FINAL REPORT ON WESTCARB FUELS MANAGEMENT PILOT ACTIVITIES IN LAKE COUNTY, OREGON

Goslee, K., T. Pearson, S. Grimland, S. Petrova, J. Walls and S. Brown.

Winrock International

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Abstract

This report summarizes work by Winrock International, Lake County Resources Initiative (LCRI), and other Lake County, Oregon partners to implement hazardous fuel reduction/biomass energy pilot activities in WESTCARB Phase II (2006-10). Wildfire is a significant source of GHG emissions in Oregon and throughout the WESTCARB region. WESTCARB developed methodologies to evaluate, validate and demonstrate the potential of reducing hazardous fuel for biomass energy to contribute to GHG mitigation and adaptation. The report describes hazardous fuel reduction pilot activities on Federal and private lands in Lake County; pre- and post-treatment measurements to quantify forest carbon impacted by treatment and/or fire; analysis of data from these pilots to determine the net GHG impact of the fuel reduction treatments; and related work by LCRI to facilitate continued hazardous fuels reduction efforts in Lake County.

Keywords: *Carbon, sequestration, hazardous fuel reduction, forest, Lake County*

Executive Summary

Introduction

The West Coast Regional Carbon Sequestration Partnership (WESTCARB), led by the California Energy Commission, is one of seven US Department of Energy regional partnerships working to evaluate, validate and demonstrate ways to sequester carbon dioxide and reduce emissions of greenhouse gases linked to global warming.

Earlier analyses by Winrock showed wildland fire to be a substantial source of greenhouse gas (GHG) emissions throughout the region. Actions to reduce hazardous fuel loads, so as to reduce the probability, areal extent, or severity of wildfires, could result in lower net GHG emissions when compared to a baseline scenario without such treatments. Fuel reduction may also contribute to carbon sequestration by enhancing forest health or growth rates in post-treatment stands. Finally, for treatments where fuel removal to a biomass energy facility is feasible, additional GHG benefits may be created by substituting the biomass for fossil fuel rather than leaving the biomass in the forest to decompose.

Hazardous fuel reduction/biomass energy pilot activities were implemented in the two WESTCARB terrestrial pilot locations, Shasta County, California and Lake County, Oregon. These projects provide real-world data on carbon impacts of treatments, costs, and project-specific inputs to a related WESTCARB task, in which Winrock International and the WESTCARB Fire Panel are working to investigate whether the development of a rigorous methodology to estimate GHG benefits of activities to reduce emissions from wildland fires is feasible.

Purpose

This report provides results from the WESTCARB Phase II hazardous fuel reduction pilot activities in Lake County, Oregon. In addition we report on the revised 2010 Long-range Strategy for the Lakeview Federal Stewardship Unit, a related activity done in conjunction with the WESTCARB research efforts.

Project Objectives

The overall goal of WESTCARB Phase II is to demonstrate the region's key carbon sequestration opportunities through pilot projects, methodology development, reporting, and market validation. WESTCARB research will inform policymakers, communities, and businesses on how to invest in carbon capture and storage technology development and deployment to achieve climate change mitigation objectives.

The specific objectives of the Phase II Lake County fuel reduction pilots are to investigate the feasibility of fuels-treatment-based terrestrial sequestration by conducting pilot projects in a representative West Coast forest; compile information on site conditions, fuel treatment prescriptions, and costs; and inform and field-test the WESTCARB fire GHG emissions methodology. Fuels treatments were implemented on two project areas: Bull Stewardship and Collins-Hot Rocks.

Methodology for measuring impacts of hazardous fuels treatments

Pre- and post-treatment measurements were made on two fuels treatment projects in Lake County, Oregon. These projects involved removal of non-commercial biomass and sawtimber with the overall objective of reducing fuel loading and risk of catastrophic wildfire. The actual fuels treatments were not

initiated under WESTCARB support, but they provided an opportunity to conduct on-the-ground measurements of actual hazardous fuel reduction efforts.

The fuel reduction activities were located in the southwest corner of the county. One project area, Bull Stewardship, was on the Fremont-Winema National Forest, and the other, Collins-Hot Rocks, was on privately owned land.

A total of 38 plots were established in the Bull Stewardship and 22 in the Collins Companies Hot Rocks lands. Pre- and post-treatment measurements on these plots addressed live trees greater than 5 cm diameter at breast, canopy density, standing dead wood, understory vegetation, forest floor litter and duff, and lying dead wood. These represent the forest carbon pools that are likely to be affected by fire, treatment, or both, and so are critical to the accounting of hazardous fuel reduction treatment impacts and potential wildfire impacts on forest carbon.

These measurements were used to determine the carbon stocks before and after treatment and before and after a potential wildfire, for each project area. Growth modeling was conducted with the Forest Vegetation Simulator for both with and without treatment stands. Emissions from a potential fire were modeled in both with- and without-fuels treatment scenarios using both the Fuel Characteristic Classification System and the Forest Vegetation Simulator fire and Fuels Extension (FVS-FFE). FVS was also used to project growth on burned stands, incorporating the impacts of fire on the future stand.

Because it was not possible to send harvested biomass that did not go into sawtimber to a biomass energy plant and it was instead piled for burning, the CO_2, CH_4, and N_xO emissions from burning this biomass were calculated. Board feet of timber harvested was converted to metric tons of carbon, with retirement rates applied.

Project Outcomes

<u>Bull Stewardship</u>

Including carbon stored in long term wood products and emissions from pile burning, for treated stands without wildfire, a total of 73.2 tons of carbon per acre are stored, with 60.4 t C/ac still stored in the same stands following a wildfire.

Incorporating the risk of fire of 0.6% to calculate net emissions or removals (section 2.8), the fuels treatment on the Bull Stewardship project resulted in an effective immediate net emissions of 36.7 t CO_2-e/ac (10.0 tons of carbon per acre).

In the absence of a wildfire, the fuels treatments and commercial harvest result in short term emissions of 59.4 t CO_2/ac and emissions of 36.5 t CO_2/ac over 60 years (table A1).

Table A1: Net short and long term emissions from fuels treatment without fire on Bull Stewardship in tons of carbon dioxide per acre (+ = removals; - = emission)

	Short term 10 years	Long term 60 years
Harvested timber	**17.2**	**12.6**
Treatment emissions	**-68.2**	**-40.7**
Pile burning emissions (CO_2e)	**-8.4**	**-8.4**
NET	**-59.4**	**-36.5**

For the treatment to yield benefits to the atmosphere, the emissions from treatments will need to be offset by reductions in emissions from a potential wildfire hitting the area. In order for the treatment to have an impact, such a fire would have to occur before fuels have returned to hazardous conditions, at which point it will be necessary to re-treat the forest. According to the FVS-modeled results, if a wildfire were to occur in the year of treatment, after 10 years the net emissions from treatment would be 40.7 t CO_2/ac.

Collins-Hot Rocks

Including carbon stored in long term wood products and emissions from pile burning, for treated stands without wildfire, a total of 34.1 tons of carbon per acre are stored, with 25.1 t C/ac still stored in the same stands following a wildfire.

Incorporating the risk of fire of 0.6% to calculate net emissions or removals (section 2.8), the fuels treatment on the Collins-Hot Rocks project resulted in an effective immediate net carbon emission of 76.3 t CO_2-e/ac (20.8 tons of carbon per acre).

In the absence of a wildfire, the fuels treatments and commercial harvest result in short term emissions of 108 t CO_2/ac and emissions of 113 t CO_2/ac over 60 years (table A2).

Table A2: Net immediate and long term emissions from fuels treatment without fire on Collins-Hot Rocks in tons of carbon dioxide per acre (+ = removals; - = emission)

	Short term 10 years	Long term 60 years
Harvested timber	**8.8**	**6.2**
Treatment emissions	**-101.9**	**-104.9**
Pile burning emissions (CO_2e)	**-17.6**	**-17.6**
NET	**-110.7**	**-116.3**

For the treatment to yield benefits to the atmosphere, the emissions from treatments will need to be offset by reductions in emissions from a potential wildfire hitting the area. In order for the treatment to

have an impact, such a fire would have to occur before fuels have returned to hazardous conditions, at which point it will be necessary to retreat the forest.

According to the FVS-modeled results, if a wildfire were to occur in the year of treatment, after 10 years the net emissions from treatment would be 81.1 t CO_2/ac.

Related Efforts

The Lakeview Stewardship Group developed the 2005 Long-Range Strategy for the Lakeview Federal Stewardship Unit (Lakeview Stewardship Group 2005; see http://www.lcri.org/unit/longrange.htm) and the revised 2010 Long-range Strategy for the Lakeview Federal Stewardship Unit. In conjunction with the WESTCARB research efforts, the work of the Lakeview Stewardship Group have recently borne fruit in six important developments.

- After lengthy negotiations, a 20-year Interagency Biomass Supply MOU was signed on November 1, 2007. The purpose of the MOU is to provide a framework for planning and implementing forest and rangeland restoration and fuels reduction projects that address identified resource needs while being supportive of the Lakeview Biomass Project.

- The efforts of Lake County Resources Initiative (LCRI) and its Lake County partners have resulted in a commitment to the first 10-year Stewardship Contract in the US Forest Service Pacific Northwest Region. The contract, considered a model for the region, provides long-term supply of material necessary for the recent investments in a biomass power plant and small-log mill described below.

- Oregon Governor Kulongoski's office and biomass plant developer DG Energy jointly announced in January 2007 that DG Energy will construct a 13 MW biomass plant in Lakeview. This represented the culmination of multi-year efforts by all the partners in the Lakeview Stewardship Group to reach agreement around sustainable harvest levels and long-term biomass supply mechanisms necessary for investment in new capacity. Since collecting all the data from the stewardship contracts and other significant information from private lands it has been determined that a 25 MW biomass plant is sustainable. Currently the project is scheduled for a final decision on construction during summer 2010 and breaking ground in September 2010 with an estimated completion date of December 2012.

- Oregon Governor Kulongoski in March 2007 announced that the Collins Companies will expand their Fremont Sawmill operation in Lakeview by building a new $6.8 million dollar small-log mill. The small-log mill is the direct result of the 20-year Interagency Biomass Supply MOU and 10-year Stewardship Contract efforts spearheaded by LCRI, and provides an added tool for improving management of forests and hazardous fuels in Lake County.

- Considerable changes have occurred on Fremont-Winema National Forest since the beginning of the WESTCARB project in 2006. The original Forest Service prescriptions for Bull Stewardship, Burnt Willow and Kava are for much lighter treatments than treatments currently being implemented by the Forest Service. One of the critical outcomes is that there is infrastructure in place to restore the Forest Service lands to healthy conditions that will be able to better adapt to climate change.

- The national office of the Forest Service announced in February 2010 that they are accepting proposals for the Collaborative Forest Landscape Restoration Program (CFLRP). Region 6, which includes Lake County, sent in five proposals with the Lakeview Stewardship Group, with

Fremont-Winema proposal being the number one priority. Over 10 years this could mean an additional 20 million dollars above regular appropriations for fuels management and restoration in the 500,000 acre Lakeview Federal Stewardship Unit.

Conclusions and Recommendations

In both projects, the treatments resulted in overall carbon emissions. This result clearly has negative implications for the future potential of fuels treatments as a carbon projects offset category. Within the treated areas, both projects had significant net emissions when considering treatment and the risk of a potential wildfire. If a fire were to occur in the year of treatment, all projects would still experience net emissions, though the impact of treatment emissions would be slightly reduced.

Both pilots led to a projected decrease in crown fire potential, which decreases fire severity and size. While treatments lead to net carbon emissions in both the short and long term in all projects, there are, of course, additional benefits to fuels treatments, such as increased ability to successfully fight fires and decreased cost of fire fighting; reduced loss of life and property; and reduced potential damage to wildlife habitat.

The results from this study in combination with the paired study in Shasta County and the allied study in Mendocino National Forest underlie the unsuitability of fuels treatment as a potential greenhouse gas offset generating activity. Instead we argue the shift should be made to policies minimizing greenhouse gas emissions from wildfires and from fuel treatments while minimizing wildfire risks to lives, homes, wildlife habitat, and livelihoods in the WESTCARB region.

1.0 Introduction

1.1 Background and overview

The West Coast Regional Carbon Sequestration Partnership (WESTCARB), led by the California Energy Commission, is one of seven US Department of Energy regional partnerships working to evaluate, validate and demonstrate ways to sequester carbon dioxide and reduce emissions of greenhouse gases linked to global warming. Terrestrial (forestry and land use) sequestration options being investigated include afforestation, improved management of hazardous fuels to reduce GHG emissions from wildfires, biomass energy, and forest management. Shasta County, California and Lake County, Oregon were chosen for Phase II terrestrial sequestration pilot projects because of the diversity of land cover types present, opportunities to implement the most attractive terrestrial carbon activities identified in Phase I, and replication potential elsewhere in the WESTCARB region.

Earlier reports identified fire as a significant source of GHG emissions throughout the WESTCARB region. Average estimated emissions from fires for the 1990-96 analysis period were: 1.03 $MMTCO_2e$ for Oregon (Pearson et al 2007a); 1.83 $MMTCO_2e$ per year for California (Pearson et al 2009); 0.18 $MMTCO_2e/yr$ for Washington (Pearson et al. 2007b); and 0.47 $MMTCO_2e/yr$ for Arizona (Pearson et al. 2007c).

The estimated baseline GHG emissions helped focus attention in Phase II on the questions: can actions by landowners to manage forest fuel loads be shown to produce measurable GHG reductions by decreasing the risk, severity, or extent of catastrophic wildfires? If so, can scientifically rigorous methods for measuring, monitoring, and verifying these GHG reductions serve as the basis for new protocols and market transactions, ultimately allowing landowners who reduce hazardous fuels to receive "carbon credit" revenues and improving the cost-effectiveness of fuel reduction? To explore these questions, hazardous fuel reduction (and where possible, removal of fuel for biomass energy generation) was chosen as a WESTCARB Phase II pilot activity in Shasta and Lake counties, and the WESTCARB Fire Panel was formed to develop fire GHG methodologies and protocols as needed.

1.2 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 inform policymakers, communities, and businesses on how to invest in carbon capture and storage technology development and deployment to achieve climate change mitigation objectives.

The specific objectives of the Phase II Lake County fuel reduction pilots are to:

- Verify the feasibility of fuels-treatment-based terrestrial sequestration by conducting pilot projects in a representative West Coast forest;
- Compile information on site conditions and fuel treatment prescriptions;
- Inform and field-test the WESTCARB fire GHG emissions methodology by:
    - Collecting measurements of real-world fuel treatments to quantify:
        - The carbon stocks available to be burned before and after treatment,
        - The direct impacts of fuel treatments on carbon stocks in different carbon pools (e.g. increases in dead wood, decreases in dense growth), and
        - The fuel removed from the forest for potential biomass energy applications;

- Providing input data for fire models used to simulate fire behavior and emissions in the baseline (without-treatment) and with-treatment scenarios.

- Promote continued hazardous fuels reduction efforts on Lake County forests and support the location of a biomass power plant in Lakeview through the work of the Lake County Resources Initiative including:
    - Serving as a liaison to the Lakeview Stewardship Group to assist in identifying the sustainable scale for the biomass power plant in Lakeview.
    - Serving as a liaison to secure a Memoranda of Understanding with U.S. Forest Service, Bureau of Land Management, and Oregon Department of Forestry stating a commitment to supply the biomass power plant.

1.3 Report Organization

The report is organized in four sections: project approach, results, related work and conclusions/ recommendations. Section 2 summarizes the private- and federal-lands fuel treatments chosen for study as WESTCARB pilot activities, and methods used for pre- and post-treatment measurements and data analysis. Section 3 provides results of those measurements and analyses. Section 4 details related work undertaken by the Lake County Resources Initiative regarding continued hazardous fuels treatments in Lake County. Section 5 discusses the findings and provides recommendations based on this research.

2.0 Project Approach

2.1 Fuel reduction project locations and descriptions

Pre- and post-treatment measurements were made on two fuels treatment projects in Lake County, Oregon. These projects involved removal of non-commercial biomass and sawtimber with the overall objective of reducing fuel loading and risk of catastrophic wildfire. Treatments also included chipping and removal of biomass fuel to a biomass energy plant. The actual fuels treatments were not initiated under WESTCARB support, but they provided an opportunity to conduct on-the-ground measurements of actual hazardous fuel reduction efforts.

The fuel reduction projects were located in the North Warner Mountains, northeast of Lakeview, Oregon. Figure 1 shows Lake County land ownership and forest classes. The fuel reduction activities were located in the southwest corner of the county.

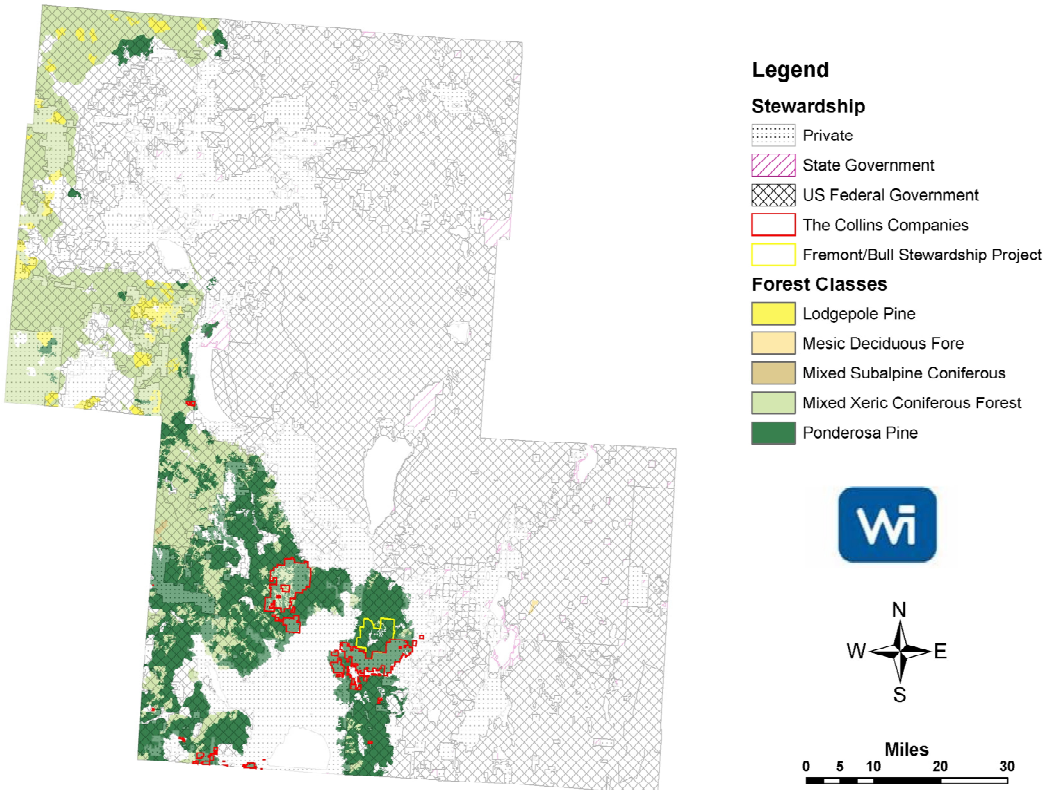

Figure 1. Lake County forest classes, Collins Companies lands (red) and Bull Stewardship Project boundary (yellow) adjacent to the eastern Collins Companies parcel.

The study on fuels treatments in Lake County was designed to examine the major ownership classes on forestlands in the county: Federal Government-owned National Forests and privately-owned industrial timberlands (Fig. 1 and 2):

- Federal lands - Fremont-Winema National Forest
- Private industrial timberlands – Collins Companies lands

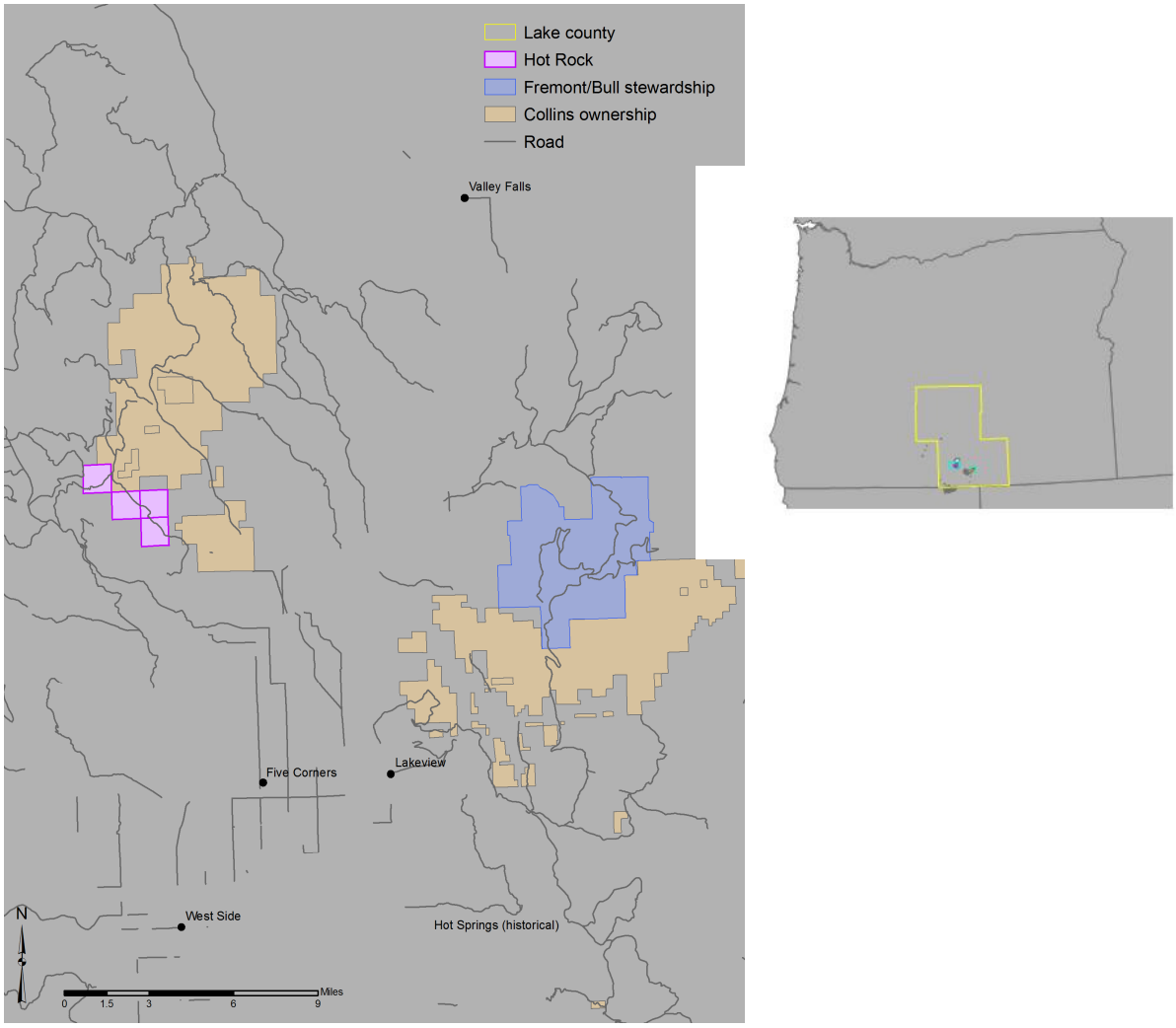

Figure 2. Lake County - US Forest Service Bull Stewardship Project (blue), and Collins Company Hot Rocks fuel treatments (pink).

2.1.1 Fuel reduction on Bull Stewardship Project lands

Location

The Bull Stewardship Project, on US Forest Service Fremont-Winema National Forest lands, was implemented by Collins Companies. The project is located approximately 9 miles northeast of the town of Lakeview, Oregon within the boundary of the Lakeview Federal Sustained Yield Unit in the Crooked Creek and Deep Creek Watersheds. The treatment area was 1,200 acres.

Treatment

Fuel reduction treatments began in July 2006, with pre-treatment measurements by Winrock/LCRI crews immediately preceding treatment. Treatments on Bull Stewardship were suspended in 2006 and began again in 2007. The treatments were ultimately completed in 2008. Stoppages were due to excessive fire risks.

The overall objective of the Bull Stewardship Project is forest health improvement and wildfire risk reduction, accomplished through a combination of commercial timber harvest and non-commercial biomass removals. Two types of treatment unit are included: timber harvest/stewardship and stocking level control. The treatment units within Bull Stewardship are shown in Figure 3.

On the timber harvest/stewardship units, the prescription calls for removal of commercial timber >9" diameter at breast height (DBH) (timber harvest component) and removal of non-merchantable material 7-8.9" DBH (stewardship component). The contractor has the option to remove non-merchantable material, including slash from commercial timber and whole non-commercial (<9") trees, for chipping and transport to a cogeneration facility.

On the stocking level control units, several different prescriptions exist, all requiring treatment of material 2 ft tall through 8.9" DBH inclusive. This material remains where it is cut, to reduce fuel loading (fuel ladders), but is not removed to a landing for further processing, and there is no commercial (>9") timber removal on these units. The objective is to favor Western White Pine and Ponderosa Pine. Specific prescriptions on the different stocking level control units include:

> Treatment 1: Cut all coniferous live trees that are 2 feet tall through 8.9" DBH inclusive. Inclusive trees shall be cut within two drip lines of all western white pine or ponderosa pine 18"DBH or greater.
>
> Treatment 2: Cut all coniferous live trees that are 2 feet tall through 8.9" DBH inclusive within two drip lines of all western white pine or ponderosa pine 11"DBH or greater.
>
> Treatment 3: Cut all coniferous live trees that are 2 feet tall through 8.9" DBH inclusive within two drip lines of all ponderosa pine 18"DBH or greater.
>
> Treatment 4: Cut all coniferous live trees that are 2 feet tall through 6.9"DBH inclusive. Inclusive trees and all white fir and lodgepole pine shall be cut within two drip lines of all western white pine or ponderosa pine 18"DBH or greater. Do not cut any western white pine or ponderosa pine within the two drip lines of another western white pine or ponderosa pine. Do not include white fir 18"DBH or greater in spacing calculations.

According to Forest Service records, 1.22 million cubic feet (1,002 cubic feet/acre) were harvested in the course of the treatment.

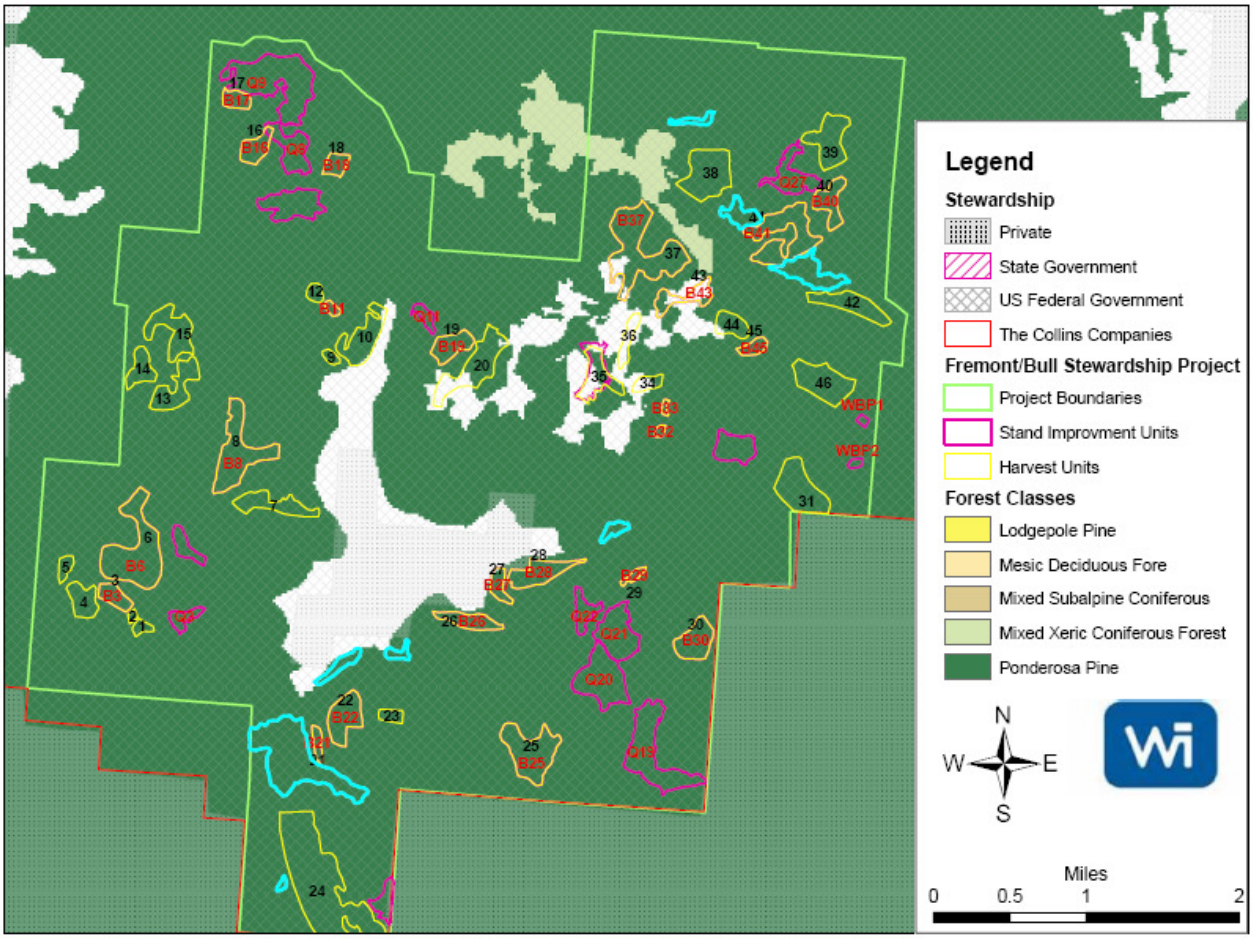

Figure 3. Treatment units on the Bull Stewardship Project. Treatments include commercial harvest units (yellow), stand improvement/stocking control units (pink), and combined timber harvest/stand improvement (blue).

2.1.2 Fuel reduction on Collins Companies lands

Location

Forest health/wildfire risk reduction projects on Collins Companies lands were included as WESTCARB pilots to evaluate approaches, costs and benefits of fuel reduction on private industrial timber lands. In 2007, Collins Companies began implementing fuels treatments on Collins lands in the Hot Rocks harvest units. See Figures 1 and 2 for overall Collins ownership boundaries in Lake County (red boundary), and Figure 4, showing the Hot Rocks harvest units. The total area treated was 288 acres.

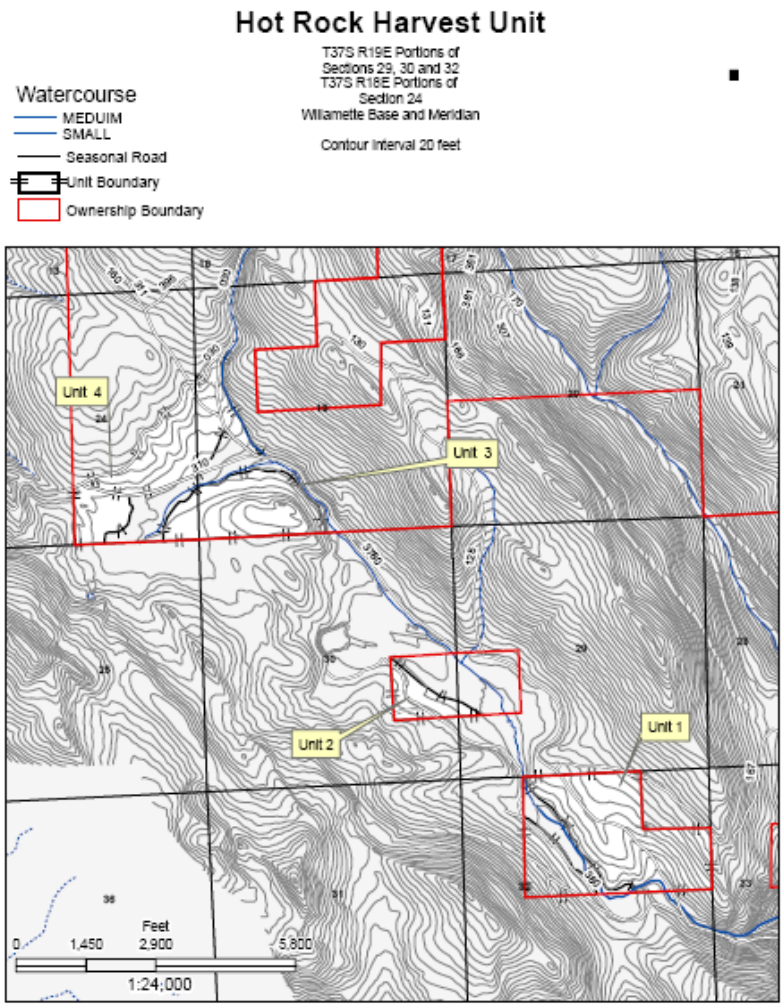

Figure 4. Hot Rocks harvest units, Collins Companies lands.

Treatment

Treatments were begun in June 2008 and completed in October 2008. The objectives of the Collins-Hot Rocks project was forest health improvement and wildfire risk reduction, accomplished through a combination of commercial timber harvest and non-commercial biomass removals. Treatments included selection harvest, commercial thinning, and variable retention harvest.

Selection harvest entails cutting trees greater than 8" dbh, with a post-harvest target of 80ft^2 basal area per acre and 160 trees per acre. Commercial thinning also targets a post-harvest basal area of 80ft^2/ac, but the minimum cutting diameter is 3", and there are approximately 120 residual trees per acre. The variable retention post-harvest targets are 30 trees per acre and 20ft^2/acre. In all three harvest systems, the focus is on choosing retention trees which are defect and disease free, possess phenotype superiority and a live crown ratio[1] greater than 50%. Some wildlife trees are also retained based on nesting potential.

[1] The ratio of tree crown length to total tree length.

The harvest removed 2,501 thousand board feet of sawtimber (8.7 thousand board feet /ac).

2.2 Pre- and post-treatment measurement methods

Field pre-treatment measurements[2] of Bull Stewardship and Collins-Hot Rocks fuels treatments were made in 2006 and 2007 and post-treatment measurement of both projects were made in 2008 and 2009.

2.2.1 Measurement Methods

The purpose of the measurements was to quantify the carbon stocks available to be burned before and after treatment, the direct impacts of fuel treatments on carbon stocks in different carbon pools (e.g. increases in dead wood, decreases in dense growth), and the fuel removed from the forest for biomass energy during treatment. Measurements also provided input data for fire models used to simulate fire behavior and emissions in the baseline (without-treatment) and with-treatment scenarios.

A total of 38 plots were established in the Bull Stewardship and 22 in the Collins Companies Hot Rocks lands.

Appropriate measurements of the following forest components were made at each plot:

- All trees >5 cm diameter at breast height, measured in nested plots and numbered for post-treatment measurements;
- Canopy density, measured at 36 points centered on the plot center;
- Standing dead wood;
- Understory vegetation, forest floor litter and duff, measured in clip plots and sub-sampled for dry weight determination;
- Lying dead wood, measured along transects, categorized by density class, and sub-sampled for density determination.

These represent the forest carbon pools that are likely to be affected by fire, treatment, or both, and so are critical to the accounting of hazardous fuel reduction treatment impacts and potential wildfire impacts on forest carbon. See Annex A for detailed Standard Operating Procedures followed in conducting pre- and post-treatment measurements of Lake County fuels treatments.

Plot locations were pre-assigned and random within units, taking into consideration elevation and species differences between units (higher elevation White Fir, higher elevation Lodgepole Pine, lower elevation White Fir/Ponderosa Pine). On navigation to each pre-assigned plot location, GPS coordinates were recorded and the plot center was marked using brightly painted rebar for ease of relocation post-treatment. Slope was noted for later analysis (plot-to-hectare expansion factor). All trees >5cm DBH were measured in a nested circular plot design, and numbered for post-treatment tally. Forest floor litter and duff was sampled in two 30 cm x 30 cm quadrats per measurement plot, and sub-samples collected for dry weight determination in a laboratory. The diameter of lying dead wood was measured along two 50 m line transects, categorized by density class, and sub-samples collected for density determination (dry weight per unit of green volume) and sent to a laboratory for drying. Post-treatment measurements were similar to pre-treatment as the objective is to examine the impact of treatments on

[2] Field crews were made up of staff from Winrock and LCRI

forest carbon stocks. Trees were measured pre-treatment, and thus were only tallied to record removed/remaining post treatment. Forest floor litter and duff was re-measured in quadrats, and lying deadwood re-measured in line transects.

2.3 Fire modeling methods

Based on the field data disaggregated by carbon pool, emissions from a potential fire were modeled in both with- and without-fuels treatment scenarios. The modeling was conducted using two different approaches.

1. The FCCS program (**Fuel Characteristic Classification System**) was developed by the Pacific Northwest Research Station to capture the structural complexity and geographical diversity of fuel components across landscapes and to provide the ability to assess elements of human and natural change. FCCS is a software program that allows users to access a nation-wide library of fuelbeds or create customized fuelbeds. The fuelbeds are organized into six strata: canopy (trees), shrubs, nonwoody vegetation, woody fuels (lying deadwood and stumps), litter-lichen-moss, and ground fuels (duff and basal accumulations). FCCS calculates the relative fire hazard of each fuelbed, including crown fire, surface fire behavior, and available fuel potentials. It also reports carbon storage by fuelbed category and predicts the amount of combustible carbon in each category.[3]

2. In addition to the FCCS modeling, fire effects were modeling using the **Forest Vegetation Simulator Fire and Fuels Extension** (FVS-FFE). FVS provides different outputs to FCCS and FVS can be used to project growth, incorporating the impacts of fire on the future stand.

The two models produced slightly different results, as they use different modeling methodologies and different biomass equations. They also produce somewhat different output. Reported outputs from FCCS include flame length in feet; crown fire potential as a scaled index from 0-9; rate of spread in feet per minute; and carbon consumed for live canopy, dead wood, and total. Reported results from FVS-FFE include flame length in feet; the crowning index in miles/hour; and total carbon consumed. Results for both prescribed fire and wildfire are reported from FCCS, while only wildfire is reported from the FVS-FFE results.

Although FVS uses a somewhat simpler methodology than FCCS for projecting fire impacts, it is based on established fire models and allows for growth projections. In order to address growth over time, FVS projections are used throughout the results, but FCCS output is presented to demonstrate the range of potential fire emissions.

2.4 Fire risk

Annual burn probability is difficult to project accurately as it is a factor of the likelihood of ignition and the conditions on the ground at the time of ignition, including fuels, climate, temperature, and topography (see Finney, 2005). WESTCARB research conducted by the Oregon Department of Forestry and the USDA Forest Service shows that the average overall conditional burn probability (probability that wildfire reaches a stand given one ignition source) in southeastern Oregon is 2.2% for untreated landscapes and 1.7% for the treated landscape, a 22.6% reduction in burn probability as a result of

[3] More information is available at the FCCS website: http://www.fs.fed.us/pnw/fera/fccs/. The modeling was conducted by Dr. David "Sam" Sandberg – Emeritus of the PNW Research Station Fire and Environmental Application Team.

treatment (Jim Cathcart, 2010, Oregon Department of Forestry, pers. comm.). This is an overestimate of annual burn probability as it does not include the probability of an ignition. The mean fire return interval from 2001 to 2008 for dry-mesic mixed conifer forests in Lake County is 153 years (Eric Waller, 2010, UCB CFRO, pers. comm.). The inverse of this provides an annual burn probability of 0.6%. It is important to note that this is a generalized probability and is not based specifically on pre- and post-treatment conditions for these projects, but rather for Lake County as a whole.

2.5 Growth modeling

Stand growth, both with- and without-treatment and considering all pools, was modeled with the US Forest Service's Forest Vegetation Simulator (FVS), using the Inland California and Southern Cascades variant. The standard allometric equations in the Fire and Fuels Extension (FFE) of FVS were used to produce biomass and carbon reports in conjunction with forest growth. Data from both the pre- and post-treatment inventories were used, with the pre-treatment inventory year counted as year zero to compare with and without treatment scenarios. Growth was projected over a 60 year period, and did not include any additional future treatments. To incorporate the effects of wildfire on growth, FVS-FFE was also used to model wildfire behavior.

2.6 Modeled scenarios

For both fire and growth, four different scenarios were modeled for both projects. Each scenario includes the following carbon pools: above-ground live, below-ground live, standing dead, and lying dead. For the treated scenarios, carbon stored in merchantable timber after 100 years is included. To simplify calculations, the emissions arising from wood product conversion and subsequent retirement are included at the beginning of the project.

	Untreated	Treated
No Wildfire	1.Untreated, no fire	3.Treated, no fire
Wildfire	2.Untreated, wildfire	4.Treated, wildfire

- *Scenario 1* gives the situation where there is no treatment or fire. At time zero it represents simply the carbon stocks (tons of carbon per acre) prior to treatment.
- *Scenario 2* is the carbon emissions and remaining stocks following a wildfire on untreated lands.
- *Scenario 3* is the carbon stocks remaining after the treatment, incorporating any emissions that were a result of treatment activities but in the absence of any fire.
- *Scenario 4* is the carbon emissions and remaining stocks following a wildfire on treated lands.

2.7 Harvested timber and biomass

Timber harvested is converted to metric tons of carbon according to Smith et al. (2006) that provides a factor of 7.48 thousand cubic feet and 0.44 thousand board feet per metric ton of carbon. The fraction of carbon in primary wood products remaining over time in end uses and stored in land fill, as described

in Smith et al. (2006), are then applied: after 10 years, 48.9% of carbon will remain in use as long-term wood products, and 12.5% will be sequestered in landfills; after 60 years, 20% of carbon will remain in long-term wood products, and 25.1% in landfills; after 100 years, 13% will remain in wood products and 27.9% in landfills.

While the intention for this project was to use harvested biomass for energy production, there have been setbacks in the development of a biomass energy plant in the area and thus no demand for such a product(see section 4.2). As a result, the harvested biomass has been piled and burned or piled awaiting the completion of a biomass power plant. For this reason, all harvested biomass that did not go into sawtimber is considered an emission as it will most likely be burned prior to completion of the plant. There are many forested areas in need of hazardous fuels reduction without access to a biomass facility, and so this method of accounting, while it leads to increased emissions, will be broadly applicable.

The burning of these piles leads to emissions of methane and nitrous oxide as well as carbon dioxide. The following emissions factors are recommended by the US EPA (Battye and Battye 2002):

Assuming a smoldering fire: CH_4[4]: 0.21 t CO_2-e/t burned

NO_x[5]: 0.34 t Co_2-e/t burned

2.8 Net impact calculations

Net project benefits following a treatment must incorporate

- carbon stocks in the forest;
- carbon emissions in a wildfire, accounting for the probability of fire;
- growth;
- carbon stored as long-term wood products;
- emissions from biomass harvested but not removed from the forest.

The net emissions or removals in year one are calculated as

$$[(Ct + Cw + Ce - Cb) * (1 - risk)] + [(Ctf + Cw + Ce - Cbf) * (risk)]$$

Where

Ct	carbon stocks remaining in the forest after treatment and without a wildfire
Cw	carbon stored as wood products
Ce	reduced emissions from using biomass for energy generation
Cb	carbon stocks in the forest before treatment and without a wildfire
risk	probability of fire
Ctf	carbon stocks remaining in the forest after treatment and with a wildfire
Cbf	carbon stocks remaining in the forest before treatment and with a wildfire

[4] Global warming potential of 21 used

[5] Global warming potential of 310 used

This equation states that the net emissions in year 1 are equal to:

The high probability that there will **be no fire** multiplied by the difference between stored carbon before and after treatment

Plus

The low probability that there will **be a fire** multiplied by the difference in total carbon storage after a fire in the treated stand and in the baseline stand.

3.0 Project Outcomes

3.1 Bull Stewardship

3.1.1 Field results

Prior to treatment, the Bull Stewardship project had 81.6 tons of carbon per acre across all pools. Following the treatment, the average carbon stock was 66.3 t C/ac. Treatment therefore resulted in a decrease in carbon stocks of 15.3 tons per acre, 19% of pretreatment stocks. The breakdown by pool is shown in Table 1, and the confidence limits at a 90% confidence interval for the aboveground live carbon pool are shown in Table 1a.

Table 1: Bull Stewardship carbon stocks (metric t C/ac) before and after fuels treatments

Carbon pool	Pre-treatment	Post-treatment	Difference
Trees	48.2	35.0	*-13.2*
Roots	13.8	9.7	*-4.1*
TOTAL TREES	62.0	44.7	*-17.3*
Standing dead	1.2	0.8	*-0.4*
Down dead wood	14.4	10.5	*-3.9*
TOTAL DEAD WOOD	15.6	11.3	*-3.7*
Forest Floor	3.6	9.8	*6.2*
Shrubs/herbaceous	0.5	0.6	*0.1*
TOTAL	81.6	66.3	*-15.3*

Table 1a. Upper and lower confidence limits at 90% CI for Bull Stewardship aboveground live carbon stocks (metric t C/ac) before and after fuels treatments

Aboveground live carbon	Pre-treatment	Post-treatment
LCL	43.5	30.3
mean	48.2	35.0
UCL	52.9	39.7
CI as a % of mean	9.7%	13.3 %

3.1.2 Potential fire emissions

Using FCCS-created fuel beds, a wildfire in the untreated stands would yield 52.8 tons of CO_2 per acre of emissions, while a wildfire in the treated stands would yield 42.0 t CO_2/ac (Table 2). Using the FVS Fire and Fuels Extension, a wildfire in the untreated stands would yield 42.7 t CO_2/ac of emissions, while a wildfire in the treated stands would yield 47.1 t CO_2/ac (table 3).

The potential flame length and rate of spread are essentially the same following the treatment as they are before treatment. The crown fire potential is lower in the treated stands.

Table 2: FCCS fire modeling results for Bull Stewardship

	Prescribed Fire		Wildfire	
	Pre-treatment	**Post-treatment**	**Pre-treatment**	**Post-treatment**
Flame Length (ft)	3.2	3.2	7.6	7.5
Crown Fire Potential (scaled index 0-9)	3.9	3.8	4.7	3.5
Rate of Spread (ft/min)	5.7	6.0	27.5	29.5
CO_2 emissions (t/ac)				
Canopy	-4.4	-5.1	-13.8	-15.4
Dead Wood	-28.2	-18.3	-36.3	-24.0
Litter	-2.4	-2.6	-2.8	-3.1
Total	-35.0	-26.0	-52.9	-42.5

Table 3: FVS fire modeling results for Bull Stewardship

	Wildfire	
	Pre-treatment	**Post-treatment**
Flame Length (ft)	6.6	6.7
Crowning index (miles/hr)[6]	14.5	24.7
CO_2 emissions (t/ac)	-42.7	-47.1
Total stand carbon remaining	69.5	53.5

3.1.3 Timber and biomass

The harvest on Bull Stewardship yielded 1,020 ft^3/ac. According to the conversion factor in Smith *et al.* (2006), this equals 7.6 t C/ac. Based on carbon disposition rates, a total of 4.7 t C/ac will remain stored in either long-term wood products or landfill after 10 years; 3.4 t C/ac will remain stored in either long-term wood products or landfill after 60 years; and 3.1 t C/ac will remain stored in either long-term wood products or landfill after 100 years.

Subtracting the removed sawtimber (7.6 t C/ac) from the total carbon removed in treatment (15.3 t C/ac), the remaining piled biomass represents 7.7 t C/ac or 15.4 tons of biomass per acre. This yields the following emissions (as described in section 2.7):

CH_4: 15.4 t burned * 0.21 t CO_2-e/t burned = 3.2 t CO_2e/ac

NO_x: 15.4 t burned * 0.34 t Co_2-e/t burned = 5.2 t CO_2e/ac.

The total CH_4 and NO_x emissions from pile burning are 8.4 t CO_2e/ac.

3.1.4 Growth modeling

Based on FVS modeling (Table 4), in the absence of fire, the treatment resulted in an initial decrease in carbon stocks of 15.3 t C/ac (compare columns 1 and 2), but the treated stands had slightly higher growth than untreated stands (4.2 t C/ac), for a total decrease in live stocks of 11.1 t C/ac over a 60 year period relative to no treatment.

In the event of a wildfire in year zero, the treated stands contain 16.2 t C/ac less than the untreated stands (difference between columns 3 and 4 in Table 4). Over 60 years, carbon stocks in both treated and untreated stands decreased, but the decrease was somewhat less for treated stands. There was a total decrease in live stocks for treated stands of 6.8 t C/ac relative to untreated stands after 60 years.

[6] The 20-foot windspeed required to cause an active crown fire.

Table 4. Modeled total stand carbon pre and post treatment and with and without fire on the Bull Stewardship project. Modeling conducted using the Fuels and Fire Extension of FVS. Data in metric tons of carbon per acre

Year	Untreated, no fire (1)	Treated, no fire (2)	Untreated, wildfire (3)	Treated, wildfire (4)
0	81.6	66.3	69.7	53.5
10	84.9	66.3	60.0	46.5
20	86.1	68.7	52.2	41.6
30	86.6	70.5	47.5	38.4
40	86.6	72.6	44.5	36.4
50	86.5	74.3	42.3	35.1
60	86.5	75.4	40.9	34.1
Total change	*4.9*	*9.1*	*-28.8*	*-19.4*
Total % change	*106%*	*114%*	*59%*	*64%*

FVS growth modeling (Table 5) indicates that after 60 years in the absence of wildfire, treated stands continue to have fewer trees per acre, a lower basal area, lower quadratic mean diameter[7] (QMD), and fewer cubic feet and board feet than untreated stands. However treated stands with wildfire have proportionally more and larger trees, higher basal area, and more merchantable timber than the original stand after 60 yr.

Table 5. Projected Growth on Bull Stewardship project, modeled in FVS

	Untreated			Treated		
	Year 0	Year 60 – no fire	Year 60 - wildfire	0	Year 60 – no fire	Year 60 – wildfire
Trees per acre	271	90	31	145	87	23
Basal area	214	200	63	143	176	53
QMD	12.1	20.2	19.3	13.4	19.3	20.6
Cubic feet	5,915	6,106	1,833	4,304	5,415	1,595
Board feet	28,406	31,462	8,861	22,116	28,047	8,284

However, the rate of change (Table 6) is greater in the treated stands for all measurements except QMD. This indicates that while the treated stands did not catch up to the untreated stands in absolute numbers, they had a lower mortality rate and a higher per tree growth rate overall. In addition, the trees remaining in the treated stands remained larger, on average, than those in the untreated stands.

[7] The diameter corresponding to the mean basal area of a stand.

In the event of a wildfire, treated stands have fewer trees per acre, and lower basal area, cubic feet and board feet after 60 years, but they have a higher rate of change in all categories except QMD than do untreated stands.

Table 6 Percent change after 60 years of growth on Bull Stewardship project

	Untreated		Treated	
	No fire	Wildfire	No fire	Wildfire
Trees per acre	33%	11%	60%	16%
Basal area	93%	29%	123%	37%
QMD	167%	160%	144%	154%
Cubic feet	104%	31%	126%	37%
Board feet	111%	31%	127%	37%

3.1.5 Net GHG emissions/sequestration

Including carbon stored in long term wood products and emissions from pile burning, for treated stands without wildfire, a total of 71.6 tons of carbon per acre are sequestered with 58.8 t C/ac still sequestered in the same stands following a wildfire. Figure 5 shows the tons of carbon per acre sequestered on Bull Stewardship in each of the four scenarios, the total carbon stored following treatment when wood products and biomass energy are included, and the percent change from untreated to treated and unburned to burned lands.

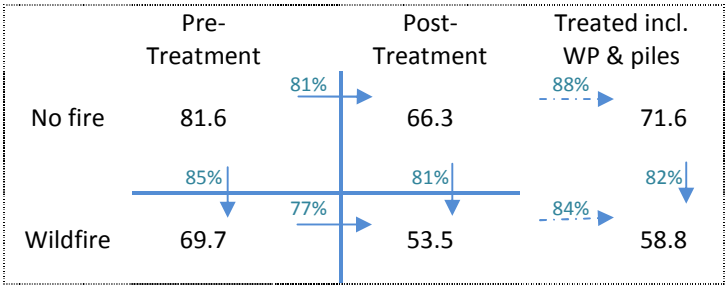

Figure 5: Tons of carbon per acre stored on Bull Stewardship project lands in each scenario, and including carbon stored in wood products and emissions from pile burning. Percentages show change from untreated lands to treated or from unburned to burned. WP = storage in long term wood products

Incorporating the risk of fire of 0.6%, and utilizing the equation described above for net emissions or sequestration (section 2.8), [(Ct+Cw +Ce-Cb)*(1-risk)]+[(Ctf+Cw+Ce-Cbf)*(risk)], the fuels treatment on the Bull Stewardship project resulted in an effective immediate net emissions of 36.7 t CO_2-e/ac (10.0 tons of carbon per acre).

In the absence of a wildfire, the fuels treatments and commercial harvest result in short term emissions of 59.4 t CO_2/ac and emissions of 36.5 t CO_2/ac over 60 years (table 7).

Table 7: Net short and long term emissions from fuels treatment, without fire, on Bull Stewardship in tons of carbon dioxide per acre (+ = removals; - = emission)

	Short term 10 years	Long term 60 years
Harvested timber	**17.2**	**12.6**
Treatment emissions	**-68.2**	**-40.7**
Pile burning emissions (CO_2e)	**-8.4**	**-8.4**
NET	**-59.4**	**-36.5**

For the treatment to yield benefits to the atmosphere, the emissions from treatments will need to be offset by reductions in emissions from a potential wildfire hitting the area. In order for the treatment to have an impact, such a fire would have to occur before fuels have returned to hazardous conditions, at which point it will be necessary to re-treat the forest. According to the FVS-modeled results, if a wildfire were to occur in the year of treatment, after 10 years the net emissions from treatment would be 40.7 t CO_2/ac. Therefore, the treatment leads to net emissions with or without fire, but total emissions are somewhat lower in the event of a wildfire.

3.2 Collins – Hot Rocks

3.2.1 Field results

Prior to treatment, the Collins-Hot Rocks project had 54.9 tons of carbon per acre across all pools. Following the treatment, the average carbon stock was 35.0 t C/ac. Treatment therefore resulted in a decrease in carbon stocks of 19.9 tons per acre, 36% of pretreatment stocks. The breakdown by pool is shown in Table 8 and the confidence limits at a 90% confidence interval for the aboveground live carbon pool are shown in Table 8a.

Table 8: Collins-Hot Rocks carbon stocks (metric t C/ac) before and after fuels treatments

Carbon pool	Pre-treatment	Post-treatment	Difference
Trees	35.4	13.9	*-21.5*
Roots	9.8	4.0	*-5.8*
TOTAL TREES	45.2	17.9	*-27.3*
Standing dead	1.1	0.5	*-0.6*
Down dead wood	3.2	12.1	*8.9*
TOTAL DEAD WOOD	4.3	12.6	*8.3*
Forest Floor	4.9	4.1	*0.5*
Shrubs/herbaceous	0.5	0.5	*0.0*
TOTAL	54.9	35.0	*-19.9*

Table 8a. Upper and lower confidence limits at 90% CI for Collins-Hot Rocks aboveground live carbon stocks (metric t C/ac) before and after fuels treatments

Aboveground live carbon	Pre-treatment	Post-treatment
LCL	27.4	10.9
mean	35.4	13.9
UCL	43.4	17.0
CI as a % of mean	22.6 %	22.1 %

3.2.2 Potential fire emissions

Using FCCS-created fuel beds, a wildfire in the untreated stands would yield 26.8 tons of CO_2 per acre of emissions, while a wildfire in the treated stands would yield 48.6 t CO_2/ac (Table 9). Using the FVS Fire and Fuels Extension, a wildfire in the untreated stands would yield 28.6 t CO_2/ac of emissions, while a wildfire in the treated stands would yield 33.1 t CO_2/ac (Table 10).

The potential flame length and rate of spread are substantially greater following the treatment that it is before treatment. The crown fire potential however is lower in the treated stands. This may indicate that the treatment increased deadwood, leading to a low and fast-moving fire, but reduced the potential for the fire to reach the crown.

Table 9: FCCS fire modeling results for Collins-Hot Rocks

	Prescribed Fire		Wildfire	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Flame Length (ft)	2.0	3.6	4.5	8.5
Crown Fire Potential (scaled index 0-9)	3.3	2.1	4.0	3.2
Rate of Spread (ft/min)	3.1	4.8	13.3	24.0
CO_2 emissions (t/ac)				
Canopy	-3.5	-2.6	-10.8	-7.7
Dead Wood	-10.5	-30.4	-13.0	-38.5
Litter	-2.4	-1.3	-2.8	-1.7
Total	-16.4	-34.3	-26.6	-47.9

Table 10: FVS fire modeling results for Collins-Hot Rocks

	Wildfire	
	Pre-treatment	Post-treatment
Flame Length (ft)	3.8	8.2
Crowning index (miles/hr)[8]	11.6	20.6
CO_2 emissions (t/ac)	-28.6	-33.1
Total stand carbon remaining	46.7	26.0

[8] The 20-foot windspeed required to cause an active crown fire.

3.2.3 Timber and biomass

The harvest on Hot Rocks yielded 8.7 mbf/ac[9]. According to the conversion factor in Smith et al. (2006), this equals 3.9 t C/ac. Based on carbon disposition rates, a total of 2.4 t C/ac will remain stored in either long-term wood products or landfill after 10 years; 1.7 t C/ac will remain stored in either long-term wood products or landfill after 60 years; and 1.6 t C/ac will remain stored in either long-term wood products or landfill after 100 years.

Subtracting the removed sawtimber (3.9 t C/ac) from the total carbon removed in treatment (19.9 t C/ac), the remaining piled biomass represents 16.0 t C/ac or 32.0 tons of biomass per acre. This yields the following emissions (as described in section 2.7):

CH_4: 32.0 t burned * 0.21 t CO_2-e/t burned = 6.7 t CO_2e/ac

NO_x: 32.0 t burned * 0.34 t Co_2-e/t burned = 10.9 t CO_2e/ac.

The total CH_4 and NO_x emissions from pile burning are 17.6 t CO_2e/ac.

3.2.4 Growth modeling

Based on FVS modeling (Table 11), in the absence of fire, the treatment resulted in an initial decrease in carbon stocks of 19.9 t C/ac (compare columns 1 and 2), and a reduced increase in carbon stocks of 8.7 t C/ac after 60 years, for a total decrease in live stocks of 28.6 t C/ac over a 60 year period relative to no treatment.

In the event of a wildfire in year zero, the treated stands contain 20.7 t C/ac less than the untreated stands (difference between columns 3 and 4). Over 60 years, carbon stocks in both treated and untreated stands decreased, but the decrease was slightly less for treated stands. There was a total decrease in live stocks for treated stands of 17.9 t C/ac relative to untreated stands after 60 years.

Table 11: Modeled total stand carbon pre and post treatment and with and without fire on the Collins-Hot Rocks project. Modeling used the Fuels and Fire Extension of FVS. Results in metric tons of carbon per acre

Year	Untreated, no fire (1)	Treated, no fire (2)	Untreated, wildfire (3)	Treated, wildfire (4)
0	54.9	35.0	46.7	26.0
10	61.7	33.9	39.9	20.9
20	69.0	37.3	36.0	18.6
30	73.4	41.3	34.6	17.8
40	76.8	45.6	34.6	17.8
50	79.5	49.5	35.6	18.4
60	81.8	53.2	37.1	19.2
Total change	*26.9*	*18.2*	*-9.6*	*-6.8*
Total % change	*149%*	*152%*	*79%*	*74%*

[9] Harvest data was reported in cubic feet by the Forest Service for the Bull Stewardship project and in board feet by the Collins Company for the Hot Rocks project.

FVS growth modeling (Table 12) indicates that after 60 years in the absence of wildfire, treated stands continue to have fewer trees per acre, lower basal area, and fewer cubic feet and board feet than untreated stands while the QMD is greater in the treated stands.

Table 12 Projected Growth on Collins-Hot Rocks project, modeled in FVS

	Untreated			Treated		
	Year 0	Year 60 – no fire	Year 60 - wildfire	0	Year 60 – no fire	Year 60 – wildfire
Trees per acre	480	156	70	159	119	30
Basal area	198	210	87	77	158	43
QMD	8.7	15.7	15.1	9.4	15.6	16.2
Cubic feet	4,215	6,149	2,349	1,567	4,341	1,139
Board feet	13,887	28,639	10,139	5,168	19,151	5,135

However, the rate of change (Table 13) is greater in the treated stands for all measurements except QMD. This indicates that while the treated stands did not catch up to the untreated stands in absolute numbers, they had a lower mortality rate and a higher per tree growth rate overall. In addition, the trees remaining in the treated stands remained larger, on average, than those in the untreated stands.

Table 13 Percent change after 60 years of growth on Collins-Hot Rocks project

	Untreated		Treated	
	No fire	Wildfire	No fire	Wildfire
Trees per acre	33%	15%	75%	19%
Basal area	106%	44%	205%	56%
QMD	180%	174%	166%	172%
Cubic feet	146%	56%	277%	73%
Board feet	206%	73%	371%	99%

In the event of a wildfire, treated stands have fewer trees per acre, and lower basal area, cubic feet and board feet after 60 years, but they have a higher rate of change in all categories except QMD than do untreated stands.

3.2.5 Net GHG emissions/sequestration

Including carbon stored in long term wood products and emissions from pile burning, for treated stands without wildfire, a total of 34.1 tons of carbon per acre are sequestered with 25.1 t C/ac still sequestered in the same stands following a wildfire. Figure 6 shows the tons of carbon per acre sequestered on Bull Stewardship in each of the four scenarios, the total carbon stored following treatment when wood products and biomass energy are included, and the percent change from untreated to treated and unburned to burned lands.

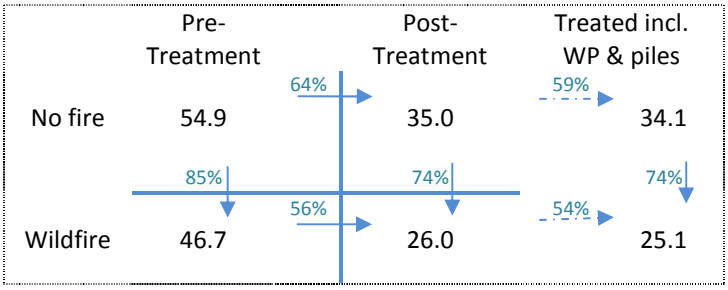

Figure 6: Tons of carbon per acre stored on Collins-Hot Rocks lands in each scenario, and including carbon stored in wood products and emissions from pile burning. Percentages show change from untreated lands to treated or from unburned to burned. WP = storage in long term wood products

Incorporating the risk of fire of 0.6%, and utilizing the equation described above for net emissions or sequestration (section 2.8), [(Ct+Cw +Ce-Cb)*(1-risk)]+[(Ctf+Cw+Ce-Cbf)*(risk)], the fuels treatment on the Collins-Hot Rocks project resulted in an effective immediate net carbon emission of 76.3 t CO_2-e/ac (20.8 tons of carbon per acre).

In the absence of a wildfire, the fuels treatments and commercial harvest result in short term emissions of 111 t CO_2/ac and emissions of 116 t CO_2/ac over 60 years (table 14).

Table 14: Net short and long term emissions from fuels treatment without fire on Collins-Hot Rocks in tons of carbon dioxide per acre (+ = removals; - = emission)

	Short term 10 years	Long term 60 years
Harvested timber	**8.8**	**6.2**
Treatment emissions	**-101.9**	**-104.9**
Pile burning emissions (CO_2e)	**-17.6**	**-17.6**
NET	**-110.7**	**-116.3**

For the treatment to yield benefits to the atmosphere, the emissions from treatments will need to be offset by reductions in emissions from a potential wildfire hitting the area. In order for the treatment to have an impact, such a fire would have to occur before fuels have returned to hazardous conditions, at which point it will be necessary to retreat the forest. According to the FVS-modeled results, if a wildfire were to occur in the year of treatment, after 10 years the net emissions from treatment would be 81.1 t

CO_2/ac. Therefore, the treatment leads to net emissions with or without fire, but total emissions are lower in the event of a wildfire.

4.0 Related efforts

4.1.1 Lakeview Stewardship Group

The Lakeview Stewardship Group was formed in 1998-99, involving LCRI, the Collins Companies, Concerned Friends of the Fremont/Winema, Defenders of Wildlife, USDA Forest Service Fremont-Winema National Forest, Lake County Chamber of Commerce, Lakeview High School, Lakeview Ranger District, Oregon Department of Economic and Community Development, Paisley Ranger District, Sustainable Northwest, The Threshold Foundation, The Wilderness Society, and local citizens. These partners have been engaged in a long-term, consensus-based effort to articulate a strategy for sustainable forest management of the 495,000-acre Lakeview Federal Stewardship Unit (LFSU) in the Fremont-Winema National Forest. In the context of dramatically reduced timber harvest offerings, mill closures, economic decline and sometimes acrimonious industry vs. environment debates, the LSG has been working to develop collaborative management goals balancing the full range of economic, social and ecosystem values provided by the forest. A key output of this process was the 2005 Long-Range Strategy for the Lakeview Federal Stewardship Unit (Lakeview Stewardship Group 2005; see http://www.lcri.org/unit/longrange.htm) and the revised 2010 Long-range Strategy for the Lakeview Federal Stewardship Unit (see Annex B).

The LFSU long-term objectives are to "sustain and restore a healthy, diverse, and resilient forest ecosystem that can accommodate human and natural disturbances; sustain and restore the land's capacity to absorb, store, and distribute quality water; and provide opportunities for people to realize their material, spiritual, and recreational values and relationships with the forest." Integral to sustaining and restoring a healthy, diverse, and resilient forest ecosystem that can accommodate human and natural disturbances is the effort to improve management of wildfire on National Forest lands. Partners have focused on reaching agreement and developing new tools to reduce hazardous fuel loading and improve forest health. In relation to WESTCARB goals, the most important of these tools are: stewardship contracts, Memoranda of Understanding and other mechanisms for long-term biomass supply as the basis for investments in new capacity; installing new biomass energy and small log processing facilities in Lakeview, to promote cost-effective utilization of the full range of material removed from the forest to meet stewardship and fuel reduction goals; and exploring new ways to manage forest carbon, including developing the science and policy basis for transacting carbon credits from fuel reduction.

LSG efforts have recently borne fruit in six important developments, summarized below.

4.1.2 Twenty-year biomass supply MOU

After lengthy negotiations, a 20-year Interagency Biomass Supply MOU was signed on November 1, 2007. The parties to the MOU include Lake County Resources Initiative, Lake County, Town of Lakeview, City of Paisley, DG Energy LLC, DG Investors LLC, The Collins Companies, Oregon Department of Forestry, USDA Forest Service Fremont-Winema National Forest, and Bureau of Land Management- Lakeview District. The purpose of the MOU is to provide a framework for planning and implementing forest and rangeland restoration and fuels reduction projects that address identified resource needs while being supportive of the Lakeview Biomass Project. In the MOU, each of the parties offers specific

commitments relevant to fire risk reduction, forest health, biomass energy and a sustainable forest industry in the region. For the Forest Service, these include exploring new long-term supply mechanisms and offering at least 3,000 treatment acres per year within and another 3,000 acres per year outside the Lakeview Federal Stewardship Unit. BLM meanwhile commits to offer 2,000 treatment acres per year District-wide. LCRI's commitments include providing local coordination between the Collins Companies, Jeld-Wen and Forest Service on the WESTCARB project, with the goal of establishing a financing system for reducing uncharacteristically large fire events and provide additional revenues for restoration activities, and working with Iberdrola Renewables to support construction of an appropriately sized (25 MW) biomass plant in Lake County. The Oregon Department of Forestry's commitments include using SB1072 authorities to facilitate 10-year stewardship contracts, developing a cooperative state-wide MOU among state agencies, Forest Service and BLM bringing together elements of existing state programs under Energy, Economic and Community Development, Fish and Wildlife, and Forestry, and supporting the work of federal agencies to develop stewardship contracts and promote bioenergy.

The MOU was reviewed by Forest Service and BLM legal counsel and is in effect. The MOU signing was November 1, 2007, at a ceremony in Lakeview for the launch of the biomass plant and small-log sawmill. Undersecretary of Agriculture Mark Rey was in attendance along with many State dignitaries including two national environment group and two regional environmental groups. The text of the 20-year Interagency Biomass Supply MOU is included in Annex C.

4.1.3 Ten-year stewardship contract

The efforts of LCRI and its Lake County partners have resulted in a commitment to the first 10-year Stewardship Contract in the US Forest Service Pacific Northwest Region. The contract, considered a model for the region, provides long-term supply of material necessary for the recent investments in a biomass power plant and small log mill described below. The 10-year stewardship contract awarded to the Collins Companies on July 22, 2008 guarantees 3,000 acres of treatment per year and a total of $100,000 of work over the 10-year period. Specific treatment prescriptions are planned on a two year cycle. The MOU states in addition to the 10-year stewardship contract in the Unit there will be two additional 10-year contracts, one on Forest Service lands outside the Unit and one on BLM lands. There contracts have not been pursued because of the current economic downturn.

4.1.4 Biomass Power Plant

Oregon Governor Kulongoski's office and biomass plant developer DG Energy jointly announced in January 2007 that DG Energy will construct a 13 MW biomass plant in Lakeview. This represented the culmination of multi-year efforts by all the partners in the Lakeview Stewardship Group to reach agreement around sustainable harvest levels and long-term biomass supply mechanisms necessary for investment in new capacity. In their initial efforts to locate a biomass plant in Lake County, LCRI received volume estimates for slash piles that ranged from 1 to 11 bone dry tons (BDT). It is impossible to appropriately size a biomass plant with this range. Using what information was available and a Coordinated Resource Offering Protocol by Mater Engineering it was decided it could sustain a 15 MW biomass plant. Since collecting all the data from the stewardship contracts and other significant information from private lands it has been determined that a 25 MW biomass plant is sustainable.

Marubeni Sustainable Energy subsequently bought the development rights from DG Energy in 2007. In 2009 Iberdrola Renewables purchased the development rights from Marubeni. As a result of new supply information the plant size has gone from a net 13MW to a net 24.9 MW and the investment went from $20 million to over $70 million. Currently the project is scheduled for a final decision on

construction this summer 2010 and breaking ground in September 2010 with an estimated completion date of December 2012. The project is designed to use biomass from overstocked forests, helping to reduce wildfires, improve forest health and create jobs. The Lakeview Biomass Project was designated an "Oregon Solutions" initiative by Governor Kulongoski, resulting in a collaborative process involving federal and state agencies, industry, and non-profit organizations to build consensus for the project and secure a sustainable supply of biomass.

The Governor's press release is at http://governor.oregon.gov/Gov/P2007/press_011007b.shtml and is included in Annex D. The Oregon Solutions Declaration of Cooperation is included in Annex E and a 2010 support letter from the Governor is in Annex F.

4.1.5 New small log mill in Lakeview

Oregon Governor Kulongoski in March 2007 announced that the Collins Companies will expand their Fremont Sawmill operation in Lakeview by building a new $6.8 million dollar small log mill. The small log mill is the direct result of the 20-year Interagency Biomass Supply MOU and 10-year Stewardship Contract efforts spearheaded by LCRI, and provides an added tool for improving management of forests and hazardous fuels in Lake County. The combination of the existing Fremont Sawmill for processing larger logs, the new small-diameter log mill, and the new biomass energy plant will provide the tools necessary for cost-effective utilization of the full range of material removed from the forest to meet stewardship, forest health restoration, and wildfire risk reduction objectives. The biomass plant and small log mill, the result of an "Oregon Solutions" initiative involving nearly 70 public, private and community organizations, represent two sides of "an integrated solution to effective management of forest health and reducing fire danger in the Fremont National Forest. Both the biomass facility and the small log mill serve as models for collaboration between industry, conservationists and state government in enhancing forest health, developing renewable energy and creating jobs" (Governor Kulongoski's press release, March 7, 2007). The full text of the press release is included in **Annex D**.

A November 1, 2007 ceremony in Lakeview served as the ribbon-cutting for the new small-diameter sawmill and initial kickoff for the biomass energy plant, as well as the signing ceremony for the 20-year biomass supply MOU and announcement of the first 10-year stewardship contract offer by the Forest Service - Pacific Northwest Region.

In addition to the ecological outcomes, the economic outcomes are significant for a rural community. The sawmill and biomass plants are making an $80 million dollar investment in a county that is 78% public ownership. These investments have resulted in retaining 85 sawmill jobs, and will create 18 jobs at the biomass plant and 50-75 jobs in the woods. An Oregon Business 2010 report estimates these investments will have an annual payroll of over $18 million and will pay over $1 million/year in income tax to the State of Oregon (see attached Business Oregon report, Annex G). South Central Oregon Economic Development District estimates that local taxing districts such as the Town of Lakeview, Lake County, Library, Hospital, cemetery, school district, etc. will receive an estimated $1.8 million yearly in taxes. Oregon has established what is called Empowerment Zones and companies locating in these zones can get up to 15 years property tax abatement. The Lakeview Biomass plant is in an Empowerment Zone where they will be paying a substantially less Community Service Fee in lieu of property tax for 15 years. The Biomass Impact

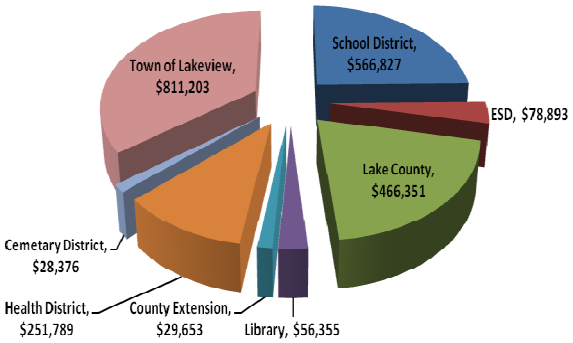

Figure 7: Distribution of increased tax revenue resulting from biomass facility in year 16 and beyond

to Taxing Districts graph (figure 7) is based on estimated taxes in year 16 and beyond.

4.1.6 Influence on hazardous fuels management

Considerable changes have occurred on Fremont-Winema National Forest since the beginning of this project in 2006. The original Forest Service prescriptions for Bull Stewardship, Burnt Willow and Kava were much lighter treatments than treatments currently being implemented by the Forest Service. In designing these projects, the Forest Service was cautious on their prescriptions as they were concerned about possible lawsuits. When the Lakeview Stewardship Group reviewed the completed treatments in these early stewardship projects they informed the Forest Service that treatments need to be heavier in order to reduce fuel loads enough to influence fire behavior and restore natural fire to the landscape. In addition, the Collins Companies invested in a new small diameter sawmill that took merchantable material from a 9" DBH to a 7" DDH, resulting in an increase in the volume of sawlogs taken off the forest. Another significant change that occurred during the project was the collapse of the economy in 2008 with lumber prices being so low that all sawmills were losing money. Because logging contractors can request an extension to carry out a prescription, this delayed the work until a time when the market returns to more favorable conditions.

The 20-year MOU and the Lakeview Stewardships Group's *2005 Long-range Strategy for the Lakeview Federal Stewardship Unit* was significant enough that The Collins Companies invested $6.8 million in a new sawmill rather than closing down the sawmill. The other significant changes during this time were that the Lakeview Stewardship Group informed the Forest Service they wanted the Forest Service to concentrate on commercial logging operations, and eliminate fire salvage logging. The sawmills viability hinged on getting approximately 20MBF off the Lakeview Federal Stewardship Unit. As a result of the 10-year Stewardship Contract Collins was awarded in 2008, the goal of 20 MBF was exceeded as shown in Figure 8. World market conditions have reduced the amount since 2008, and it will likely climb again with better market return. One of the critical outcomes is that the infrastructure is in place to restore the Forest Service lands to healthy conditions that will be able to adapt to climate change.

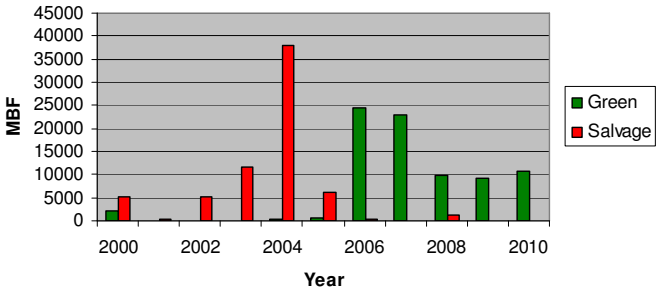

Figure 8: Board feet harvested in Lake County between 2000 and 2010 through either salvage logging or green harvests

4.1.7 Collaborative Forest Landscape Restoration Program (CFLRP)

The National office of the Forest Service announced in February 2010 that they are accepting proposals for the Collaborative Forest Landscape Restoration Program (CFLRP). Projects must be collaborative in nature, address at least a 30,000 acre landscape, and and include a strategic plan. The CFLRP stated that

up to 10 projects could be chosen this fiscal year and no more than two from any one region would be funded. Region 6 sent in 5 proposals with the Lakeview Stewardship Group Fremont-Winema proposal being the number 1 priority. Over 10 years this could mean an additional 20 million dollars above regular appropriations for fuels management and restoration in the 500,000 acre Lakeview Federal Stewardship Unit. As part of the CFLRP proposal the Lakeview Stewardship group revised their 2005 Long-range Strategy for the Lakeview Federal Stewardship Unit, see Annex H. Final CFLRP awardees will be notified by late summer.

5.0 Conclusions and Recommendations

In both projects, the treatments resulted in significant net carbon emissions[10]. This result clearly has implications for the future potential of fuels treatments as a carbon projects offset category.

The reasons for the net emission from hazardous fuel reductions are multiple. In the case of the Collins-Hot Rocks project, deadwood stocks increased following the treatment. This may be due to an increase in the amount of limbs and branches left following the treatment. Because the projects included sawtimber removal, the live standing carbon removed was substantial. However, due to milling inefficiencies and the retirement of wood products over time, only a fraction of the carbon removed as sawtimber is stored in wood products over the long term. Had it been possible to utilize biomass for energy production, some of the emissions may have been offset, but there would still be net emissions as a result of treatment. As it was, the piling and burning of biomass further contributed to overall emissions.

While the Bull Stewardship treatment led to a slight decrease in fire intensity, the Collin-Hot Rocks treatment led to an increase in fire intensity, and both led to an increase in potential emissions from a fire. Both treatments led to a substantial increase in large woody fuel loads and subsequent biomass consumption. If the woody fuels that resulted from the treatments been removed from the site, there likely would have been a decrease both in surface fire behavior and potential carbon release. Both treatments produced an apparent decrease in crown fire potential from future fires, which reduces the severity and size of wildfires, and improves the ability to control a fire.

The rate of growth increased slightly following the treatments, but in the absence of a wildfire, total carbon stocks in the treated areas still had not surpassed those in untreated areas after 60 years. Following a wildfire, carbon stocks continued to decline for both the treated and the untreated stands.

Within the treated areas, both projects had significant net emissions when considering treatment and the risk of a potential wildfire. If a fire were to occur in the year of treatment, all projects would still experience net emissions, though the impact of treatment emissions would be slightly reduced.

One critical factor not addressed in this study is the impact of fuels treatment on fire intensity and emissions outside the treated area itself. In many cases, the reduced intensity of fire in a treated area decreases the intensity of fire in the surrounding untreated areas, increasing the beneficial aspects of the treatment without removing additional biomass. This is often referred to as a fire shadow. The size of a fire shadow along with the level of reduced emissions varies based on a number of factors, including topography, location of treatment, climatic conditions, and fire intensity. Incorporating the fire shadow

[10] A complete accounting of emissions would have also incorporated equipment use. Though this project did not address equipment emissions, a similar project in Shasta County found emissions ranging from 0.8 to 1.8 tons CO_2/ac. While this is not an insignificant amount, it is a small fraction of the emissions which result from the removal of biomass from the forest.

in the overall emission calculations would decrease the net emissions in most cases, but given the extent of emissions for both projects, it is likely that inclusion of a fire shadow would yield lower emissions but significant emissions would still result from treatment.

Both pilots led to a decrease in crown fire potential, which decreases fire severity and size. While treatments lead to net carbon emissions in both the short and long term in both projects, there are, of course, additional benefits to fuels treatments, such as increased ability to successfully fight fires and decreased cost of fire fighting; reduced loss of life and property; and reduced potential damage to wildlife habitat.

These results are mirrored well in the results from the Alder Springs treatment in Mendocino National Forest conducted under funding from the US Forest Service. In Alder Springs, net emissions of 26.3 tons of carbon dioxide per acre were recorded immediately after treatment climbing to a total of 86.9 t CO_2-e/ac after 60 years.

The results from this study in combination with the paired study in Shasta County and the allied study in Mendocino National Forest underline the unsuitability of fuels treatment as a potential greenhouse gas offset generating activity. Instead we argue the shift should be made to policies minimizing greenhouse gas emissions from wildfires and from fuel treatments while minimizing wildfire risks to lives, homes and livelihoods in the WESTCARB region.

5.1 Benefits to California

The research questions being explored in Lake County, and the validation and demonstration of new climate change mitigation opportunities, are equally relevant to California's public and private forests. Debates around managing the multiple economic, social and ecosystem benefits of the State's forests, and the need for creative and aggressive approaches to managing catastrophic wildfire at California's wildland-urban interface, have risen to prominence in the media and public consciousness. Moreover wildfire conditions are projected to worsen with global warming (California Energy Commission 2006), making new strategies for managing the fire-prone forests an important climate adaptation as well as climate mitigation opportunity.

Results from the Lake County, Oregon and Shasta County, California[11] hazardous fuel reduction pilot activities indicate that hazardous fuels treatments do not represent potential carbon offset projects. A third WESTCARB report[12] discusses in more depth the reasons such projects do not lead to offsets and addresses shortcomings of similar research that has indicated otherwise.

Regardless of these findings, wildfire poses a significant threat to ecosystems, property, and people, and fighting wildfire represents a large investment of resources. Carefully planned and properly implemented hazardous fuels treatments are a critical means of ensuring the safety of nearby communities and the health of forests. In addition, fuels treatments can lead to increased timber

[11] Goslee, K., T. Pearson, S. Grimland, S. Petrova, and S. Brown. 2010. *Final Report on WESTCARB Fuels Management Pilot Activities in Shasta County, California.* California Energy Commission, PIER. CEC-500-XXXX-XXX.

[12] Pearson, T., K. Goslee, and S. Brown. 2010. *Emissions and Potential Emission Reductions from Hazardous Fuel Treatments in the WESTCARB Region.* California Energy Commission, PIER. CEC-500-XXXX-XXX.

production and reduced costs of fighting fires. While there may not be an opportunity to reduce wildfire emissions on a project by project basis, it is imperative that sound wildfire preventative strategies continue to be employed in California forests.

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Western Climate Initiative. August 22, 2007. Statement of Regional Goal.

Annex A: Standard Operating Procedures for Fuels Measurements in 2007

See separate attachment.

Annex B: 2010 Long-range Strategy for the Lakeview Federal Stewardship Unit

See separate attachment.

Annex C: 20-year Interagency Biomass Supply MOU

See separate attachment.

Annex D: Governor's press release on new biomass plant in Lakeview, OR

See separate attachment.

Annex E: Oregon Solutions Declaration of Cooperation

See separate attachment.

Annex F: Governor's Letter of Support for new biomass plant in Lakeview, OR

See separate attachment.

Annex G: 2010 Oregon Business report

See separate attachment.

Annex H: Lakeview Stewardship Group CFLRP proposal

See separate attachment.