AN ANALYSIS OF WILDFIRE FUEL TREATMENTS AS A CARBON OFFSET PROJECT TYPE

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The authors are solely responsible for the entire content of this report, including any errors or omissions.

PREFACE

The California Energy Commission Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

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An Analysis of Wildfire Fuel Treatments as a Carbon Offset Project Type is the final report for the West Coast Regional Carbon Sequestration Partnership – Phase II (contract number MR-06-03G, work authorization number MR-045) conducted by The Climate Trust and Oregon Department of Forestry. The information from this project contributes to PIER's Energy-Related Environmental Research Program.

For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-654-4878.

ABSTRACT

Fuel treatments involve the removal of biomass from targeted areas in the forested landscape to reduce the risk of uncharacteristically severe wildfires caused by excess biomass in the forest. This report describes a landscape-scale case study in southern central Oregon that modeled the impact of fuel treatments on wildfire behavior and associated carbon dioxide emissions and assesses the project's ability to generate carbon offsets that meet the quality criteria identified by the Offset Quality Initiative. The report makes two primary findings. The first is that the case study is likely a carbon-neutral project, meaning that few or no offsets would result from the project activity. The second is that, while this project type could generate quality offsets, the adoption rate would likely be low due to the current inability to implement quality offset projects on federal lands and the expense of the activities required to ensure that the carbon benefit is real and permanent. For these reasons, fuel treatment projects are unlikely to be a viable source of quality offsets. This report recommends that a federal policy decision be made to determine if offset projects can involve federal lands. This is important not only for this project type but for others that hope to utilize waste biomass (e.g., biochar and energy generation projects). This report also encourages the development of fuel treatment projects because the risk of uncharacteristically severe wildfires is likely to increase with climate change and such projects provide a host of climate change adaptation and mitigation benefits.

Keywords: Carbon offsets, fuel treatment, wildfire risk, restoration, carbon credits, carbon dioxide emissions

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State and federal policies to suppress wildfires on forestlands in the United States have caused many federally owned forested landscapes to hold more biomass, both living and dead, than they would under a natural fire regime. This greater fuel load increases the likelihood of an uncharacteristically severe wildfire, which would emit an abnormally large amount of carbon dioxide (CO_2).

Fuel treatment projects are actions to reduce the risk of wildfire on a given landscape by removing biomass from specific forest stands to limit a fire's spread and intensity. There is hope that these projects could also reduce CO_2 emissions—primarily through the avoidance of CO_2 emissions from uncharacteristically severe wildfire—and could therefore be eligible to sell carbon offsets to help overcome funding barriers to implementation.

Purpose

This report presents findings from a landscape-scale case study in southern central Oregon that modeled the impact of fuel treatments on wildfire risk and associated CO_2 emissions; it then provides an assessment of the project type's ability to generate quality carbon offsets.

Project Objectives

The overall goal of WESTCARB Phase II is to validate and demonstrate the region's key carbon sequestration opportunities through pilot projects, methodology development, reporting, and market validation. WESTCARB research will facilitate informed decisions by policy makers, communities, and businesses on how to invest in carbon capture and storage technology development and deployment to achieve climate change reduction objectives. The sequestration opportunity presented here is the avoided loss of forest biomass due to uncharacteristically severe wildfire.

Project Outcomes and Conclusions

The case study indicates that it is possible to model both the baseline and project scenarios in a way that enables an accounting for the carbon benefit (or cost) of the fuel treatment project. It also indicates that:

- Fuel treatment projects may provide net gains in carbon emissions because the biomass removed from the landscape acts as a debit on the project that must be overcome before the project can accrue carbon offsets.
- Extrapolation of the case study results on fuel treatments, wildfire risk, and avoided CO_2 emissions indicates that this class of projects is more likely to be carbon-neutral than to provide significant emissions benefits.

Analysis of this project type indicates that even if the project provides quality offsets, the adoption of the project type may be limited due to the following project design requirements:

- The risk of reversal is high, which requires significant contributions of some of the offsets to buffer pools to insure against this risk.
- The need to continue to implement fuel treatment practices periodically on the landscapes for an additional 100 years after a project is completed can be a disincentive when recruiting project participants.
- The cost of third party verification will be high due to the need for verifiers to have specialized experience in wildfire ecology, forestry, and probabilistic simulation models.
- The cost of monitoring and verification will be high due to the long span of time that both activities are periodically required to occur (project life plus 100 years).

This report's analysis also concludes that in order to provide certainty that the emissions event would have happened, fuel treatment projects should be considered as a subset of the improved forest management (IFM) project type; in effect, a fuel treatment project is a commitment to manage the risks of wildfire on a forested landscape. This allows the project lifetime to be defined so as to include an uncharacteristically severe wildfire occurrence in the baseline case with near certainty.

Recommendations

This report finds that fuel treatment projects are likely to be near carbon-neutral and therefore do not make good offset projects. However, fuel treatment projects could be critical to long-term climate strategies, because changes in climate will likely increase the risk of uncharacteristically severe wildfires. In addition, there is potential to use the biomass removed by fuel treatment practices to create energy or biochar, both of which could benefit the climate and rural economies.

This report recommends that federal policy makers provide clarity about the appropriate role for private financing on public lands, because additionality concerns for projects on public lands is such an important issue for this project type. It is also recommends that studies be conducted to properly define how the CO_2 emission benefits (or carbon neutrality or even a carbon cost) from the fuel treatment projects are linked with either the biochar or energy creation project activities. It is the overall net reduction of CO_2 emissions to the atmosphere—both from the forestland as a result of treatment and from the power plant or other end use as a result of utilization—that will define the potential of the combined activity to provide a climate benefit. Projects will need to be carefully constructed so that the offsets are of high quality.

In conclusion, although fuel treatment projects face significant barriers to providing quality offsets, they continue to have the potential to play an important role in both climate change mitigation and climate change adaptation.

Benefits to California

Results of WESTCARB fuel treatment case study and evaluation will inform voluntary efforts, such as those by California Climate Action Registry members interested in offsetting greenhouse gas (GHG) emissions through forestry. WESTCARB will also inform regulatory developments, such as the process now underway by the California Air Resources Board (ARB) to design a GHG regulatory program under the California Global Warming Solutions Act of 2006 (California Assembly Bill 32). Projects demonstrated to be cost-effective, verifiable, environmentally beneficial, and attractive to both regulated entities and landowners/carbon credit suppliers may become eligible for trading under the market-based compliance program ARB adopts.

CHAPTER 1: Introduction

Formed in 2003, the West Coast Regional Carbon Sequestration Partnership (WESTCARB) is a collaborative research project bringing together scientists, foresters, and engineers from more than 90 public agencies, private companies, and nonprofit organizations to identify and validate the best regional opportunities for removing or otherwise keeping carbon dioxide (CO_2) out of the atmosphere—either through geologic sequestration and related capture and storage technologies or through terrestrial sequestration practices on agricultural, range, and forestlands.

Phase I of WESTCARB conducted regional assessments and baselines for terrestrial carbon sequestration for the states of California, Oregon, and Washington and identified promising practices and other opportunities for increasing terrestrial sequestration. One terrestrial sequestration opportunity identified for Oregon was to conduct wildfire fuel treatment and thinning projects (henceforth referred to as "fuel treatment projects") in forests at risk of uncharacteristically severe wildfire ("problem wildfire") as a means to reduce CO_2 emissions from these forests during such problem wildfires.

1.1 Definition of fuel treatment projects

Fuel treatment projects involve selectively removing woody material (e.g., down logs, standing dead trees, and live tree stocking) in fire-prone forests as a means to reduce the severity and extent of wildfire should the forest burn. Treatments are conducted through mechanical harvesting methods, sometimes followed by prescribed burning. The goal of fuel treatment projects is to improve the health and resiliency of the treated forest area and to slow the progression of wildfire to surrounding untreated forest areas. Fuel treatment projects do not eliminate the risk of wildfire from the forest. Rather such projects reduce wildfire intensity, reducing the amount of woody material and vegetation burned and thereby decreasing the amount of CO_2 emitted.

The majority of the material removed in fuel treatment projects has little or no commercial value. For example, of Oregon's 67 wood combustion facilities, only 10 use woody residues to generate power and of those 10, only four sell power to the public energy grid. Most of these facilities rely on sawmill residues and wood waste for fuel supply; only two facilities provide direct markets for the utilization of forest residues. A 2006 study named "Biomass Energy and BioFuel from Oregon's Forests[1]" estimates that the economics necessary to make this material pay for itself in energy production is not competitive with the current values of electricity. As a result, at best only a portion of the area in need of fuel treatment would be economically recoverable if additional biomass energy facilities were built.

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[1] Mason, Bruce and Girard, Inc.; Pacific Energy System, Inc.; Oregon State University; and Jim Bowyer. 2006. Biomass energy and biofuel from Oregon's forests. Portland, Oregon: Oregon Forest Resources Institute. [Unconventional pagination.]

1.2 Climate mitigation potential

The lack of commercial value (or the high cost relative to that value where commercial end uses do exist), provides a financial barrier to conducting fuel treatment projects. With the emergence of voluntary carbon offset markets and the anticipation of compliance-driven offset markets, foresters and landowners began wondering if carbon offset revenues from fuel treatment projects could make these projects financially viable.

Recognizing the lack of markets for the material removed in fuel treatment projects, the Oregon Governor's Advisory Group on Global Warming identified "reduce wildfire risk by creating a market for woody biomass from forests" as a key greenhouse gas (GHG) mitigation strategy. The strategy premised that if more end-use markets for woody material removed from fuel treatment projects existed (e.g., more biomass energy facilities), then more fuel treatment projects could be conducted. The ability of these projects to also generate revenue from the sale of carbon offsets would further expand the number of fuel treatment projects conducted. However, the advisory group's recommendation is premised on the assertion that fuel treatment projects lead to lower amounts of CO_2 reaching the atmosphere than the amount of CO_2 in the atmosphere absent the fuel treatment project.

1.3 Purpose of this report

This report aims to evaluate the viability of fuel treatment as a high quality carbon offset project type. Chapter 2 outlines the criteria used to evaluate offset quality. Chapter 3 examines the results of a case study simulation of a landscape fuel treatment project in Lake County, Oregon. Chapter 4 evaluates the specific case study against relevant offset quality requirements, while Chapter 5 evaluates the project type against offset quality requirements to better understand the strengths and weaknesses of this class of projects as an offset project type.

CHAPTER 2:
What Makes a Quality Carbon Offset Project?

2.1 Offset quality criteria

This report uses offset quality criteria established by the Offset Quality Initiative (OQI) as an evaluative framework. OQI, a consortium of six national nonprofit organizations working to provide leadership on GHG offset policy and best practices, states that offsets should:

1. Be real
2. Be additional.
3. Be based on a realistic baseline.
4. Be accurately quantified and monitored.
5. Be independently validated and verified.
6. Be unambiguously owned.
7. Address leakage.
8. Address permanence.
9. Do no net harm[2].

In the following sections The Climate Trust interprets each of the OQI criterion as it relates to the fuel treatment project type (further discussion can be found in Chapter 5).

2.2 Interpretation of criterion "Be real"

Project-based offset credits should represent actual emission reductions and not simply be artifacts of incomplete or inaccurate accounting (OQI, p.3).

The fuel treatment project must demonstrably increase the store of carbon on the forested landscape when compared with the store of carbon on the forested landscape absent the project. It is critical to the integrity of the offset market that the carbon benefit not simply be due to misleading accounting. All relevant carbon pools must be accounted for in both the baseline and project scenarios.

Fuel treatment practices remove biomass, which actually reduces the amount of CO_2 sequestered in the project boundary. Any emission benefits earned by the project must exceed

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[2] For a more general discussion of these criteria, see *Ensuring Offset Quality: Integrating High Quality Greenhouse Gas Offsets Into North American Cap-and-Trade Policy* (2008), available at http://www.offsetqualityinitiative.org/briefings.html

this loss of carbon stores within the project lifetime in order for the project to earn offset credits. Emission benefits earned from biomass that leaves the forested landscape but remains sequestered as long-living harvested wood products may be credited to the project so long as the eventual decomposition or combustion of the wood is accounted for. However, biomass used to generate energy is considered outside the boundary of the project and may not be credited.

Fuel treatment projects present a unique issue for the criterion "be real" because the avoided emissions event (the problem fire in the baseline case) is probabilistic, meaning there is a chance that it will not occur. Since the baseline case of an offset project is a counterfactual (it does not happen because the with-project scenario takes its place), it is impossible to determine through observation whether the problem fire would have occurred. However, the fuel treatment project type can remain eligible for offset credits if it can provide certainty that the problem fire that the project is designed to avoid would have occurred in the absence of the project. It is possible to provide this certainty using statistical methods outlined in Chapter 5.

2.3 Interpretation of criterion "Be additional"

Because offsets are used to compensate for emission reductions that an entity operating under an emissions cap would otherwise have to make itself, the reductions resulting from offset projects must be shown to be "in addition to" reductions that would have occurred without the incentive provided by offset credits. The revenue from selling the project's emission reductions should be reasonably expected to have incentivized the project's implementation for an offset project to be considered additional (OQI, p.3).

Additionality requires that the fuel treatment project prove that it would not have been executed without carbon offset funding. In order to do so, it must demonstrate that the fuel treatments were not required by law or contractual obligation and that offset funds helped overcome some other barrier to implementation such as a lack of financial viability.

The additionality criterion is complicated by the fact that the carbon market has not yet come to consensus on whether to implement projects on public lands. This is a major issue for this project type because most of the anticipated demand for fuel treatments is on federally owned forestlands, which are required to be managed for the public good, including climate change mitigation. Fuel treatment projects would not be considered additional if fuel treatments are viewed as within the mandate of public land management agencies.

However, such forest management efforts are underfunded and offset funding could be used to overcome this financial barrier. The risk is that using carbon funding to implement CO_2 reduction projects on public lands would decrease the likelihood that governments would ever provide sufficient public funding. In order to avoid this risk, the carbon market has determined that offset projects should not be implemented on federal lands until legislation or rulemaking clarifies the appropriate relationship between private financing and public management activities and priorities.

2.4 Interpretation of criterion "Be based on a realistic baseline"

A GHG emission baseline must be established in order to quantify an offset project's GHG reductions. A baseline represents forecasted emission levels in the absence of the offset project; this is sometimes referred to as the baseline scenario, or the "without-project" case. The difference between the baseline and the actual emissions after the offset project is implemented represents the reductions achieved by the project, and this amount is credited as an offset. Offsets are only as credible as their baselines (OQI, p.3).

The baseline scenario for the fuel treatment project—an untreated landscape that has a higher risk of problem wildfire—must be modeled to produce a realistic estimate of the specific landscape's carbon stock, including pre-fire and post-fire conditions. In addition, the quantification of both baseline and "with project" scenarios must explicitly account for any significant forest management changes within the project boundary.

The baseline calculation must apply a principal of conservativeness that overestimates carbon stocks, because an underestimated carbon stock in the baseline scenario would inaccurately increase the quantity of carbon offsets generated by the project activity.

2.5 Interpretation of criterion "Be accurately quantified and monitored"

Emission reductions from offset projects must be accurately quantified. Each project must have a unique monitoring plan that defines how, when, and by whom data will be collected and emissions quantified (OQI, p.4).

A fuel treatment project must include a unique monitoring plan that defines how, when, and by whom data will be collected and emissions quantified. Both the avoided emissions and the project-related emissions must be quantified according to an industry-accepted method. The principle of conservativeness must be applied so that at each point of quantification the carbon emission benefits will be underestimated rather than overestimated.

Because an avoided problem wildfire cannot be monitored directly, the monitoring plan must focus instead on assuring that landscape and wildfire conditions are below any thresholds that have been defined as triggering such an emissions event.

2.6 Interpretation of criterion "Be independently validated and verified"

All GHG reductions should be verified by an independent, qualified, third-party verifier according to approved methodologies and regulations. Verifiers should be entities whose compensation is not in any way dependent on the outcomes of their decisions. Regulatory regimes should have an approved list of offset project verifiers and should have procedures in place to ensure that conflicts of interest are avoided. Ex post monitoring and verification reports should be used as the basis for issuing offset credits (OQI, p.4).

A qualified independent third party must validate the modeling technique, or how the baseline and project case were calculated, and the resulting baseline carbon stocks. Modeling techniques and parameters must be transparent, publicly available, and have gone through a stakeholder consultation process. Also, a third party must verify that the fuel treatment activities took place and that the carbon stocks on the land have been accurately reported. Verification of the increased carbon stocks is required for both the project lifetime and for the commitment period following it to ensure that more carbon than expected has not been emitted.

2.7 Interpretation of criterion "Be unambiguously owned"

Clear and uncontested title to offset credits should be established by contractual assignment and/or government recognition of ownership rights. Furthermore, the transfer of ownership of any and all offset credits must be unambiguous and documented. Once sold, the original seller of the offset credit (and the project owner) must cede all rights to claim future credit for the same reductions in order to avoid double counting. Finally, offsets must be serialized and accounted for in a registry or other approved tracking system (OQI, p.4).

The landowner must clearly own the rights to carbon stored on the land or must have clearly transferred those rights to an appropriate party (such as the party performing the fuel treatment). This is evaluated on a project-by-project basis. All issued offsets must correspond to a unique serial number that is stored on a public registry.

2.8 Interpretation of criterion "Address leakage"

Leakage is defined as an increase in emissions outside of the project's emissions boundary that occurs as a result of the project's implementation. For example, avoiding deforestation through an offset project in one area could simply shift forest harvesting (and the resultant emissions) to a different region or country. Offset program design should include monitoring/verification plans and protocols that provide the necessary mechanisms to properly account for potential leakage over the life of an offset project (OQI, p.5).

A fuel treatment project must address and mitigate any activity-shifting leakage or market leakage that may cause higher emissions as a result of the project activities. Leakage is not considered to be a risk for this project type, which is further discussed in Chapter 5.

2.9 Interpretation of criterion "Address permanence"

There is a risk that emission reductions generated by certain offset project types can be reversed, and thus are not permanent. Permanence is a type of project risk most often associated with biological and geologic sequestration of emissions. For example, reductions realized through a forest sector project could be reversed through a forest fire. Regulatory regimes should address permanence through policy mechanisms *that ensure the minimization of loss in the case of project reversal. Such mechanisms include reserve pools, buffer accounts, and insurance, among others (OQI, p.5).*

Observed wildfire behavior within the project area must not exceed expected levels for the project lifetime and the following commitment period.

2.10 Interpretation of criterion "Do no net harm"

Offset projects should not cause or contribute to adverse effects on human health or the environment, but should instead seek to provide health and environmental co-benefits whenever possible (OQI, p.5).

Fuel treatment projects must adhere to all relevant state and federal forestry practices and regulations that protect water quality, endangered species, and biological diversity. Further, projects must only take place in locations that have been identified by existing local and regional needs assessments. Such assessments must have been developed in a transparent way with stakeholder participation and must have explicitly addressed habitat impacts and the drought resistance of the forest (in addition to wildfire risk).

CHAPTER 3:
Case Study: Simulation of Fuel Treatments and Wildfire Emissions

3.1 Description of the project area

The simulated case study area is the Drews Creek watershed located in Lake County in southern Oregon. The Drews Creek watershed was selected because it contains dry ponderosa pine and mixed conifer forest types at risk of problem wildfires and is at the beginning stages of fuel treatment planning by the Fremont-Winema National Forest. The watershed is approximately 169,200 acres, of which approximately 77,500 acres are privately owned and 91,700 acres are owned and managed by the U.S. Department of Agriculture (USDA) Forest Service. The Drews Creek watershed encompasses a relatively narrow band of topographical relief. The forested area of the watershed is 140,526 acres. Stands dominated by ponderosa pine account for about 68% of the forest land in the watershed, about 17% of the area is in juniper woodlands, and western juniper dominates 26% percent of all forested types, encroaching on the hot dry ponderosa pine sites. Stands dominated by white fir represent a minor contingent of the landscape, at around 6% of the forested acres. Dry grasslands, dry shrub lands, and dry meadows comprise nearly 50% of non-forested lands (defined as land with tree cover less than 10%) with the balance being agricultural lands and wet meadows associated with the major streams.

Dead or down wood fuel loadings are variable across the drainage but follow various gradients:

- In the treated low-elevation pine stands, typical fuel loadings range from 2 to 5 short tons of biomass per acre.
- Untreated pine stands tend to be more variable, averaging 3 to 15 short tons biomass per acre.
- As white fir joins the stands at low elevations, loadings increase rapidly, particularly where root disease is present. Typical loadings here can range from 15 short tons to as high as 50 short tons biomass per acre or more if there has been recent disturbance that has killed trees or made them more susceptible to wildfire.

For the period of 1949-1999 the watershed had 688 wildfire ignitions, an average of 14 fire starts per year. The high was 38 ignitions in 1977 and the low was one in 1963. All fires were actively suppressed and 88% were suppressed at less than 0.25 acres, 10% between 0.26 to 9.9 acres, and the balance at larger acreages. Forty-four fires larger than 10 acres occurred over this period; the total area burned for these fires was approximately 9,000 acres.

3.2 Overview of the offset project

The project boundary for the fuel treatment case study was the entire Drews Creek watershed that was assumed to benefit from the project practices (i.e., the project included both the stands treated as well as the remaining untreated stands within the watershed). The proposed offset project was to treat a percentage of the forested stands within Drews Creek watershed (i.e., the landscape) with thinning operations to lower tree stocking and removing associated logging slash and other wildfire fuel. In some cases, thinning was followed by prescribed under burn to further reduce wildfire fuel loadings.

Avoided wildfire emissions were estimated for a single random wildfire ignition that occurred during extreme burning conditions (i.e., high temperature, low-moisture fuel, and prevailing winds). The emissions estimates were based on the probability distribution of wildfire extent and intensity, including the probability of a problem wildfire.

3.3 Spatial modeling of wildfire and effectiveness of fuel treatments

The case study used ArcFuel[3] as the simulation platform for the analyses. ArcFuel is a library of ArcGIS[4] macros developed to streamline spatial modeling of wildfire behavior, stand growth and yield, and fuel treatments for planning purposes. ArcFuel brings together various data layers—gradient nearest neighbor (GNN) treelists, digital elevation grids, stand polygons, Forest Vegetation Simulator[5] (FVS) growth and yield outputs, LANDFIRE[6] fuel model data, slope, and aspect—and processes them in ways that facilitate communication between fire simulation, stand growth and yield, and spatial modeling programs. Carbon stocks were modeled through FVS' Fire and Fuel Extension (FFE) application. Specifically, FVS-FFE accounts for the following carbon pools:

- Aboveground merchantable live biomass
- Below-ground live and dead biomass
- Standing dead biomass
- Dead and down woody debris
- Forest floor (litter and duff)
- Understory (shrub and herb)

FVS-FFE also accounts for the fate of carbon stored in merchantable material removed, specifically the amount of continued storage in wood products and landfills and the amount lost to decomposition. However, the FVS-FFE does not account for soil carbon stores.

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[3] For more information on ArcFuel, see: http://www.fs.fed.us/wwetac/arcfuel/.

[4] For more information on ArcGIS, see: http://resources.esri.com/gateway/index.cfm.

[5] For more information on the Forest Vegetation Simulator, see: http://www.fs.fed.us/fmsc/fvs/.

[6] Landscape Fire and Resource Management Planning Tools Project. For more information, see: http://www.landfire.gov/.

Stands were selected for treatment based on criteria developed by Fremont-Winema National Forest staff. Virtually all stands eligible based on basal area [at least 70 square feet (ft^2) per acre] also met additional distance to road and slope criteria. The area treated was 94 treatment units, averaging 175 acres each, totaling 17,740 acres. The treatment units covered approximately 12.6% of the watershed's forestland. Of the 17,740 acres selected, 12,825 acres met thresholds for treatment (9.1% of the watershed's forestland). The treatment prescriptions called for thinning from below to a residual basal area of 70 ft^2 per acre for mixed conifer or fir-dominated stands and 50 ft^2 per acre for pine-dominated stands, followed by slash removal and under burning. The treatments were simulated with FVS and consisted of a 3-year sequence of thinning from below, site removal of surface fuel, and under burning.

Relatively few burn periods (defined as the period within a 24-hour day where wildfire activity is the greatest) generally account for the majority of the total area burned in large wildfires (e.g. >5,000 hectares) in the western United States, and wildfire suppression efforts have little influence on fire perimeters during these extreme events. Based on input from forest staff and historical data from remote automated weather stations, each fire event was simulated as an 8-hour burn period with a 25 mph wind under the extreme dry fuel moisture conditions. Wind was randomly simulated from three directions for each burn period and ignition locations were random. These conditions resulted in an average targeted simulated fire size of 11,000 acres.

Each stand had estimated conditional burn probabilities (BP_i), which represent the probability of a fire at the i^{th} 0.5 meter (m) flame length wildfire intensity category reaching the stand. Different flame lengths are predicted depending on the direction the fire encounters a stand relative to the major direction of spread (i.e., heading, flanking, or backing fire). The conditional burn probability for a given stand is an estimate of the likelihood that a stand will burn given a random ignition somewhere in the watershed under the weather conditions represented in the simulation.

Random ignitions were also allowed to originate outside the watershed to include wildfire events that burned into the watershed. The treated and untreated landscapes were each simulated with 10,000 wildfires to generate burn probability surfaces at 90m resolution. This represented both the conditional probability of wildfire reaching the stand (given an ignition on the landscape) and the conditional probability of the wildfire's intensity (given that wildfire reached the stand).

3.4 Quantifying effects of wildfire on carbon stocks

To quantify the potential effects of wildfire on carbon stocks, each possible stand condition (as represented by the GNN tree list data, both treated and untreated) for each possible wildfire intensity (as represented by flame length category) was burned through FVS-FFE. Each stand condition in the study area was burned within FVS-FFE under a pre-defined surface fire flame length ranging from 0.5m to 10m in 0.5m increments. The post-wildfire carbon reports in FFE were then examined to determine the amount of carbon in each carbon pool after burning. The result was a carbon loss function for each stand condition representing all the possible post-wildfire carbon stocks by wildfire intensity class including no wildfire.

Carbon loss is defined here as the reduction in post-wildfire carbon stocks for a given wildfire intensity when compared with the carbon stocks present if no wildfire occurred; the amount reduced is equivalent to CO_2 emissions lost to the atmosphere from the fire. As such, it ignores nitrous oxide (N_2O) emissions from fire events and any CO_2 emissions related to fossil fuel combustion during fuel treatment activities. For treated stand conditions, carbon loss included the sum of carbon loss from treatment and from wildfire. Treatment carbon losses occur as a result of non-merchantable biomass removal, the burning or decomposition of non-merchantable material remaining on site, carbon losses associated with the end-use and fate of merchantable material removed, and from the CO_2 emissions from the under burns.

The carbon stocks representing the amount of stored carbon post-wildfire (for untreated stand conditions) and post-treatment/wildfire (for treated stands) was matched with the burn probability data to calculate expected carbon stocks for each stand as follows in Equation 1:

$$E[C]_{LS_j} = \left[\sum_{i=0}^{20} \left[BP_{ij} \times SC_{ij} \right] \right] + WPC_j$$

Where:

$E[C]_{LSj}$ = Expected carbon (mass per unit area) post-wildfire for the *j*th stand and LS = TRT for the treated landscape and NO-TRT for the untreated landscape.

BP_{ij} = Conditional burn probability of wildfire intensity class *i* reaching stand *j*; where:

$\sum_{i=1}^{20} BP_{ij} = BP_j$ where BP_j is the overall burn probability of wildfire reaching stand *j*

BP_{0j} = Conditional probability of no fire = 1-BP_j;

and $\sum_{i=0}^{20} BP_{ij} = 1$

SC_{ij} = total stand carbon, post-wildfire of wildfire intensity class *i* burning in stand *j*; *i*=1 to 20.

SC_{0j} = total stand carbon in stand *j* if no wildfire occurs.

WPC_j = carbon stored in wood products from treatment in stand *j*.

For the untreated landscape, $WPC_j = 0$ for all j. For treated areas on the treated landscape, SC_{ij} represents total stand carbon post-treatment and post-wildfire for intensity class i burning in stand j for $i = 1$ to 20, and for treated stands on the treated landscape, SC_{0j} represents total stand carbon post-treatment if no wildfire occurred.

3.5 Calculating the carbon offsets

The expected carbon offset is calculated for each stand by comparing the expected post-wildfire amount of carbon stored in the stand on the treated landscape with the amount of carbon stored in the same stand post-wildfire on the untreated landscape. (If the stand had been treated, then the post-treatment/post-wildfire conditions are compared with the same stand's untreated/post-wildfire conditions). If the amount of carbon stored in the stand post wildfire on the treated landscape is greater than the amount of carbon stored post-wildfire on the untreated landscape, then carbon offsets would represent the positive CO_2 emission benefit that occurred as a result of undertaking the treatment.

The carbon offset, $E[(\Delta C)]$, for the entire project is calculated as follows in Equation 2:

$$E[(\Delta C)] = \sum_{j=1}^{n} (E[C]_{TRT_j} - E[C]_{NO-TRT_j})$$

where:

n = is the total number of stands in the watershed,

$E[C]_{TRT_j}$ = is the expected carbon stock post treatment and wildfire in stand j; treated landscape

$E[C]_{NO-TRT_j}$ = is the expected carbon stock post-wildfire, stand j; untreated landscape, and

$E[C]_{TRT_J} - E[C]_{NO-TRT_j}$ = the carbon offset occurring in stand j as a result of treatment.

$E[(\Delta C)] > 0$ is a necessary condition for the offset to be used as mitigation for CO_2 emissions from an unrelated source.

3.6 Modeling Results

The simulated fuel treatments were effective in reducing the intensity and extent of wildfire. Fuel treatment had the desired effect of reducing the likelihood of fire reaching a given stand as measured by conditional burn probability. For untreated stands on the treated landscape, the likelihood of wildfire to spread to untreated stands was also reduced as a result of applying the treatments. There was a shift in the conditional burn probability distribution for treated stands, making low intensity fires much more likely than if the stands had not been treated, as well as reducing the overall likelihood of wildfire in those stands. Average fire size on the treated landscape was 32% lower than average fire size on the untreated landscape. Also, the largest fire simulated on the treated landscape was 15,000 acres compared with over 19,000 acres for the untreated landscape. In general, the treated landscape experienced a greater number of smaller wildfires when compared with the untreated landscape.

Thinning from below and fuel move practices removed 716,063 metric tons of CO_2 equivalent[7] ($mtCO_2e$), or 55.9 $mtCO_2e$ per treated acre, representing 19.1% of the total biomass in treated stands. Of this amount, 530,843 $mtCO_2e$, or 74%, was emitted to the atmosphere (41.3 $mtCO_2e$ per treated acre) with the remaining 185,219 $mtCO_2e$, or 26%, remaining stored in long-lived wood products (14.3 $mtCO_2e$ per treated acre). Under burning emitted another 372539 $mtCO_2e$ of CO_2 (29.0 $mtCO_2e$ per treated acre) representing 13.3% of the total biomass in treated stands. In total, carbon lost from the fuel treatment activity totaled -903,383 $mtCO_2e$ (-70.6 $mtCO_2e$ per treated acre). In comparison, only an expected 12,319 $mtCO_2e$ (0.7 $mtCO_2e$ per acre) of avoided carbon loss accrued to the treatment polygons as a result of the treatment's effect of reducing both the likelihood and intensity of wildfire in treated stands. Similarly, only 10,278 $mtCO_2e$ of expected avoided carbon loss accrued to the untreated polygons (0.1 $mtCO_2e$ per acre) as a result of the treatment's effect of reducing the likelihood of wildfire, for a total benefit of 22,597 $mtCO_2e$ of expected carbon loss avoided (0.2 $mtCO_2e$ per forested acre). The net expected carbon benefit accruing to the treated landscape when compared with the untreated landscape is $E[(\Delta C)] =$ -880,786 $mtCO_2e$ (-6.3 $mtCO_2e$ per forested acre) carbon, which indicates an overwhelming net gain in carbon emissions arising from the fuel treatment project.

The case study results show a gain in carbon emissions from conducting the fuel treatment project; that is, carbon stocks on the untreated landscape (the project baseline) are higher than on the treated landscape, even though they provide a lowered chance of problem wildfire. This is due to the probabilistic nature of wildfire and, specifically, the high probability that wildfire does not occur on a given landscape in a given year. Even if an ignition on the landscape occurs, the corresponding risk of wildfire for a given stand is low (usually below 3%). Since the dominant baseline scenario for each stand is that the fire never reaches it, fuel treatments provided no avoided CO_2 emissions benefit in this case study. Further, not every wildfire that does reach the stand, even under severe weather and fuel moisture conditions, is a problem wildfire, and less severe wildfires present significantly smaller carbon losses. And when a problem wildfire does occur, the amount of carbon loss compared with the stored carbon before the wildfire is still relatively small since the immediate effect of severe wildfire is to transfer carbon from the live tree carbon pools to the dead tree carbon pools.

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[7] Emissions and losses are reported here as metric tons of carbon dioxide equivalent ($mtCO_2e$), because some losses are in the solid form of carbon and others are in the gaseous form of carbon, namely CO_2. All outputs of the model were originally expressed as short tons carbon, so the units have been changed using a multiplier of 3.67 to change from carbon to CO_2 and 0.9072 to change from short tons to metric tons.

The case study results show that for any given ignition in the year after the completion of fuel treatments, the expected avoided carbon loss from one wildfire ignition is 22,597 $mtCO_2e$. The Drews Creek watershed experiences 14 wildfire ignitions a year on average; if independence is assumed in the wildfire outcomes from one ignition to another and it is assumed that one-third, say 5, of the 14 ignitions per year for Drews Creek occurred during the severe weather and fuel moisture conditions used in this study, then the expected avoided CO_2 emissions from the same fuel treatment investment would be 112,984 $mtCO_2e$ (the avoided carbon loss of 22,597 $mtCO_2e$ multiplied by an assumed five avoided events for that year). However, even when properly accounting for the number of chances in a given year a problem wildfire could have occurred, the added carbon benefit is still not enough benefit to make up for the 903,383 $mtCO_2e$ lost from the fuel treatment activity.

CHAPTER 4:
Case Study: Evaluation of Offset Quality

The case study simulation results reveal whether fuel treatment projects meet some of the conditions necessary to be considered a quality offset project. The case study focused on quantification and modeling techniques, so it is most applicable to use those offset quality criteria related to baseline and quantification. Therefore, this chapter evaluates how the case study performed against the following three criterion: (1) Be real, (3) Be based on a realistic baseline, and (4) Be accurately quantified and monitored. Chapter 5 discusses all of the OQI offset quality criteria in the context of the project type.

4.1 How the case study performed against criterion "Be real"

For the case study's offsets to be considered "real," the project would have needed to count all relevant carbon pools and determined that CO_2 emissions reductions occurred that could be quantified as offset credits. However, the case study resulted in an initial net loss in carbon stocks to the atmosphere, so no offsets were generated. The estimated net loss is real in that the carbon gains and losses of all the relevant carbon pools (aboveground biomass, below-ground biomass, dead wood, litter, and wood products, and landfills) were accounted for[8]. The project did not attempt to account for transportation fuel combustion or other project-related emissions. Further, the model did not attempt to incorporate anticipated changes to vegetation or wildfire risk as a result of climate change.

In addition, in order for the case study's offsets to be considered "real," the problem wildfire in the baseline scenario must have a probability of one of occurring in the baseline scenario (that is, it must have occurred with near certainty absent the project activity). There was uncertainty that the problem wildfire would have occurred in the baseline case, so there is no certainty that there would have been an emissions event that the project is avoiding.

Conclusion: The Drews Creek watershed case study did not meet the "Be real" criterion because all estimates were expected values (i.e., estimates that reflect the average outcome given the probability distributions of wildfire *including the probability that no wildfire occurs*) and there was not an absolute probability of one that the problem wildfire would have occurred. Also, the project did not account for project-related fossil fuel emissions.

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[8] Soil carbon was not accounted for due to a lack of data and models. This could be a key omission in the case study analysis as areas that are intensively burned by severe wildfire could result in significant losses of soil carbon that would be avoided by the lower intensity burns that follow fuel treatment. This omission is conservative in that it would tend to underestimate rather than overestimate project crediting.

4.2 How the case study performed against criterion “Be based in a realistic baseline”

The case study simulation demonstrated that establishing a realistic “without project” baseline for fuel treatment projects is feasible. The Drews Creek case study estimated the probability of wildfire occurrence and wildfire intensity on both the untreated (“without project”) and treated (“with project”) landscape, using identical methods and models. This is a significant advancement over previous studies estimating the carbon benefits from fuel treatments that had to rely on knowing in advance where the problem wildfire was going to occur[9] since this approach explicitly took into account the uncertainty inherent in wildfire occurrence, both in terms of extent and severity. As such, the case study modeling approach is realistic in that expected outcomes to carbon stocks—a weighted average of all possible outcomes for all types of wildfire including no wildfire based on the probability of each outcome—are used to quantify emission benefits (or costs).

Conclusion: The Drews Creek watershed case study met the criterion “be based on a realistic baseline” because the baseline modeling approach explicitly took into account the uncertainty inherent in fire occurrence and behavior. As such, the modeling approach is realistic. This is as compared with previous modeling of fuel treatments that assumed advanced knowledge of the occurrence, extent, and severity of the wildfire.

4.3 How the case study performed against criterion “Be accurately quantified and monitored”

The case study simulation results show that wildfire emissions and avoided emissions from fuel treatment activities can be modeled and reported using a sound probabilistic approach to wildfire. However, conservativeness was not applied in estimating the baseline stocks and emissions—both the “with project” and “without project” outcomes were modeled at the same level of accuracy and precision. To be conservative, the emissions from the “with project” case should be higher than the expected value, while the emissions from the “without project” case should be lower than the expected value.

Conclusion: The Drews Creek watershed case study partially met the criterion “be accurately quantified and monitored” because both the baseline and “with project” scenarios were modeled using identical techniques and the quantified offsets is simply the difference between the two. However, it did not provide methods to monitor the quantified reductions.

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[9] See Hurteau and others 2008 for an example.

4.4 Conclusions

The Drews Creek watershed case study does not result in a quality offset project. First, the case study resulted in an increase in CO_2 emissions, so no real offsets can result from the project as described. Further, there is too much uncertainty that a problem wildfire would have occurred during the project lifetime, meaning that there is no certainty that an emission was avoided by the project. In addition, the project did not address the majority of the offset criteria, including permanence, additionality, and ownership.

CHAPTER 5: The Fuel Treatment Project Type: Discussion of Offset Quality and Potential

Due to the limited scope of the case study, quality criterion (1), (3), and (4) were the only offset requirements that could be evaluated. However, it is possible to use the case study as a foundation for discussing whether and under what conditions wildfire fuel treatments may qualify as an offset project type. This chapter discusses the project type more generally within the context of the OQI's quality criteria.

5.1 Be real

In order to "Be real" this project type must provide certainty that the avoided emission event (the problem wildfire) occurred, all relevant carbon pools must be taken into account, and the project must result in an actual carbon benefit.

This project type can meet the "Be real" criterion if the project is properly designed. For example, one reasonable way to provide certainty that the problem wildfire would occur during the project lifetime is to increase the required duration of the project until the certainty of the emission event is 100%. While problem wildfire is probabilistic for a given wildfire ignition in a given year, eventually it is going to happen. "Eventually" can be quantified using the absolute probability (usually estimated based on historical fire frequency data) that an area will incur a catastrophic wildfire. For example, if the absolute annual probability that a problem wildfire event will occur in a given stand is 2% (= 0.02), then this type of wildfire would occur within 50 years with near certainty (since 1/0.02 = 50). Therefore, this project would have a 50-year project lifetime (plus a 100-year verification period afterward). Because fuel treatments are estimated to last for 10 to 15 years, multiple fuel treatments must be implemented over the course of the project life to maintain fire suppression qualities.

The project would also need to account for all the relevant carbon pools (though soil carbon can justifiably be omitted for simplification) and for the emissions associated with any project activities such as fossil fuel combustions, the construction of any roads, etc.

5.2 Be additional

The project type would not currently meet OQI's regulatory requirement for additionality if it is performed on federal lands. If a project was conducted on private lands, it would need to demonstrate that there was a barrier (financial or otherwise) to fuel treatment implementation that the sale of carbon credits helped to overcome.

Since most projects would occur on federal lands, this project type is unlikely to meet the "Be additional" criterion until policymakers provide clarity as to the appropriate role for carbon market financing on public lands.

5.3 Be based on a realistic baseline

This project type can meet the "Be based on a realistic baseline" criterion if the project is properly designed utilizing a probabilistic modeling technique (similar to that used in the case study). However, it must accurately model pre- and post-fire carbon stocks over the entire project lifetime.

5.4 Be accurately quantified and monitored

This project type can meet the "Be accurately quantified and monitored" criterion if the project is properly designed to have a unique monitoring plan that accurately and conservatively quantifies carbon stocks.

The offsets from this project type can be quantified as the difference between baseline and project carbon stocks (plus any associated carbon stored as harvested wood product) by using a modeling technique similar to that used in the case study. As discussed in Chapter 2, the project's crediting must be conservative to ensure quality offsets.

Fuel treatment projects need to be monitored over time against a clearly defined set of conditions or thresholds that indicate the avoidance of the problem wildfire on the treated landscape (e.g., average fire size, number of fires suppressed, etc). Any behavior on the landscape that exceeds these thresholds would trigger an on-site third party verification. If the verification indicates that carbon stocks have been reduced below a threshold level, then a reversal has occurred. Reversals are discussed further under permanence.

5.5 Be independently validated and verified

This project type can meet the "Be independently validated and verified" criterion if the project is properly designed so that the modeling technique would be validated by a transparent stakeholder process. In addition, the monitoring reports would need to be verified by qualified independent third parties and on-site verifications would be required on a regular basis and after any fire large enough to trigger verification requirements.

5.6 Be unambiguously owned

This project type can meet the "Be unambiguously owned" criterion if the project is properly designed to carefully document which participant claims ownership. All participants with a potential claim to ownership over the reduction (e.g., the entity performing the treatment, the landowners, or the entities utilizing any removed biomass) would need to agree to, and provide evidence of, clear and uncontested ownership over the offsets. All issued offsets need to correspond to a unique serial number that is stored on a public registry.

5.7 Address leakage

Leakage is not expected to be a concern with this project type. Any activity-shifting leakage concerns (i.e., that fewer fuel treatments are performed on other lands due to the project activity) would be addressed as part of concerns about additionality. Any market-shifting leakage (i.e., the additional harvested wood product or biomass brought to market) would be expected to increase carbon stores on the land of other entities, and therefore can be safely and conservatively excluded from analysis.

5.8 Address permanence

This project type can meet the “Address permanence” criterion if the project is properly designed to maintain the project case fire levels for 100 years past the project lifetime. For example, if the project lifetime is 75 years, the monitoring, verification, and fuel treatments would have to be conducted for a total of 175 years. This is due to the fact that without further treatment, the baseline landscape wildfire fuel loadings and other conditions will reset themselves and the expected wildfire severity will increase, emitting the carbon that was sequestered by the project activity. With this consideration, the offset project becomes a commitment to scheduling a series of repeated landscape fuel treatment projects over time so as to maintain the “with project” wildfire risk conditions that give rise to lower expected wildfire emissions.

In addition, fuel treatment projects would involve many of the permanence efforts that improved forest management projects do, including contractual requirements to maintain project activities over the project lifetime, buffer pool contributions to account for unintended reversals, and contractual obligations to reimburse credits in the case of an intended reversal. A reversal would occur if it is determined that a wildfire exceeds a given threshold size and severity.

5.9 Do no net harm

This project type can meet the “Do no net harm” criterion if the project is properly designed to adhere to all relevant state and federal forest practice regulations that protect water quality, endangered species, and biological diversity. The project must take place in a location that has been identified by an existing local and regional needs assessment that was transparently developed with stakeholder participation and explicitly addresses habitat impacts and the drought resistance of the forest in addition to wildfire risk.

5.10 Summary evaluation

It is theoretically possible to generate quality offsets if fuel treatment projects result in real emission reductions, are not located on federal land, and are properly designed. However, without emission reductions, there are no offsets to be generated. Further, quality forestry offsets cannot be located on federal lands until federal legislation or rule making clarifies the role of private financing of public management activities. If these two major hurdles can be overcome, it is recommended that the project be designed as outlined in this chapter, which is consistent with an improved forest management project.

CHAPTER 6: Lessons Learned

This report analyzes the viability of fuel treatment projects as a source of high quality carbon offsets. To make this determination, the report evaluated a fuel treatment case study to ascertain whether the assumed CO_2 benefit of the fuel treatment could be realized. Based on the case study, it was then determined what requirements the project type must meet to produce quality offsets. Following are the primary lessons learned from this analysis.

6.1 Fuel treatment projects: Evaluation as a carbon offset

While it is possible to design a quality fuel treatment offset project, it is unlikely that any projects of this type will be implemented for three primary reasons:

1. There are no indications that this project type actually results in emission reductions, so no offsets would be produced.

2. The activities necessary to ensure offset quality are likely to make this project type cost-prohibitive for some of the reasons cited below and detailed in Chapter 5:

    - The risk of reversal is high, which requires significant contributions of some of the offsets to buffer pools to insure against this risk.
    - The need to continue to implement fuel treatment practices periodically on the landscapes for an additional 100 years after a project is completed can be a disincentive when recruiting project participants.
    - The cost of third party verification will be high due to the need for verifiers to have specialized experience in wildfire ecology, forestry, and probabilistic simulation models.

3. The cost of monitoring and verification will be high due to the long span of time that both activities are periodically required to occur (project life plus 100 years).
4. The project potential is limited because the majority of potential projects would be on federal forestlands, which do not currently meet the “Be additional” criterion.

6.2 Fuel treatment projects: The opportunity

Regardless of their potential (or lack thereof) as a carbon offset project, fuel treatment projects remain necessary to provide clean water, fish, and wildlife habitat; make forests more resilient to wildfire (ideally, restoring fire’s ecological role in maintaining forest health and resilience), and protect communities from the risks associated with wildfires.

The need for conducting well planned and socially accepted fuel treatment projects will become even more important as a means to adapt western forests to climate change since most climate modeling scenarios predict that western forests will expand in area and increase in woody biomass. Climate-driven changes in wildfire regimes will likely be the dominant driver of change in western U.S. forests over the next century. For example, due to increased temperatures, reduced snowpack, and reduced summer precipitation, models predict an increase in the length of the fire season and in the likelihood of fires east of the Cascade Range. The frequency of wildfire is expected to increase along with severity and extent, and forests will experience unprecedented mortality and loss of productivity from insects and disease infestations.

6.3 Fuel treatment projects: Next steps

The following two areas warrant further investigation to conclusively determine if fuel treatments are a good source of offsets.

- If there is a federal decision that this project type can be implemented on federal lands, it would be prudent to definitively determine if there is a carbon benefit from this project type through further studies to attempt to receive offset funding.
- It may be possible to effectively use the removed biomass to create energy or biochar, both of which could benefit the climate and the rural economies. Further study is needed to properly define how the CO_2 emission benefits (or carbon neutrality or even a carbon cost) from the fuel treatment projects is linked with either of these project activities. It is the overall net reduction of CO_2 emissions to the atmosphere—both those accruing to the forestland as a result of treatment and those accruing to the power plant or other end use as a result of utilization—that will define the potential of the combined activity to provide a climate benefit. Projects will need to be carefully constructed so that the quality offset criteria are met.

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