits should lead to more informed choices.

A couple of caveats should be noted. First, this analysis addresses only the stand-level benefits of fuel treatment in terms of the carbon and climate benefits that occur for a stand and the products that flow from that stand. Accounting for the landscape-scale benefits of a comprehensive and effective fuel treatment program, which could well reduce the size or frequency of

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large fires, could generate reductions in forest carbon emissions that we have not addressed here. Second, the prospect of climate benefits depends critically on the likelihood of fire encountering the treated area during the effective lifespan of the treatment. Because only a few of the 14 FVS variants used in this analysis include regeneration models by default, we consider these results preliminary.

Under the auspices of a 2013 Joint Fire Science Program grant, we are exploring techniques for modeling regeneration, which, especially following treatment or fire, could conceivably lead to rapid development of ladder fuels and increases in post-treatment forest volume, either one of which could alter these preliminary conclusions. We think, however, that the conceptual approach—of modeling fuel treatments and their effects on the FIA inventory plots under alternative scenarios—is a promising way to enhance statistical rigor in our understanding of the climate implications of fuel treatments.

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