Public Interest Energy Research (PIER) Program

FINAL PROJECT REPORT

EMISSIONS AND POTENTIAL EMISSION REDUCTIONS FROM HAZARDOUS FUEL TREATMENTS IN THE WESTCARB REGION

Prepared for: California Energy Commission

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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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Emissions and Potential Emission Reductions From Hazardous Fuel Treatments in the WESTCARB Region is the final report for the *WESTCARB Fuels Management Pilot Activities in Shasta County, California,* West Coast Regional Carbon Sequestration Partnership – Phase II project, Contract Number 500-02-004, Work Authorization number MR-045 conducted by Winrock International. 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 916-327-1551.

ABSTRACT

This report summarizes efforts by Winrock International and the West Coast Regional Carbon Sequestration Partnership Fire Panel to develop a methodology for estimating greenhouse gas benefits of project activities to reduce emissions from wildland fires in low- to mid-elevation mixed conifer forests. These efforts focused on low- to mid-elevation mixed conifer forests and included a conceptual framework to aid in determining the full impacts of hazardous fuels treatments. The framework was developed based upon four workshops with carbon and fire experts, numerous consultant activities, and field measurements of hazardous fuels treatments in Shasta County, California and Lake County, Oregon. The task of developing a rigorous methodology to quantify baseline emissions from wildland fires and emission reductions attributable to fuel reduction is complex. The methodological challenges of modeling wildland fire behavior and emissions, the relatively low annual risk of fire for any given potential project location, and the emissions resulting from fuels treatments complicate the development of the methodology. Given current hazardous fuel removal technologies and the low probability of fire on any given acre in any given year, hazardous fuel reduction treatments in the forest types addressed in this report cannot directly generate offsets. However, careful design of fuel treatments built from the methodology employed in this analysis can minimize risks to lives and property while minimizing emissions

Keywords: Carbon, sequestration, emission, forest, hazardous fuel reduction, California, wildland, fire, wildfire, greenhouse gas

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Report for the
West Coast Regional Carbon Sequestration Partnership
Phase II

Protocol for monitoring and estimating greenhouse gas benefits from hazardous fuels management in Western U.S. forests

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Overview

This paper introduces key concepts and provides an approach for developing baseline, measuring and monitoring methodologies as part of a protocol for estimating potential greenhouse gas benefits from improved fuel management programs in western U.S. forests. First, we outline what is needed and provide our preliminary approach and calculations. We then discuss the specific factors involved in our approach, and introduce several ***key questions and uncertainties*** that will guide discussions at the WESTCARB Fire Workshop (Redding, October 24-25, 2006).

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SECTION 1: General Approach

1.1 What is needed and why?

Our goal is to develop a **cost-effective, practical, transparent protocol** for estimating, to acceptable levels of accuracy and precision, the carbon benefits associated with improved management of hazardous fuels in forests susceptible to wildfires. We assume that fuels management activities would be executed by private or public landowners as specific “projects” that would occur over finite areas while remaining embedded in the larger surrounding landscape.

Developing protocols for project activities that are designed to **reduce or avoid emissions** of greenhouse gases present several major challenges, the main one being the baseline. The reason for this challenge is that the baselines for such projects, by their very nature, are projections into the future of what would happen, and generally what would happen in the future is based on what has happened in the past. For the project type presented here, there is potentially a greater challenge because of the very nature of fires—they are unpredictable. The key for developing the protocols is to recognize that the baseline will never be perfect, but that an agreed on methodology can be reached using the best science available.

Like some other types of forestry projects implemented for carbon credits, the development of a fuels management protocol will likely require the collection of project-specific data. Assumptions and default factors will be warranted in cases where collecting data is cost-prohibitive and/or the project is overly complex (such as for the development of the baseline methodology, outlined below). The use of default values is common practice under both national and international accounting guidelines, but it is essential that these assumptions remain both conservative and transparent.

Improved fuels management can reduce losses of carbon stocks from forest ecosystems; reduce the areal extent of burning; reduce fire severity; increase carbon sequestration in residual forest stands; and increase substitution of forest fuels for more carbon-intensive fossil fuels – all which lead to potential **greenhouse gas benefits**. These benefits are estimated as the difference in selected carbon pools between a “baseline” case and a “with project” case, with various fuel reduction treatments as project scenarios. Other greenhouse gases to consider in addition to carbon dioxide might include methane (CH_4) and nitrous oxide (N_2O).

For example, **Figure 1** illustrates how the carbon that would burn in a “business as usual” case (hatched box) might be diverted into a fuel reduction treatment plan (gray box) to reduce the severity of catastrophic wildfires and their associated carbon emissions. Removing hazardous fuel loads before they burn would lead to less intense fires and would thereby cause a larger unaffected vegetation pool. This pool would need to be managed continuously to prevent the excessive buildup of new fuels, but resources allocated towards suppressing fires could be re-directed towards preventing them through better forest management. Because fuels removed from forests could be transported to biomass energy plants and burned as alternative energy sources to fossil fuels, landowners could potentially generate two streams of revenue: dollars from selling carbon credits and dollars from selling biomass.

The focus of this protocol will be on elucidating the carbon benefits that arise from decreasing the extent of fires and the emissions from fires within project boundaries. Project emissions will include the emissions associated with fuel treatment including cutting, transporting and burning of fuels.

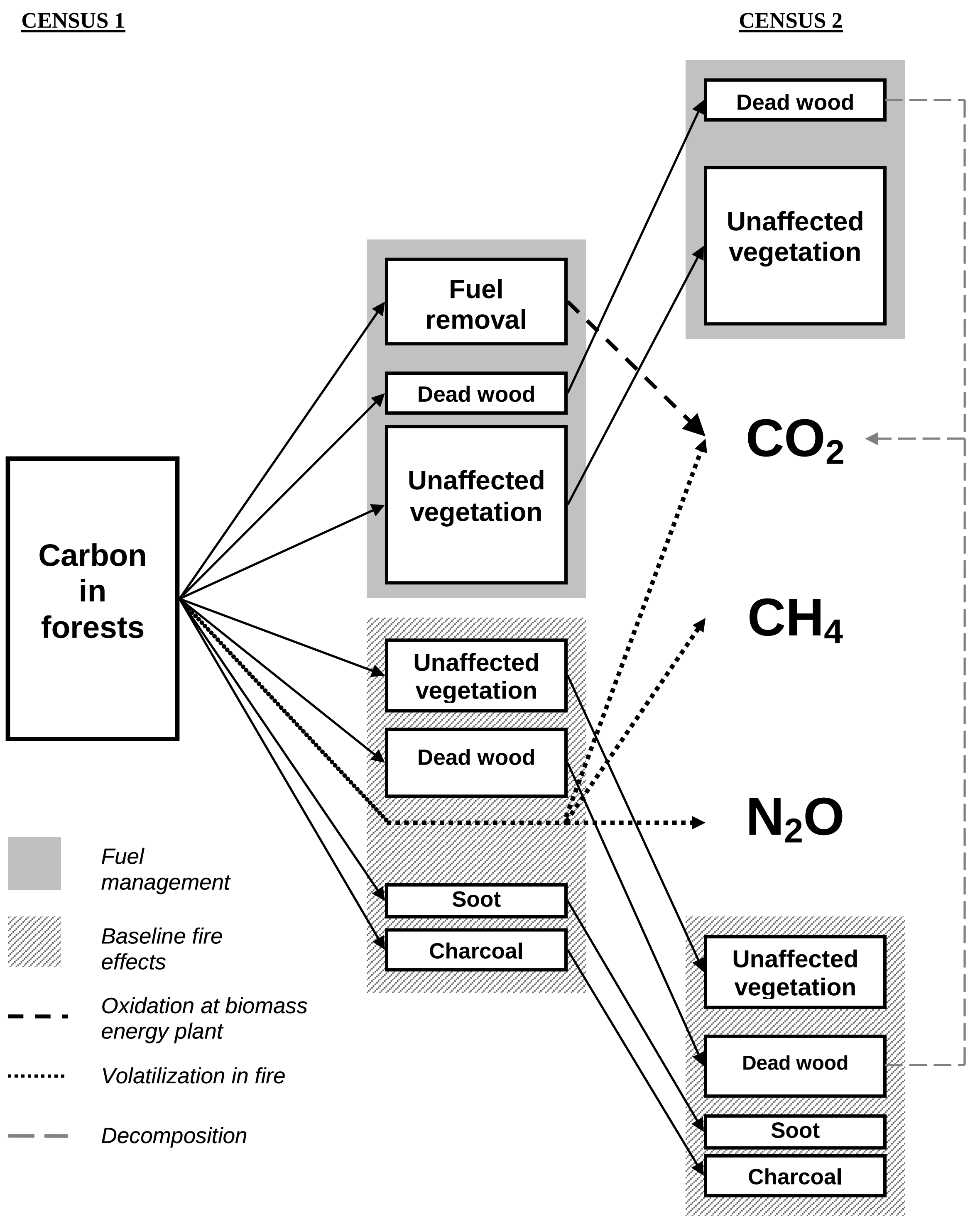

Figure 1. The fate of carbon in forests under baseline (no fuel management) and with-project (with fuel management) scenarios. The goal of a fuel management program would be to divert carbon that would ordinarily burn in a fire (hatched box) towards a program involving fuel removal (gray box). The fate of the fuels removed would depend on the specific treatment; this figure shows fuel removed and transported to a biomass energy plant. Such a management program would result in less intense, less severe fires and a larger pool of unaffected carbon.

1.2 Approach to calculations

Baselines are used as a reference case to estimate the emissions and removals of greenhouse gases attributed to changes in the use and management of land. Baseline scenarios are defined by projecting and quantifying the carbon emissions of a "business as usual" approach to forest management, i.e., the emissions that would occur if current management practices were to continue into the future. In this case, the baseline is related to the likelihood that a fire event would occur at any given location as well as the net carbon, as CO_2 (and potentially other non-CO_2 greenhouse gases such as methane and nitrous oxide), that would be emitted during a typical fire event. A carbon baseline has three components: (1) **a projection of the area** of the forest that burns over a given time frame**,** (2) the change in forest **carbon stocks and associated GHG emissions** resulting from the fire (e.g., Census 1 and Census 2 in Figure 1), and (3) the **pre-fire and post-fire rates of carbon accumulation** in the forest. Each of these can be addressed separately.

The **with-project case** is the net emissions of carbon resulting from project implementation. In the case of fuels management, projects would involve treatments that would reduce the quantity of hazardous fuels. The difference between this "with-project" value and the baseline value would then be calculated as the **carbon benefit** (Figure 2). Initially, net carbon emissions may increase temporarily as a result of project implementation, but these emissions would be offset by the treatment effect.

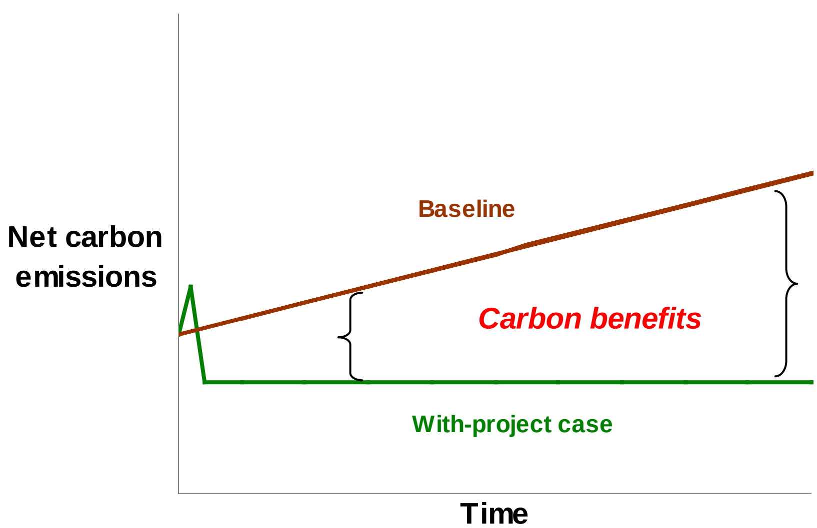

Figure 2. Hypothetical baseline emissions, with-project emissions, and the resulting carbon benefits from changes in management of the land.

1.2.1 Potential calculations

The carbon benefits of fuel reduction activities *could* be estimated as follows:

A. Baseline Emissions

1. Determine the project area (areas of treatment)
2. Stratify lands by age class and fuel load
3. Measure the fuel loads on project lands for each age class stratum

4. **4.** Estimate the mean forest carbon stock based on standard protocols procedures (existing within the CA Climate Action Registry [CCAR])
5. **5.** Obtain an estimate of the baseline area burned per year from "registry" tables (to be established specific to this methodology) for most recent past 10-yr period and assume fixed for future 10-yr period
6. **6.** For each stratum, solve the following equations, then add together for total baseline emissions:

$$BE = BE_{CO_2} + BE_{CH_4} + BE_{N_2 0} \pm BE_R$$

$$BE_{CO_2} = \sum_{1}^{n} A_n \times (C_n \times F_n) \times 3.67$$

where:

BE = Baseline emissions (t CO_2-e/ 10 yr)
BE_{CO2} = Baseline carbon dioxide emissions (t CO_2-e/ 10 yr)
BE_{CH4} = Baseline methane emissions (t CO_2-e/ 10 yr)
BE_{N2O} = Baseline nitrous oxide emissions (t CO_2-e/ 10 yr)
BR_R = Emissions/removals of carbon dioxide due to the differential pre- and post-fire effects on rates of carbon accumulation (t CO_2-e/ 10 yr)
A = Area burned =percent per year (ha/yr) x area of treated strata *n* x 10 years
C = Carbon stock in age class *n* (t C/ha)
F = fraction of initial carbon stocks lost to fire in age class *n* and fuel load *n* (from Table 3)

7. **7.** Repeat analysis every 10 years for duration of "project" (could extend for several decades) to reassess the rate of emissions as a result of new treatments, regulations, climate change scenarios, etc. – or just develop updated baselines if management conditions have remained unchanged.

B. Project Emissions

1. **1.** Track biomass of fuels removed from forest
2. **2.** Track any fires that occur during the project period on the project lands. Measure carbon stock in all pools immediately after any fire.
3. **3.** For each stratum, solve the following equation then add together for total project emissions.

$$PE = FE + FTE + EE \pm RE$$

where:

PE = Project carbon emissions (tCO_2-e)
FE = Emissions from any fires that occur on project lands (tCO_2-e)
FTE = Emissions that occur due to fuels treatment (tCO_2-e)
EE = Emissions that occur due to transport and/or combustion of fuels (tCO_2-e)
RE = Emissions/removals due to the differential pre- and post-treatment effects on rates of carbon accumulation (tCO_2-e)

C. Project Benefits

In any given year, project benefit is equal to average annual baseline emissions minus project emissions.

$$PB = BE - PE$$

where:
BE = Baseline carbon emissions (t CO_2-e)
PE = Project carbon emissions (tCO_2-e)

SECTION 2: Baseline

2.1 Background

The WESTCARB II project focuses on terrestrial sequestration pilot activities in two counties: Shasta County, CA, and Lake County, OR (to facilitate early protocol development Shasta County will initially be the sole focus). Although there are several different forest types in these counties, for initial protocol development we focus on the **mixed conifer forest type** (including ponderosa pine, mixed conifer, etc.[1]) found typically in large parts of southern Oregon and northern California. We selected this general forest type based on Schoennagel et al. (2004), who proposed that western forests at **low and mid-elevations** that historically had low to mixed severity fires are good candidates for fuel treatments to restore their historical stand structure and fire regimes.

Historically, the surface fuel layer of low-elevation, ponderosa pine forest were dry during the summer fire season that resulted in frequent and low-intensity surface fires. More recently, fire suppression activities have disturbed this historical fire regime and have resulted in a build-up of ladder fuels at intermediate heights that carry surface fires into the crown, where they can lead to large, catastrophic fires. Mixed-intensity fire regimes occur mostly at mid-elevations, in mixed conifer forest stands defined by a mixture of tree species and densities. The frequency, severity and size of fires in these forests are affected by fuel accumulation and climate, and the impact of suppression practices on fuel loads in these forests varies depending on the tree composition of the forest stand.

2.2 Estimation of area that would burn

The area component of the baseline is a projection into the future of the likely area that would burn in a fire. This raises two key issues:

What should be the spatial scale?
And what should be the temporal scale?

The **spatial scale** needs to be large enough to capture the trend, but not so large that it masks more localized trends caused by differences in state and county-level regulations that govern forest management practices, human demographics and infrastructure, boundaries related to policies, variation in climate and precise species composition. After looking at various scales, we decided to use the two California Department of Forestry **CA-FRAP** (California Fire and Resource Assessment Program) northern California analysis units: **Cascades Northeast** and

[1] The mixed conifer forest type contains the following WHR types: Sierran mixed conifer, Klamath mixed conifer, ponderosa pine, eastside pine and jeffrey pine.

North Coast. (Figure 3) We also stratified the forests by land ownership class (publicly and privately owned) to reflect differences in management practices, and suggest developing separate carbon baselines for public and private lands to account for these differences. We expect a similar approach could be used, with some modifications, for forests in the remainder of the WESTCARB region.

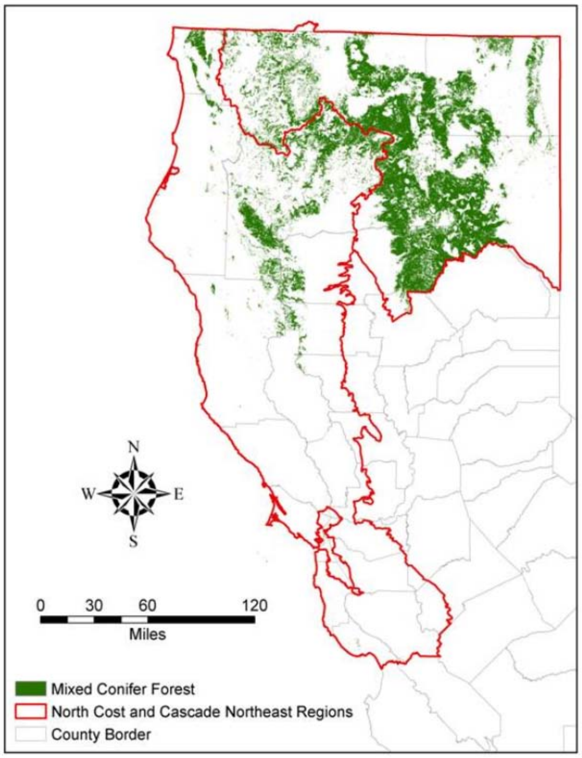

Figure 3. Distribution of mixed conifer forest across the North Coast and Cascades Northeast regions based on the California Land Cover Mapping & Monitoring Program

For the **temporal scale**, the question is: how far back in the historical record does one go to develop a trend for projecting into the future? How far into the future? In many respects, developing an estimate for the area component of the baseline is akin to developing baseline estimates of avoided tropical deforestation. After extensive investigation and model-testing, Brown et al. (2006) concluded that a reasonable and reliable estimate of the rate of deforestation could be obtained from change detection of remote sensing imagery over a recent **past period of about 10 years**. This 10-year rate is then expressed as an average percent of the forest remaining (area deforested over the about 10-year period divided by total area at the beginning of the period, expressed in percentage terms).

Future rates of deforestation, like fire, can be hard to project because they are subject to many factors. However, in the case of deforestation, a general consensus is developing that the rate of deforestation can be reliably projected about **10 years into the future**, with reassessments occurring every 10 years thereafter to adjust the baseline area component. We propose that these time periods could also be appropriate for fire baselines as this time frame is long enough to incorporate natural variations in forest dynamics among years, but also reflects the more recent forest management situation upon which other scenarios will be based.

Using the forest class map and fire data from CA-FRAP (California Fire and Resource Assessment Program), the area of mixed conifer class in the Cascades Northeast and North Coast counties is about 4.6 million acres, with the majority of this area as public land (2.7 million acres, or 58%) and 1.9 million acres (42%) as private land. The total area of forests that have burned in the last 10 and 20 years is 110,776 ac and 283,801 ac, respectively (Table 1, Fig. 4), with approximately 80% of this area burned on public lands in the last 10 years. It is clear from Fig. 4 that many large fires that occurred in this region were <u>not</u> located in the mixed conifer forest type.

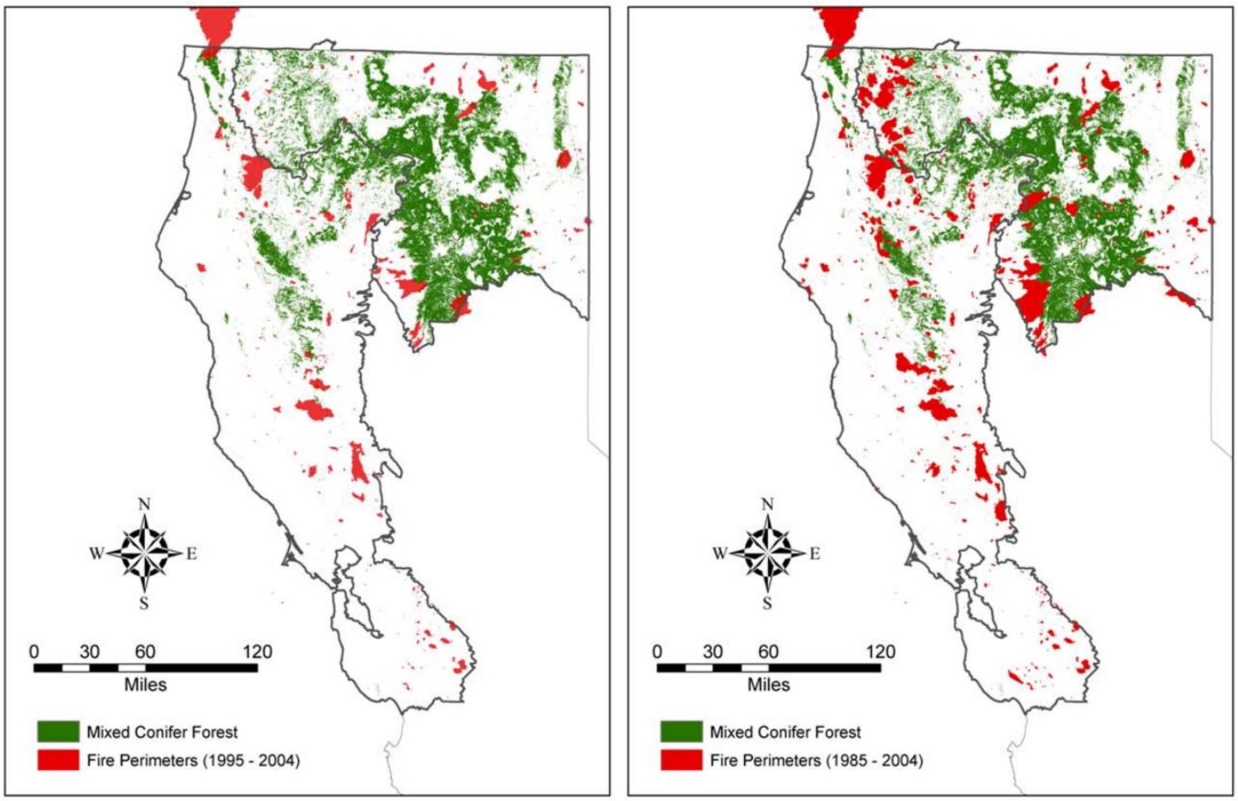

Figure 4. Distribution of mixed conifer forest and fire perimeters for 10-yr period (left) and for 20-yr period (right) across the North Coast and Cascades Northeast regions of the California Land Cover Mapping & Monitoring Program

Table 1. Area of mixed conifer forests that burned in the Cascades Northeast and North Coast analysis regions of CA between 1985 and 2004 (data from CA-FRAP)

Year	1 **Area (ac)** Public	2 **Area (ac)** Private	1 **Percent** Public	2 **Percent** Private
1985	1,863	367	0.070	0.019
1986	129	393	0.005	0.021
1987	83,344	4,272	3.116	0.224
1988	1,976	4,881	0.074	0.256
1989	400	379	0.015	0.020
1990	4,505	15,175	0.168	0.795
1991	314	818	0.012	0.043
1992	5,132	41,741	0.192	2.188
1993	81	1,013	0.003	0.053
1994	5,241	1,001	0.196	0.052
1995	103	0	0.004	0.000
1996	7,342	392	0.275	0.021
1997	79	39	0.003	0.002
1998	3,836	1,020	0.143	0.053
1999	13,670	5,547	0.511	0.291
2000	20,959	4,757	0.784	0.249
2001	16,906	4,345	0.632	0.228
2002	19,895	2,272	0.744	0.119
2003	1,988	3,016	0.074	0.158
2004	2,809	1,799	0.105	0.094
Total 20 years	190,573	93,228		
Total 10 years	87,588	23,188		

Table 2. Ten year average annual percentage of the total mixed conifer forest area burned in the Cascades Northeast and North Coast analysis regions of CA (data from CA-FRAP)

	Annual percentage **Public**	 **Private**
1985-1994	0.385	0.367
1986-1995	0.378	0.365
1987-1996	0.405	0.365
1988-1997	0.094	0.343
1989-1998	0.101	0.323
1990-1999	0.151	0.350
1991-2000	0.212	0.295
1992-2001	0.274	0.314
1993-2002	0.329	0.107
1994-2003	0.337	0.117
1995-2004	0.328	0.122

Based on the data in Table 2, the average baseline area burned in the 10-yr period 1995-2004 in the region is 0.12%/yr for private lands and 0.33%/yr for public lands. Both Tables 1 and 2 illustrate the annual variation in area burned and the impact of catastrophic fires on the annual percentage. The integration of ten years worth of data, however, moderates the impact of catastrophic fires and captures trends in fire incidence (Table 2).

We propose that the area component of the baseline be developed collaboratively between the state Department of Forestry and the relevant US Forest Service units within the state. We envision that the **baseline for area burned will be expressed as an annual percentage for the most recent past 10-year period, and projected forward for the next 10 years**. Lookup tables could provide these projections as values (rates) for each agreed-upon subregion/forest type within the state for a given 10 year period, and could be modified annually to produce updated values. One could imagine that, if indeed landowners became engaged in this type of project for carbon benefits, a project registry could provide the baseline rate of area burned by a "vintage year", which would then be applicable for the next 10 years of the project.

TOPIC 1: Questions, issues and uncertainties for the area baseline:

1. How many years to include in project baseline calculations?
2. Should we separate by forest type and regions within a State?
3. Or should it be by all forests within a region of a State?
4. Are the LCMMP regions a reasonable way to aggregate forests to reflect the factors that affect fire (climate, humans, etc.)?
5. Or should it just be by forest type and State?
6. Is the grouping of 5 WHR types into a mixed conifer forest type reasonable? (Klamath mixed conifer, Sierran mixed conifer, ponderosa pine, eastside pine, Jeffrey pine)
7. Is it reasonable to separate public from private lands? Would it make more sense to separate industrial forest lands which will have different fire relations and then lump the remaining private lands with the public lands?
8. Is the method for calculating baseline area sufficient? Or is it necessary to require modeling for every project?
9. Is an index of climate needed as a modifier for the projected area likely to be burned, and if so what index and how used?
10. Should we try to account for the expected reduction in area burned outside of the treated area that results from treatments inside a project areas?

2.3 Estimation of carbon emissions

The **baseline** emissions are basically equal to the **area** that would burn in the absence of the project **multiplied by the carbon emissions** estimated to result from the burned area. **Pre-fire carbon stocks** exist in live and dead standing trees, understory vegetation, litter and downed dead wood; all of these carbon stocks are potential fuel for fire. Historically, in the mixed conifer forest type, fires would pass through the understory relatively quickly and consume downed dead wood, understory vegetation, and litter. One hundred years of fire suppression has led to a growth in the stocks of all potential fuels. In particular, **tree density has increased** so that young trees can carry fires directly into the canopy of the forest (ladder fuels), and understory vegetation and dead wood stocks have grown so that flame lengths can threaten the canopy.

Pre-fire carbon stocks have five potential endpoints during and after a fire (Figure 1). The first proportion survives the fire to continue as live vegetation, a second proportion is volatilized during the fire and immediately released to the atmosphere, and the remainder is divided between pools of dead wood, soot and charcoal. Soot and charcoal are stable forms of carbon and can remain virtually unchanged for long time periods, while dead wood releases the stored carbon gradually into the atmosphere as it decomposes. The amount of carbon that transfers to these various forms during a fire depends upon a variety of factors, including the quantity of fuel (relative to the carbon stocks in non-fuel tree vegetation), its moisture content, and prevailing weather conditions.

The question becomes: what data are needed to develop the carbon stock component of the baseline that is specific to a particular parcel of land? It is assumed that the resulting **changes** in the forest carbon stocks and thus C emissions due to a fire are related to the **quantity of fuel** on the land and the **initial carbon stock**. For a similar relative amount of fuel (and all else equal), it is assumed that a young forest with low carbon stocks will suffer a greater proportion of loss in carbon stocks after a fire than an older forest with higher carbon stocks.

To quantify the impact of fire on changes in carbon stocks and the resulting C emissions, we propose using tables for both land ownership types (public vs. private) that contain values for the fraction of initial carbon stocks burned and emitted as CO_2. These values would vary as a function of **fuel load** (3-5 classes, assuming, initially, all exist under dry climatic conditions) and **forest age class** (**Table 3**).

A significant proportion of the live pre-fire carbon stocks will remain as dead wood post-fire. Under normal, non-fire conditions, carbon in dead wood is released gradually into the atmosphere through the process of decomposition. During a fire, however, it is likely that all stocks of dead wood will be consumed by the fire and all dead wood that remains after the fire is the result of recently-killed vegetation. To simplify the accounting, we could assume that the carbon in any dead wood that remains after the fire would also be emitted at this time. **(**This is similar to the assumption used in the IPCC national greenhouse gas inventory methods for carbon accounting of harvested forests.)

The values (as fractions) in Table 3 represent the fraction of the initial carbon stock emitted as CO_2 and is calculated as the sum of all aboveground biomass components (live and dead) that are oxidized during the fire *and* the biomass of the fire-killed dead wood that remains after the fire, divided by the pre-fire total aboveground carbon stocks. Filling in the values in Table 3 would rely on the literature, other studies from WESTCARB partners, output from stand/fire models, and new field data. The goal of a fire management program would be to move up Table 3 by reducing fuel loads from high (or medium) to low so that a lower proportion of existing forest carbon stocks are burned by fire.

Table 3. Sample table for calculating the fraction of initial carbon stocks emitted as CO_2 resulting from a fire, as a function of fuel load (low moisture conditions) and forest age. Two such tables would be developed, one each for public and private lands.

Fuel load	**Age Class (yr)**					
	0-20	21-40	41-60	61-80	81-120	121+
1 – Low						
2						
3 - Medium						
4						
5 – High						

The impact of fire on the changes in carbon stocks is not only a function of fuel load and age class—the **moisture condition** of the fuel (related to precipitation and temperature conditions) is also a key determinant of how much of the biomass will burn on site during a fire. For example, a high fuel load with low moisture content will lead to a more severe fire than the same fuel load that is moist. The moisture condition of the fuel will also affect how the fire burns (flaming vs. smoldering) and consequently the relative emissions of methane and nitrous oxide (each with higher global warming potential than CO_2).

How non-CO_2 greenhouse gases will be included and whether airborne soot should be included as a carbon dioxide equivalent will rely on the output of the workshop, on the literature, other studies from WESTCARB partners, and on output from stand/fire models.

An additional baseline consideration is **rate of carbon accumulation in the forest pre-and post-fire**. Pre-fire rates are related to several factors such as species mix, age, management, etc. Post-fire carbon accumulation rates are strongly influenced by factors such as fire intensity (heat of burning), fire severity (extent of burning), soil moisture conditions, nutrient availability, availability of seed sources, etc.

Carbon accumulates during regrowth after a fire, and the rate depends, in large part, on the fire's severity (Figure 5). A severe fire that burns through the entire canopy would likely have a slower rate of post-fire carbon accumulation than a less severe surface fire that leaves a majority of the vegetation intact. On the other hand severe fires increase light and soil nutrients for regeneration, reduce competition for water resources (but reduce the organic carbon base in the soil for regenerating seedlings). Severe fires may lead to an arrested succession whereby a dominant understory species such as manzanita prevents tree reestablishment or where soil conditions are altered to the point where the site is not immediately suitable for seedling establishment at all.

How to incorporate the differences in rates of carbon accumulation resulting from different intensities of fire? Three possible conditions exist: (1) pre- and post-fire rates of accumulation are the same, (2) pre-fire rates are greater than post-fire rates (severe fire), and (3) pre-fire rates are less than post-fire rates. If the pre- and post-fire rates of C accumulation are the same (condition 1), then there is no impact on the baseline as the removals of CO_2 from the atmosphere are the same. For condition (2), the pre-fire forest was removing more CO_2 from the atmosphere than the post-fire forest, thus the baseline net emissions of CO_2 due to the fire need to be increased by the difference in the rates. For condition (3), the post-fire forest is now removing more CO_2 from the atmosphere than the pre-fire forest, thus the baseline net emissions of CO_2 due to the fire need to be decreased by the difference in the rates. Thus in essence is it only the differential rate of carbon accumulation during the post fire situations that needs to be known.

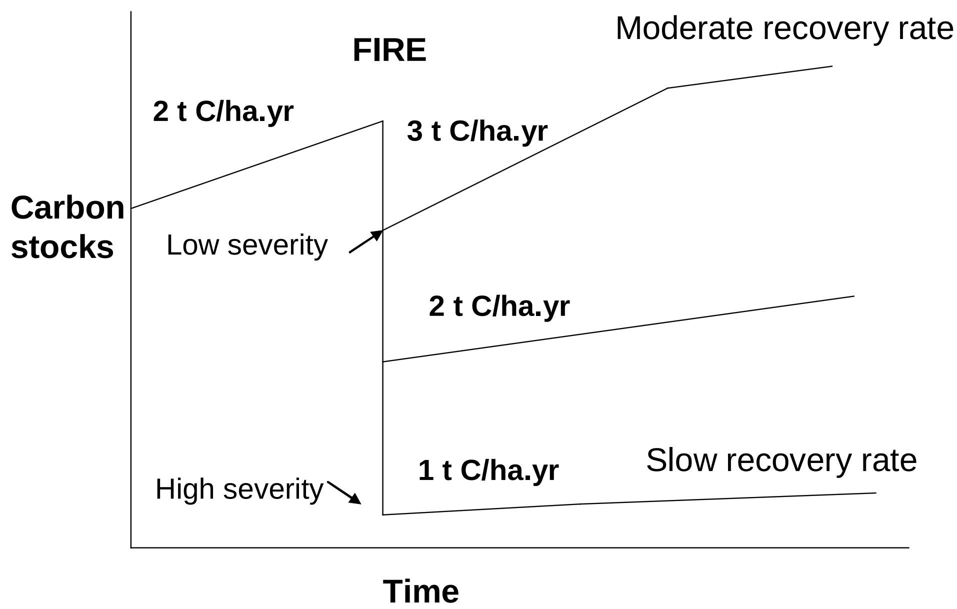

Figure 5. Illustration of hypothetical time course of carbon stocks in a forest stand pre-fire and after fires of various severities. Values on the lines are hypothetical rates of carbon accumulation pre- and post-fire

To illustrate the effects of the pre-and post fire rates of C accumulation discussed above, we use the hypothetical graphs in Fig. 5. For condition (1), the pre- and post-fire rates are the same at 2 t C/ha.yr; there is no difference in the rates of CO_2 uptake from the atmosphere and thus this component of the baseline can be ignored. For condition (2), pre-fire rate is 2 t C/ha.yr and the post-fire rate is 1 t C/ha.yr, and the difference is 1 t C/ha.yr (pre minus post). This means that the pre-fire forest was removing 1 t C/ha.yr more from the atmosphere than the post-fire forest. Thus the baseline net emissions caused by the fire is the gross emissions **plus** an amount equal to the product of the projected area that would have burned and the 1 t C/ha.yr difference in regrowth rate over the 10-yr time interval (assumed duration for the area-burned baseline component). For condition (3), the pre-fire rate is 2 t C/ha.yr and the post-fire rate is 3 t C/ha.yr, and the difference is -1 t C/ha.yr (pre minus post). In this case the post-fire forest is removing more CO_2 from the atmosphere than the pre-fire forest. The baseline net emissions are now the gross emissions from the fire **minus** the product of area projected to be burned and the 1 t C/ha.yr difference in regrowth rate over the 10-yr time interval.

<u>TOPIC 2: Questions, issues and uncertainties for the carbon stock baseline:</u>

1. How should ‘hazardous fuel’ be defined?
2. Where should boundaries be set in terms of fuel loads?
3. Is age class an appropriate method to classify the forest, and if so, where should boundaries be set in terms of age classes?
4. Should the age class categories in Table 3 be replaced by carbon stock categories?
5. How could fuel moisture condition be incorporated into the baseline calculations in a credible manner without producing an overly complex set of calculations?
6. How can we calculate CH_4 and N_2O emissions? Can we and should we do better than IPCC defaults?
7. Should the greenhouse impact of airborne soot be considered? How could this be quantified?
8. How should the differential rates of carbon accumulation between pre- and post-fire conditions be treated? Over what time interval?
9. To what extent are fuel treatments happening on public and private lands currently? And should we consider them as part of the baseline?

SECTION 3: With-Project Carbon Benefits

Once the baseline has been developed and projected, the next steps involve measuring and estimating the change in carbon stocks and resulting C emissions resulting from the treatment. Then the carbon benefit that could be “credited” to the activity is the difference between the baseline projection over an agreed-upon time frame (e.g. 10 years) and the actual C emissions monitored and estimated from applying fuel treatments on specific areas of land. In the baseline case, the C emissions are estimated from a projected percentage of the project area burned. However, in the with-project case, it is expected that the whole project area will need to be treated to claim that the occurrence of severe fires has been reduced. A first step then is to assess what types of fuel treatments make sense for such projects.

3.1 Treatment considerations

Several potential hazardous fuel reduction (HFR) treatments are available to reduce fuel loads in forests and to decrease severity of potential fire. Each of these treatments have different applications, constraints, costs, yields of merchantable and submerchantable material, revenues, air quality impacts, ground impacts and greenhouse gas emission impacts (**Table 4)**.

The important question will be to define what minimum level of treatment will be required in order to qualify the HFR treatment as producing a benefit relative to the baseline and thus eligible for crediting.

Table 4. Benefits, constraints and representative costs for hazardous fuel removal (HFR) treatments.

Fuels reduction treatment	Biomass product yield	Benefits	Constraints	Representative costs ($/acre)
R_x fire	No	Re-introduces fire	Air quality, ground impacts, fire escape, seasonal restrictions, immediate CO_2 emissions	35-300;average 92
Masticate – leave on site	No	Efficient, useful for less accessible sites	Leaves fuel on site, gradual CO_2 emissions	100-1,000
Cut-pile-burn	No	Can be used on less accessible or steep sites	Leaves fuel on site, air quality, immediate CO_2 emissions	100-750
Cut-lop-scatter	No	Can be used on less accessible or steep sites	Leaves fuel on site, gradual CO_2 emissions	105-280
Cable yarding for biomass removal	Yes	Can be used on less accessible or steep sites	Expensive, ground impacts	$80-130/CCF*
Cut-skid-chip-haul (for submerchantable biomass)	Yes	Removes fuel from site; some product value; allows renewable energy generation; greatest CO_2 benefit	More expensive; limited to gentler slopes, areas closer to roads for removal, limited haul distance to biomass plant	$34-48/BDT* + haul cost $0.35/BDT. mile $560-1,634/acre

CCF= 100 cubic feet; BDT = bone dry tons

3.2 With-project carbon emissions and removals

Implementing a hazardous fuel treatment results in carbon emissions to the atmosphere from several sources:

- Emissions resulting from the burning of fossil fuel by harvest equipment used in cutting and removing biomass, and emissions from transporting biomass to a power plant if this type of treatment is implemented.
- Emissions from the decomposing biomass fuel if left on site.
- Emissions from burning the biomass fuel either the piles left on site or in a power plant. If done in a power plant, the biomass fuel burns more efficiently than in an on-site fire, producing less soot, charcoal, and non-CO_2 GHG.

The treatment is also likely to have an effect on the rate of carbon accumulation of the treated forest, and as with fire the effect could cause the rates to increase, decrease, or be no different from the pre-treatment forest (see discussion above in relation to Fig. 5).

Unlike the baseline case, most of the emissions and removal will be monitored and estimated as would be required of any registry. The only variable that could not be readily monitored and estimated is the pre-treatment rate of carbon accumulation (also the pre-fire rate in the baseline).

However, using e.g. tree cores, well parameterized models, and other data, it is possible that acceptable rates of pre-treatment carbon accumulation could be estimated with a desired precision and accuracy (however, as illustrated in Annex 1, it is possible that knowledge of the pre-treatment and pre-fire fire rate of carbon accumulation is not needed).

3.3. Steps for monitoring a carbon project

To participate in a fuel management program, we propose the following conservative requirements for project monitoring:

1. Assume benefit for 10 years after treatment
2. Benefit only possible for treated areas
3. Re-treatment possible after 10 years for continued benefit (new baseline must be applied every 10 years
4. A minimum (as yet undefined) level of treatment is required to qualify for benefits relative to the baseline
5. Measurement required of all carbon pools immediately after fuels treatment
6. Measurement required of biomass of all fuels extracted from the forest
7. Tracking required of vehicle usage for fuels transport
8. Measurement required of any fires that occur in the project area and stocks remaining after fire.

TOPIC 3: Questions, issues and uncertainties for calculating project carbon benefits:

1. What is the minimum level of treatment that should be required to qualify for carbon benefits?
2. Is it reasonable to give benefit for 10 years following initial treatment? Is this too generous or too conservative?
3. Is there any way to consider benefits that arise beyond the project boundaries?
4. What treatments should be considered for hazardous fuel management?
5. Which treatments are most commonly used?
6. Which treatments are most profitable, in terms of both dollars and carbon benefits?
7. How long does the impact of fuels treatment last? Is the ten year constraint before re-treatment appropriate?

SECTION 4: General Considerations on Methodology

<u>TOPIC 4: General questions, issues and uncertainties for methodology:</u>

1. Is the approach taken here conservative to the point where it is hard for a project to receive benefit for the genuine good its treatments have caused?
2. What is the balance between being conservative so as not to over-credit and reflecting genuine decreases in fire extent and fire severity?
3. What is the balance between creating a simple methodology that can be applied by someone without great experience, and accurately capturing on the ground impacts?
4. Should we allow the option of using more complex methods (e.g. modeling) to quantify benefits if capacity exists (the concept of using a tier approach for such activities does exist in national accounting methods)?

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Annex 1

Here we illustrate how it may not be necessary to know what the pre-treatment and pre-fire rates of carbon accumulation are (for the baseline and with project cases, they are the same value). In the baseline and with project equations given in section 1.2.1 A and B the following terms are included:

BR_R = Emissions/removals of carbon dioxide due to the differential pre- and post-fire effects on rates of carbon accumulation
RE = Emissions/removals due to the differential pre- and post-treatment effects on rates of carbon accumulation

The term BR_R can be expressed as equal to CB-CP, where CB= background carbon accumulation rate pre fire and CP = carbon accumulation post fire.

The term *RE* can be expressed as equal to CB-CT, where CB is the same background carbon accumulation rate as pre fire or in this case pre treatment (the same forest in both cases) and CT is the carbon accumulation rate post treatment.

The carbon benefits are the difference between the baseline emissions and the project-case emissions. When simplifying the two equations representing the baseline and project emissions, the terms for BR_R and *R*E can be replaced by
(…baseline emissions eq.………+CB-CP) – (…project emissions……+CB-CT)

Simplifying this, the term CB drops out and one only needs to know the difference in the rate of carbon accumulation post fire and post treatment. Post treatment would be measured, but post fire would have to be modeled. However, this discussion does show that at least knowledge of one quantity is not needed for the fire methodology.

APPENDIX B:
Developing and Testing a Framework for Estimating Potential Emission Reduction Credits: A Pilot Study in Shasta County, California, USA

APPENDIX B

Developing and Testing a Framework for Estimating Potential Emission Reduction Credits: a pilot study in Shasta County, California, USA

Submitted to
Winrock International

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Executive Summary

To assist Winrock International in establishing a rigorous approach for emissions reduction credits (ERCs), Spatial Informatics Group, in conjunction with the University of California, is developing a methodology that that uses scientifically based models for predicting changes in fire behavior and related emissions, both with and without hazardous fuels reduction treatments. To make these predictions, our report focuses on the development and testing of four elements in this framework: fire probability mapping, delineation of firesheds, choice of a fuel classification standard, and a baseline fire hazard assessment (without fuels treatments). This work was largely performed as a pilot study using data from Shasta County, California, USA. Long-term fire probability maps were developed for Shasta County using Maxent, a recently developed probabilistic distribution modeling tool. These maps can be used to calibrate ERC analysis, and they also serve as inputs into other elements of the framework. A total of 45 firesheds were delineated for Shasta County using an analysis of spatial distribution of fuels, weather, topography, potential fire behavior, and fire risk in a multivariate clustering model. Various fuel classification systems were considered for use in the ERC framework, with the fire behavior and FCCS formats standing out as the most appropriate. Emissions estimates were made for Shasta County using mapped FCCS fuel models and for four areas in the Sierra Nevada using fire behavior fuel models, demonstrating the feasibility of using these models in an integrated manner for the framework. A baseline fire hazard analysis was also performed, after generating mapped fire behavior characteristics for the current landscape in Shasta County under a historically severe fire weather scenario.

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1. Introduction

The western U.S. has millions of acres of forestlands in overstocked condition and at risk of catastrophic wildfire. Reduction of unnaturally high fuel loads is a primary component of the National Fire Plan, the Healthy Forests Restoration Act, and other planning efforts such as the Sierra Nevada Forest Plan Amendment. Central to the economics of fuels reduction is the ability to remove and use forest biomass for higher value purposes. One strategy for changing the economics of fuels treatments is to sell emission reduction credits (ERCs), some of which may be derived from reducing wildfire emissions through forest fuels treatments (e.g. thinning of merchantable and non-merchantable trees, mastication, prescribed fire, etc), and using the resulting biomass waste stream to generate renewable electricity. EPA and those implementing AB32 in California require that ERCs be quantifiable, real, permanent, enforceable, verifiable, and surplus. An integrated approach is therefore needed to objectively quantify emissions generated from wildfires and to ultimately assess the effects of fuel treatments.

To assist Winrock International in establishing a rigorous approach for ERCs, Spatial Informatics Group, in conjunction with the University of California, is developing a methodology that includes scientifically based models for predicting changes in fire behavior and related emissions, both with and without hazardous fuels reduction treatments. The goal is to produce an integrated framework of process-based models to provide localized estimates of relative emissions reductions (i.e. conditional probabilities and emission amounts, contingent on a fire happening in a specific treated area). To perform such an assessment, fuels must be characterized as inputs to fire behavior and emissions models, and the size and shape of the area for fire hazard assessment (i.e. the fireshed) must be identified. The potential for emissions reductions to actually be realized in different locations and vegetation types must also be quantified (i.e. baseline absolute probabilities, from long-term observed relationships between fire and environmental variables that influence regional fire occurrence rates).

The ERC framework being developed consists of several components. Firesheds are delineated as units of analysis. Within a fireshed, baseline (untreated) fire hazard and emissions are estimated. Once potential treatments are defined for a fireshed, fire hazard and emissions are estimated for the treated landscape, accounting for not only changes within a treatment area, but changes due to fire shadow effects. Fire shadow effects are changes in fire behavior and emissions that occur due to treatments, but are outside of treatment areas. Potential ERCs would be based on estimates of pre- and post- treatment fire hazard and emissions. These estimates are modified by the long-term probability of occurrence across the fireshed. Fig. 1 summarizes components of this conceptual framework. This report focuses on the development of four elements of this framework: assessment of long-term fire occurrence probabilities, delineation of firesheds, choice of a fuel classification standard, and a baseline fire hazard assessment. This work was performed as a pilot study using data primarily from Shasta County, California, USA.

Shasta County, in north-central California, spreads across the northern Sacramento River Valley, from the eastern Klamath Mountains on the west to the Modoc Plateau and Mt. Lassen on the east. Elevations range from 107 m (350’) along the Sacramento River to 3188 m (10,457’) at the summit of Mt. Lassen, with precipitation ranging from ~50 cm on the Modoc Plateau to ~300 cm on Mt. Lassen. Mixed conifer forests are the most common vegetation type within the county (with more pine at the lower range, and more fir at the upper elevations). The county also includes large tracts of oak and oak/pine woodland, oak savanna, non-native annual grasslands, and mixed and montane chaparral.

2. Long-term Fire Probability Mapping

2.1 Background

Carbon accounting is a conceptually straightforward method of tallying the sources and sinks of carbon. However, quantifying carbon stocks and flows (whether historical, current, or future) for ecological systems is complex because of the spatial and temporal trends, interactions, and feedbacks of ecosystem processes. Wildfires, which are crucial disturbance processes in many of the world's ecosystems, are a prime example of that complexity. Wildfires combust biomass and are a source of carbon emissions, at least in the near term (Randerson et al., 2006), although they may act as a long-term carbon sequestration mechanism in some systems.

Fires occur as a function of a "fire regime triangle" of factors that regulate long-term fire activity: ignition sources, vegetation type, and climatic conditions during the fire season (Moritz et al., 2005; Fig 2). Spatial and temporal variation in these three factors interact, and the outcomes – the area burned, burn severity, seasonality, fire size, and fire intensity – are well described as stochastic events regulated to varying degrees by different factors in the fire regime triangle. Patterns of fire events in a specific location over time are used to describe its fire regime. For example, weather conditions and patterns vary from year to year, often in multi-year cycles (Kitzberger et al., 2007), such that long-term data are required to estimate the boundaries of historical variation in fire activity.

Applying fuel treatments to forested stands has been proposed as one method to reduce the risk of both catastrophic wildfires and the area burned during a wildfire, as well as carbon emissions from forests in California. The costs associated with treating millions of acres of forested lands are a central issue in this process, and sale of emission reduction credits may be one way of improving the economics of fuel treatments. If emission reduction credits are to be given for these treatments, it is necessary to establish a robust estimate of the baseline fire return intervals (i.e. from long-term mapped fire occurrence probabilities) for gauging the effectiveness of treatments at reducing carbon emissions. This is because some portions of the landscape are in more fire-prone environments than others, which means that some fuels treatments are more likely to achieve their emissions reduction benefits than others. Long-term expected fire occurrence probabilities are also necessary for assessing the relative merits of forest carbon sequestration projects (i.e. through quantifying environmental uncertainty and potential losses over 100 years), although establishing these baseline metrics is not carried out routinely (e.g. Richards and Stokes, 2004).

Winrock International developed a pilot study (Brown et al., 2006) to estimate historical rates of carbon emission from the area burned by wildfires within the mixed conifer forests of two ecoregions in northern California: the Cascades Northeast and North Coast, as defined by the

California Department of Forestry and Fire Protection's (CalFire) Fire and Resource Assessment Program (FRAP). Historical burn rates were proposed as a baseline for comparing the effectiveness of stand treatments in the future. A temporal moving window approach was suggested to determine baseline burning rates for the mixed conifer forest area. For example, the observed area burned over a ten year period might be used to forecast burn rates in the subsequent decade. However, there is no way to assess how many decades of data are needed to quantify variability in burn rates and if any decade sampled is representative of ongoing patterns, particularly for vegetation types that may only burn once over multiple centuries. Long-term fire occurrence probabilities can also be sensitive to the spatial window used in their determination. These shortcomings were assessed in an earlier report (Waller et al. 2007), in which a more rigorous fire probability mapping method was proposed.

A variety of statistical approaches has been developed at different spatial scales to relate fire occurrence probability at a location to variability in environmental characteristics (e.g. McKenzie et al., 2000; Cardille et al., 2001; Parisien and Moritz, 2009; Krawchuk et al., 2009). Such models can consider a wide range of predictor variables, including vegetation characteristics (e.g. cover type, productivity), topographic factors (e.g. slope, aspect, and landscape position), climate (e.g. averages and seasonality), ignition potential, and anthropogenic factors (e.g. human population pressure and land-use) as candidates to describe spatial variation in long-term fire occurrence probabilities. Many open questions remain, however, about the best variables to use, inherent sensitivities to modeling decisions, and techniques for training and testing such models. Here we describe a scientifically rigorous method of quantifying baseline fire occurrence rates, based on long-term fire patterns (i.e. multiple decades) and spatially explicit environmental variables. This approach has successfully been applied to regions of California and can be extended to the entire western U.S. (Parisien and Moritz, 2009).

2.2 Methods

We used the Maxent statistical framework, a recently developed probabilistic distribution modeling tool (Elith et al., 2006; Phillips et al., 2006), to generate spatially explicit fire probability maps for Shasta County, California. Maxent estimates the target distribution by finding the distribution of maximum information entropy (i.e. closest to uniform) subject to the constraint that the expected value of each feature under this estimated distribution matches its empirical average. This approach requires fire history records (locations) for an area as training data and spatial environmental layers as independent predictor variables of fire presence, establishing complex statistical relationships between fire occurrence and the environmental variables that characterize the most suitable locations for its occurrence. No fire absence data are required, as would be necessary for many distribution mapping tools (Philips, 2008). Special features of Maxent, including regularization and cross-validation of data, help to prevent overfitting of training data and allow the generation of robust fire-probability maps. The methodology employed here could thus be extended to any other region with appropriate fire history and environmental data (e.g. Parisien and Moritz, 2009; Krawchuk and Moritz, 2009; Krawchuk et al., 2009).

Training data for Maxent were obtained from fire history maps (1900-2007)(CalFire FRAP, 2010) and climate data (PRISM at ~800 meter resolution and Daymet at 1-km resolution) covering Shasta County. Monthly and annual means of environmental variables were sampled within the area burned by each fire for the period under consideration. Initial modeling used 32 environmental variables (Tab. 1) as predictors (independent variables), constituting the full model. Subsequent correlation analyses among these 32 variables led to the development of a reduced, 15-variable model. The reduced set included the minimum and maximum monthly values of temperature, precipitation, precipitation frequency, relative humidity, solar radiation, potential evapotranspiration, water balance, and cumulative annual deficit of soil moisture. Northern California was determined to be an appropriate geographic region from which to develop models. Final Maxent models were based on an average of a suite of four models: two different variable sets (32-variable ensemble and 15-variable ensemble) and two different fire size thresholds in each region (1000 acre and 5000 acre).

Maxent's logistic output is a relative fire occurrence probability, arbitrarily scaled between zero and one; therefore, it is not a true annual burn probability, nor necessarily a probability of burning over the time period from which the training data were collected. The results must be rescaled using fire history data to be converted to meaningful fire occurrence probabilities. The approach used here involved determining the mean annual burn rate from fire history data for the training area, and then dividing this by Maxent's mean fire probability value for the same area, to determine a conversion factor between the two products. Applying the derived ratio to the Maxent relative probability occurrence map results in the appropriate fire occurrence probability map. This result can also be inverted to give an expected fire return interval.

California's fire history data are considered fairly reliable back to 1950, but using a time window of 1950-2007 to determine an annual burn rate provides a relatively low estimate of annual burning compared to a window that includes only more recent years. Fire reporting has become more accurate (e.g. older data may be missing fires), and recently, fire activity has increased perhaps due to changes in the climate. Using 2001-2007 thus provides a more recent higher burn rate that can be thought of as an upper estimate of annual burning. Fire history data from two time windows (1950-2007 and 2001-2007) were used to generate two conversion factors that could be applied to the Maxent relative probability outputs to get upper and lower estimates of annual burn probabilities. These results were then inverted to give expected fire return interval products. In addition to considering the average output of these four models, we generated approximate 95% confidence interval products for each model based on the standard deviation (SD) output from Maxent (mean +/- (1.96*SD/root n)) where n refers to the number of bootstrapped replicates in a Maxent model run. These upper and lower confidence interval products from each model were then separately averaged to generate multi-model upper and lower confidence interval products. Further details on model fitting methods can be found in Parisien and Moritz (2009).

2.3 Results

Relative fire occurrence probabilities were mapped for Shasta County and fire return intervals were summarized with histograms according to vegetation type. For vegetation type classes, we computed probabilities according to WHR (wildlife habitat relationships) type in the FRAP-LCMMP (Land Cover Mapping and Monitoring Program) land cover map.

Among the many model input scenarios and model averaging techniques investigated, we found considerable spatial variation in long-term fire occurrence probability patterns. Consistent with our previous work, this heterogeneity (e.g. Fig. 3a) reflects important differences in environmental variables that determine how fire-prone an area tends to be. However, there was also variation among the individual model runs that were eventually averaged to produce each fire occurrence probability surface, which is reflected in mapped SD products (e.g. Fig. 3b). While it is encouraging that some regions of the study area may show relatively little variation among modeling runs (e.g. much of coastal and far northern area in Fig. 3b), other areas are much more sensitive to choices made for individual models. Furthermore, due to inherent variation in independent variables, we found that expected fire return intervals are not uniform within the climates of any given vegetation type (e.g. Fig. 4). This is not surprising, given that some locations can tend to be more fire-prone than others, even within a particular vegetation type.

The Blue oak woodland, mixed chaparral, and Sierra mixed conifer types with shorter fire return intervals, tend to be normally distributed around a most common burn rate near the mean; only Sierra mixed conifer vegetation exhibited "heavy tailed" distributions with small amounts showing very long expected fire return intervals (Fig. 4). Despite this variation, there are some clear trends among the climates of the different vegetation types. In this example, Blue oak woodlands and mixed chaparral tend to burn most frequently (~100-160 year range of fire return intervals). Fire return intervals begin to lengthen with increasing elevation to the Sierran mixed conifer forests (~120-350+ year range of fire return intervals), and even further in higher elevation fir forests (averages of ~200 years for White fir and ~300 years for Red fir forests; data not shown).

Another sensitivity examined was that of the conversion factor used to transform relative fire occurrence probabilities to expected fire return intervals. For example, recalculating the fire return interval distributions for Sierra mixed conifer with a 1950-2007 historical annual burn rate instead of one based on 2001-2007, we see that mean fire return intervals are lengthened by well over a century (Fig. 5).

2.4 Discussion

Long-term fire probability maps were developed for Shasta County using Maxent, a recently developed probabilistic distribution modeling tool. These maps are crucial for calibrating ERC analysis, and they are also useful inputs to the delineation of firesheds.

Because modeled fire probabilities can be sensitive to model training samples, the estimates given here should be interpreted with caution. For example, we find substantial differences between models, depending on whether training points are gathered from northern California or all of California. Extensive exploratory analysis and sensitivity analyses led to the conclusion that regional models were more accurate and realistic than spatially transferred models (i.e. models applied away from their source training data). While this has negative implications for spatial transferability and robustness of any particular model, it also suggests that regional datasets have enough data to develop a good local model of controls on long-term fire occurrence probabilities.

It is clear that various measures of model performance have limitations. For example, some common metrics (e.g. AUC – area under the curve) are sensitive to sample prevalence and the geographic extent over which it is applied (Lobo et al., 2008). Furthermore, it is difficult to treat any fire data as "truth" against which a product can be perfectly judged, due to the somewhat stochastic nature of fire. Various measures may be adequate for rough model comparison, but there is no one perfect measure for fire probability evaluation. At the very least, refitting models on some periodic basis is required, so that new fire occurrence data and associated environmental characteristics are integrated into long-term mapped estimates of fire occurrence probabilities. Regardless of the application, it is most appropriate to examine a suite of fire return interval estimates (e.g. low, medium, and high) for a specific area, to incorporate the potential range of natural variability inherent in fire regimes there.

3. Fireshed Delineation

3.1 Background

The term "fireshed" is increasingly being used to denote management units for fire planning. This is similar to the notion of natural resources being managed on a "watershed" basis, with actions in different portions of the watershed having effects on other parts within the watershed, or on the ultimate output (water resources) of the unit. Events or actions such as wildfire or fuels management activities in a fireshed can also have effects on areas greater than just the local area immediately affected. For example, forest thinning in one area may have a "shadow effect", not only altering fire behavior and emissions in the treatment unit, but in adjacent areas as well. The cumulative effects of multiple treatments in an area may therefore result in greater effects across the entire area than just the sum of the individual treatments. Firesheds may also capture areas where similar fire response strategies may be used to influence wildfire outcomes (Bahro et al., 2007). These examples demonstrate the need for a planning unit greater in size than that of wildfires, treatments, or other management activities.

Firesheds are generally delineated based on topography, fuels and vegetation patterns, assessment of fuel treatment effectiveness, barriers to fire spread, and fire behavior expected under relatively extreme fire weather conditions. Currently the USDA Forest Service is implementing and refining its Stewardship and Fireshed Assessment Process (SFA) across many of its forests in California (Bahro et al., 2007). An early part of this broad planning process is to delineate firesheds, within which fire management activities can be effectively planned and fuel treatment effectiveness evaluated. Fireshed delineation within the SFA process is a collaborative process, based on elements such as stakeholder input, expert opinion, and simulation of the "problem fire" for the planning area. The problem fire is a simulated fire that is of primary concern to stakeholders for its potential impact to lives, property, forests, and watersheds (Bahro et al., 2007). It is based on exploration and examination of fire history and historical weather for an area.

For the process being undertaken by Winrock International of assessing potential emission reductions from fuel treatments, an effective planning and assessment unit is also required. The fireshed concept meets the needs of this process. Here, we seek to improve on current, somewhat subjective methods of fireshed delineation by adding a new ecologically and statistically based approach. We integrate data for Shasta County on land cover, weather, topography, and fire probability into a semi-automated statistical process that divides or regionalizes the study area into firesheds.

3.2 Methods

Our methodology for delineating firesheds generally considers five main factors: the "fire behavior triangle" (fuels, weather and topography) (Pyne et al., 1996), barriers to fire spread (both natural and anthropogenic), potential fire behavior (under a "near-worst case" weather scenario), fire occurrence probability patterns (as discussed in section 2), and fire history (CalFire FRAP Database, 1900-2007). The analysis was performed in a Geographic Information System (ArcGIS 9.3 software). We began the process by performing an analysis of barriers to fire spread in Shasta County. These barriers included major roads, major water courses, urban areas, areas with no burnable vegetation, and agricultural areas. The outlines of these barriers were combined into one polygon layer. Shasta County was then divided up by this barrier layer to form "barrier units". These barrier units served as our broadest unit of analysis, as fire would likely be contained within these large units. Each barrier unit was analyzed separately. Barrier units were subsequently divided into smaller units, termed "fire basins", based on the California Watershed Boundary Dataset (WBD) subwatershed delineations (6^{th} level, 12-digit)(CalWater, 2010). These topography-based polygons are hydrologic units that define the aerial extent of surface water drainage to a point. They served well as our smallest, most basic units of analysis, as they are generally smaller than our anticipated firesheds (~3000 to ~40,000 acres), and are to some degree also naturally bounding units for fire.

Each fire basin was then attributed with a value for each of several environmental variables of interest. Fire basins were given values for majority vegetation type (from the National Land Cover Database 2001), wind speed expected under a near-worst case scenario (overall 25mph from the southwest) averaged over the entire fire basin (as modeled in WindNinja 2.0 software) (Forthofer, 2009), and topographic roughness index (TRI). The topographic roughness index is a measure of how quickly the terrain (elevation, slope aspect) changes over a given distance (Stambaugh and Guyette, 2008). Each fire basin was also assigned values for potential fire behavior (mean flame length, mean fire line intensity, and majority crown fire activity level) as modeled in FlamMap 3.0 (Finney, 2006) under near-worst case weather conditions (97.5^{th} percentile). Finally each fire basin was assigned a value for mean annual burn probability, averaged over the entire fire basin. The result of these assignments was a multivariate dataset for each barrier unit, with each fire basin as an observation, attributed with the multiple variables mentioned above.

Within each barrier unit, our goal was to aggregate the smaller fire basins into larger units (firesheds) based on multivariate analyses of the fuels, weather, topography, fire behavior, and fire probability data assigned to each fire basin. Units which were the most similar and adjacent to one another would get aggregated into larger firesheds. The minimum size of the fireshed in

Shasta County was based on the idea that that each fireshed should be larger than the "problem fire" or a near-worst case scenario fire. Our minimum fireshed size was three times the 80th percentile historical fire size, or approximately 10,000 acres. We aggregated the fire basins using several methods. The first analysis is called spatially constrained agglomerative clustering (performed in BoundarySeer 1.3 software). In this multivariate statistical method, clusters of polygons are formed by agglomerating individual polygons based on similarity of variables and adjacency (Jacquez and Maruca, 2003). Formation of clusters (in order to form firesheds) is constrained so that clusters form contiguous areas. Agglomeration of fire basins stops when the process reaches the user-defined number of clusters within a barrier unit. This number was determined for each boundary unit by performing a goodness-of-fit analysis for varying numbers of clusters. This analysis only used the numerical data available. We further refined clusters by using Wombling techniques (also in BoundarySeer 1.3) on our categorical data (land cover type and crown fire activity). In cases where clusters did not meet the minimum fireshed size requirement, they were manually combined with other clusters based on adjacency, topography, and land cover type. In some instances, it was not possible to meet the minimum size requirement due to fire barriers and county lines.

3.3 Results

Shasta County was initially divided into 16 barrier units. These barriers split the initial 141 subwatersheds into 193 fire basins. Cluster analysis grouped these fire basins into 45 unique firesheds (Fig. 6). Majority NLCD cover types represented in the firesheds were 42 (Evergreen Forest), 43 (Mixed Forest), 52 (Shrub/Scrub), and 71 (Grassland/Herbaceous). Fireshed size ranged from 6335 acres to 163,176 acres. Among firesheds, fire probability ranged from 0.26 to 0.59. Mean wind speed ranged from 21.9 to 25.1 mph. Mean TRI ranged from 1 to 1.123. Mean surface flame length varied from 2.1m to 39.6m. Mean fireline intensity ranged from 1,334 kW/m to 65,216 kW/m. 26 of 45 firesheds burned with the majority of their area in crown fire class 1 (no crown fire), while 5 firesheds burned with the majority of their area in crown fire class 2 (passive/torching) , and the remaining 14 firesheds burned with the majority of their firesheds in class 3 (active crown fire). Full details of all fireshed characteristics are summarized in Tab. 2.

3.4 Discussion

In the absence of any repeatable and objective available process for currently delineating firesheds, we have demonstrated the feasibility of a new statistically based approach. This process theoretically divides our study area into relatively homogenous units that can be used for analysis and planning at the scale of the "problem fire", which in this case was represented by approximately three times the 80th percentile fire size, or 10,000 acres. It is important to note that our delineation process is primarily statistical in nature, taking into account fuels, weather, topography, fire probability, and potential fire behavior. As such, some of the firesheds as delineated here may not be reasonable units for management or planning, which may take into account such things as political boundaries, access, other management activities, etc.

Similar to the Stewardship and Fireshed Assessment Process, our fireshed delineation process continues to be refined. Areas for further investigation include using different initial area units other than subwatersheds. For example in areas where homogenous units of vegetation have been defined (e.g. forest “stands”), these might provide a better initial units for clustering. Smaller initial units or fire basins might, however add significantly to the complexity of the analysis. The barrier analysis might also be improved by closer examination of whether certain roads, waterways, or urban areas will actually act as barriers to fire spread. In terms of clustering of fire basins, a better way to mix analysis of numeric and categorical data needs to be investigated, rather than manual adjustment of fireshed boundaries. Additionally, as mentioned above, the analysis did result in some irregularly shaped firesheds, which may prove difficult for planning and management. Integrating our statistical approach with more “expert opinion” based approaches is an avenue for further consideration.

4. Fuel Classification Standard

4.1 Background

Fuelbed characterization and classification is one of the most critical element of emissions estimation. A fuelbed is composed of the live and dead vegetative materials that can combust in a fire. It can include various vertical strata, including duff and litter on the forest floor, dead and downed woody material, live and dead herbs and shrubs, small trees in the under- and mid-story canopy, and live and dead trees of the upper canopy. Fuelbeds also vary horizontally (aerially) across the landscape. To account for horizontal variation, a particular study area can be spatially classified into one or more fuelbed types, each considered homogenous within itself. Fuel models are numerical descriptions for particular fuelbed types, which can be used to estimate fire behavior or smoke emissions. Fuel models were originally devised as a way to organize fuel data for input into Rothermel’s (1972) mathematical fire spread model (Deeming et al., 1977). Various fuel model systems exist and are in use today, which have developed along different lines for different purposes. Choosing appropriate fuel models for the emissions reduction framework will depend largely on data availability, appropriateness of available models for fire behavior and emissions estimation, and the desired level of accuracy for these estimates.

4.1.1 Fire Behavior Fuel Models

The most widely used fuel model systems have developed out of fire behavior modeling, based on the Rothermel fire spread equations (Rothermel, 1972). The most current and widely used implementations of the Rothermel equations are the computer programs BehavePlus (Andrews et al., 2008), FlamMap (Finney, 2006) and Farsite (Finney, 1998). BehavePlus is a non-spatial fire behavior prediction program, estimating fire characteristics for a single homogenous fuel bed. FlamMap and Farsite are spatial implementations, predicting fire characteristics and fire spread across a digitally mapped landscape. These programs depend on inputs of weather, topography, and a standard or custom set of fuel models to predict such fire characteristics as flame length, fireline intensity, and crown fire activity.

The original 13 fire behavior fuel models (described by Anderson, 1982), and their updated versions (described by Scott and Burgan, 2005) are widely used by fire agencies for wildfire and fuel treatment planning. In addition to weights per unit-area of different fuels particles in each stratum, these fuel models specify various other characteristics such as heat content, surface area-to-volume ratio, and moisture of extinction. The national LANDFIRE project mapped these fuel models across the country for regional scale planning (USDA, 2010). Many smaller scale mapping efforts have been done for specific areas. These fuel maps can be created by field sampling in an area with fuel model classification in mind, or by interpreting remotely sensed imagery, but more often are "crosswalked" between vegetation type classifications and fuel models. "Crosswalking" involves translating mapped vegetation types into fuel models, based on expert opinion of how a particular vegetation type might relate to a particular fuel model. Sometimes specific vegetation types can be reliably equated to particular fuel models, but other times vegetation type descriptions may not lend themselves to direct correlation.

4.1.2 Fire Danger Fuel Models

The National Fire Danger Rating System is a set of computer algorithms, programs, and models aimed at estimating fire danger. Fire danger in the NFDRS is a characterization of the potential for initiation, rate of spread and difficulty of control of a wildland fire (NWCG, 2002). It is used primarily by land management agencies for fire planning, staffing, and suppression purposes. Inputs into the NFDRS include antecedent weather, topography, live and dead fuel moisture, and fuel types. The outputs of the NFDRS are three relative ratings: Occurrence Index, Fire Load Index, and Burning Index. Fire danger estimations are designed to be representative of general conditions over broad areas, as opposed to fire behavior prediction (e.g. the FlamMap model) which is site specific.

A major input into NFDRS is the fuel model. The NFDRS contains a set of 20 fuel models developed specifically for this system, which is why NFDRS is being considered here. These twenty models are designed for making general fire danger predictions over large areas – often tens of thousands of acres in size. They are not necessarily designed to predict site-specific fire behavior, which is influenced highly by such factors as specific slope, wind speed, and fuel moisture. Additionally, while the fuel models do incorporate characteristics for dead and live woody material, they are not descriptive enough to simulate such complex processes as crown fire or post-frontal combustion. As such, the NFDRS fuel models are likely not appropriate for either the fire behavior prediction or the emissions estimation to be performed in our framework.

4.1.3 Fire Effects and Emissions Fuel Models

Fire emissions models such as Consume (Prichard et al., 2010a), the Fire Emissions Production Simulator (FEPS) (Anderson et al., 2004), and the First Order Fire Effects Model (FOFEM) (Reinhardt et al., 1997) have developed in parallel with fire behavior modeling, but have different data requirements. This is primarily due to the fact that accurate emissions estimations often require different descriptions of fuelbeds, than do fire behavior prediction models. They also require coupling of frontal surface fire, post-frontal surface fire, and crown fire in making estimates. Fire behavior fuel models are primarily designed for modeling either surface or crown fire behavior (e.g. fire at the flaming front). Pollutant emissions, however, are not only the result of fire at the flaming front, but are also greatly affected by post frontal combustion (e.g. smoldering), burning of jackpot accumulations, and other combustion processes.

Consume is a Windows-based computer application that can predict fuel consumption, pollutant emissions, and heat release based on a number of factors including fuel characteristics and environmental conditions (Prichard et al., 2010a). Among the primary benefits of this model is that it allows for very detailed specification of the fuelbed. Consume uses the Fuel Characteristic Classification System (FCCS) model for fuel classification. It accounts for virtually the entire range of vertical fuel strata, including duff, basal accumulations, squirrel middens, litter, ground lichen and moss, sound and rotten dead wood, stumps woody fuel accumulations, grasses and herbs, shrubs, trees, snags, and ladder fuels, with different algorithms for computing emissions from each of these strata. Consume also has a useful hierarchical project structure which allows the user to specify different fuelbeds within project units, and different units within a project. Users can customize fuelbeds to account for local variation.

The FCCS fuel models are a very detailed approach to fuelbed classification, describing fuelbeds in terms of various vertical strata including duff, basal accumulations, squirrel middens, litter, ground lichen and moss, sound and rotten dead wood, stumps, woody fuel accumulations, grasses and herbs, shrubs, trees, snags, and ladder fuels (Prichard et al., 2010b). The FCCS fuel models feed directly into the Consume emissions model. More than 300 fuel models have been described to date in the FCCS. The latest version of FCCS will make suggestions for crosswalks from FCCS to fire behavior fuel models, but not the other way around.

Similar to Consume, FEPS is a Windows-based computer application that can predict fuel consumption, pollutant emissions, and heat release of prescribed or wildland fires. Users describe an "event", specifying up to five fuel beds, fuel moisture, fuel consumption, and hourly values for area burning and wind. Total burn consumption values are distributed over the life of the burn to generate hourly emission and release information (Anderson et al., 2004). Users can input their own fuel characteristics or use and/or modify fuel models built into FEPS. Fuel inputs are specified as tons per acre of canopy, shrub, grass, woody vegetation, litter and duff, and users can specify whether fuels are activity (e.g. slash) or natural. Users can load values from the NFDRS fuel models, as well as the FCCS fuel models.

FOFEM is a computer program and set of algorithms used to predict first order (direct or immediate) consequences of fire. This includes predicting tree mortality, dead fuel consumption by size class and resultant fire intensity over time, pollutant emissions by flaming and smoldering combustion, and soil heating at a range of soil depths over time since ignition (Reinhardt, 2008). FOFEM uses fuel models based on vegetation type (SAF/SRM cover type or NVCS cover type). The user is allowed to choose the vegetation type in question, and each vegetation type in FOFEM has default fuel characteristics associated with it. These defaults were developed through an exhaustive search of fuels literature (Reinhardt, 2008). Input characteristics include tons/acre of litter, duff, dead woody fuels, herbaceous, shrub, and canopy fuels. The user can change these inputs for their specific study site. Additionally, the latest version of FOFEM allows for use of FCCS fuel models.

4.1.4 Choice of fuel models for ERC Framework

Tab. 3 describes the different fuel models available and the pros and cons of each. For the ERC framework being developed here, we must estimate changes in both fire behavior characteristics as well as emissions. Regarding fire behavior prediction, the fire danger fuel models are designed for the NFDRS system, which estimates broad scale surface fire danger, outputting such indices as burning index. We are more interested in specific potential fire behavior for a study site, including crown fire activity. Though they use some of the same basic equations (e.g. Rothermel, 1972), current models for predicting fire behavior and spread (BehavePlus, FlamMap, Farsite) utilize the fire behavior fuel model format (e.g. Anderson, 1982 and Scott and Burgan, 2005) in combination with vegetation canopy characteristics. Scott and Burgan (2005) is the most recent and comprehensive description of fire behavior fuel models available, and will suit the needs of the fire behavior portion of this project. These fuel models, designed primarily for modeling surface and crown fire at the flaming front (vs. post frontal combustion) do not translate easily into inputs for emissions estimates, however. We did attempt a translation of fire behavior fuel models for use in emissions models, with limited success (described below).

For the most accurate emissions estimates, we would ideally have all the data inputs for all fuel strata characteristics (such as duff and litter loading, shrub cover, dead fuels, etc) available to us for an entire study area at some small resolution (e.g. 10m). Among the fuel models used in the three primary emissions estimate programs (FCCS, SAF/SRM/NVCS vegetation cover types, NFDRS) the FCCS fuel models are included for use in all three. Additionally, the FCCS system allows for the most detailed description of fuel profiles. FCCS fuel models have been mapped from LANDFIRE vegetation characteristics for the western United States. The availability, flexibility and detail of the FCCS fuel models warrant their use in the ERC framework. The Consume model makes the best use of the detailed FCCS fuel bed descriptions.

4.2 Methods

We estimated baseline emissions for forested areas in Shasta County using mapped FCCS fuel models obtained from the LANDFIRE database (shown in Fig. 7). This process required first using fire behavior fuel models (Scott and Burgan, 2005) and canopy data from LANDFIRE to estimate baseline fire behavior for Shasta County (see section 5 for further details) in FlamMap. This allowed us to estimate the proportion of the forest canopy consumed in each FCCS fuel type, an input required in Consume. We then calculated acreage for each FCCS forest fuel type in Shasta County. For the emissions modeling, we input each FCCS fuel model, its fuel characteristics, and its acreage into Consume. We used the default (unmodified) FCCS fuel model characteristics for each fuel model. Tab. 4 summarizes the “preburn” fuel loading for forested areas in Shasta County after we input all fuel models. We were then able to simulate fire under a “very dry” weather scenario, where 10 hour fuel moisture was 6%, 1000 hour fuel moisture was 10%, and duff fuel moisture was 25%. Tab. 5 summarizes our estimates of emissions for forested areas of Shasta County modeled under this scenario.

In a separate project (described in Saah et al., 2010), we estimated emissions for four study areas in the Sierra Nevada Mountains of California, again using FlamMap and Consume. However for this project we used fuel models and canopy data from the LANDFIRE database, as well as fuel model and canopy data gathered from local field studies, in order to compare the emissions results. We also attempted to use fire behavior fuel models (Scott and Burgan, 2005) instead of FCCS fuel models in Consume, in order to assess the feasibility of this method. Similar to our simulations in Shasta County, we first modeled fire behavior in FlamMap, in order to estimate percent of the forest canopy consumed by fuel model. Next, we created our own custom fuel models by manually entering dead/downed and live surface fuel loading information published for each of the standard fire behavior fuel models, in order to use these models (instead of FCCS models) in Consume. We repeated this process for each fuel model mapped in each study area, and then simulated fire under a "very dry" weather scenario (described above), and determined the total emissions by acreage.

4.3 Results

In the emissions estimation for Shasta County, 29 FCCS fuel models were represented in the forested areas analyzed (Fig. 7). Total preburn fuel loading averaged over all fuel models was 60.08 tons/acre, with 22.5 tons/acre in the forest canopy, 2.7 tons per acre in the shrub layer, 0.2 tons/acre in the herbaceous layer, 16.7 tons/acre in the dead and down woody fuels layer, 1.9 tons/acre in litter, lichen, and moss, and 16.2 tons/acre in ground fuels (duff, basal accumulations, and squirrel middens). Canopy consumption in the various fuel models ranged from 13 to 94%. Fire simulation for the study area resulted in 55.42 tons/acre of total pollutants, with 53% of emissions resulting from smoldering or residual combustion (as opposed to flaming combustion).

For the four study sites in the Sierra Nevada, we were able to make emissions estimates using fire behavior fuel models, but the only publicly available data for these models was for surface fuels <3" in diameter and canopy fuels. This allowed for modeling fire at the flaming front and in the canopy only, not post-frontal or residual combustion (e.g. smoldering, burning of large woody debris, etc.). Using locally gathered data, total pollutant emissions were estimated to be 28.2, 28.7, 14.8, and 10.6 tons/acre for the Kings River, Last Chance, Plumas-Lassen, and Sagehen study sites respectively. Using national LANDFIRE data, total pollutant emissions were estimated to be 31.4, 42.0, 38.9, and 29.9 tons per acre for Kings River, Last Chance, Plumas-Lassen, and Sagehen respectively. LANDFIRE-based estimates were 11%, 47%, 163%, and 181% greater than local data-based estimates.

4.4 Discussion

The Sierra Nevada study described above highlights the limitations of using fire behavior fuel models for estimating emissions. Because the fire behavior fuel models characterize only those fuel elements needed for predicting surface fire behavior (and crown fire behavior if canopy data is available), this method limits emissions predictions to only those produced from the flaming front. It is clear that in order to estimate both fire behavior/hazard and emissions we will need two separate classification systems. The most descriptive and site specific fuel models are those described by Scott and Burgan (2005), which feed directly into the most commonly used fire behavior prediction models and programs (e.g. BehavePlus, FlamMap, and Farsite). These programs also allow you to create use custom fire behavior fuel models or adjust standard models to allow for fuel profiles that don't fit the standard models.

The emissions estimates made for Shasta county demonstrate the feasibility of using the FCCS fuel model format for our ERC framework. The FCCS format allows for much more complex descriptions of fuel beds than do other fuel classification systems. The >300 standard fuel models in the FCCS are built into all three of the major emissions models considered here –

Consume, FEPS, and FOFEM. Of these, Consume appears to make the best use of the different fuel strata described in the FCCS format. It also allows the user to create new fuelbeds in the FCCS format or customize standard models, when standard models don't fit the study area. If field data is collected to classify a study are in the FCCS format, some additional information would be needed to translate data into the fire behavior fuel model format, including surface area to volume information, moisture of extinction, and heat content. The FCCS program will, however, make suggestions for crosswalking an FCCS fuel model into a fire behavior fuel model. Overall, the FCCS format, with the addition of the fire behavior fuel characteristics mentioned above, would be enough information to make both fire behavior estimates as well as emissions estimates.

If using separately derived datasets for fire behavior fuel models and emissions fuel models, caution should be exercised to make sure models are consistent between datasets, especially when making fire behavior and emissions estimates on small scale projects. In addition, it is important to remember that FCCS mapping in the LANDFIRE database are derived from vegetation maps, also in the database. LANDFIRE data is intended for regional or broad scale analysis or planning efforts, and as such is generally appropriate for studies such as those considered here (e.g. Shasta County). For smaller scale, local studies, other data sources may be more appropriate.

5. Baseline Fire Hazard Assessment

5.1 Background

To measure potential change in fire behavior, we must first establish a baseline, which in this case is an estimation of potential fire behavior for a study area prior to any treatment scenarios proposed. We can then simulate modifications to the landscape, estimate fire behavior again, and measure potential changes. Changes in fire behavior can also be used as inputs into emissions models, to examine changes in potential emissions. As noted earlier, these changes are conditional on a fire occurring in a given area, which can vary considerably. We performed a baseline fire behavior assessment of Shasta County for this purpose.

5.2 Methods

Mapped data for fire behavior assessment were downloaded from the national LANDFIRE database for Shasta County, representing the most current, best coverage, and readily available data. These data layers comprised the typical landscape "data stack" used in current spatial fire behavior models, including 30m resolution maps of fire behavior fuel models, elevation, slope, aspect, canopy height, canopy cover, canopy base height, and canopy bulk density. LANDFIRE data is already co-registered for use in fire behavior programs and geographic information systems. We projected the LANDFIRE data into a UTM coordinate system in preparation for analysis. Weather inputs (temperature, humidity, and fuel moisture) for fire behavior simulations were created for three weather severity scenarios: 90^{th}, 95^{th} and 97.5^{th} percentile. The weather conditions for each scenario were determined by examining historical weather data in the program Fire Family Plus (USDA Forest Service, 2002). Spatially explicit wind conditions under each of these weather scenarios were derived at 100m resolution in WindNinja software using a typical general direction and wind speed estimated from historical analysis. Potential fire behavior was modeled using landscape, weather, and wind inputs in the fire behavior simulation program FlamMap (Finney, 2006). FlamMap does not simulate fire spread, but rather burns the entire landscape "instantaneously" to give a snapshot of potential fire behavior for the given landscape and conditions. Though a variety of outputs and measures are available, we chose to estimate flame length, fire line intensity, and crown fire activity. Flame length can be used as a measure of suppression difficulty, and fire line intensity as a measure of potential fire severity. Crown fire activity is of primary concern as well, as fuel treatments are aimed at preventing large "catastrophic" wildfires, or those that consume most or all of the forest canopy.

5.3 Results

Flame lengths in wildlands (areas with burnable vegetation) across Shasta County averaged 9.4 m, ranging from 0.1 to 237.2 m. Areas of highest flame length were generally concentrated in the forested areas of the southeast, and the mountainous areas of the north and west (Fig. 8). Fireline intensities followed a similar pattern, averaging 11,714 kW/m, ranging from 3.19 to >800,000 kW/m. The majority of forested vegetation (57%) experienced high crown fire activity (crown fire activity class 3 – active crown fire; see Tab. 6).

We also classified fire behavior characteristics into three categories: low, medium and high. Flame length classes were determined using fire suppression benchmarks as follows: Low = <1.2 m (4 ft) = fire can generally be attacked at the head or flanks by persons using hand tools, Med = 1.2 m (4 ft) – 2.4 m (8 ft) = fires are too intense for direct attack with hand tools, but equipment such as plows, dozers, pumpers, and retardant aircraft can be effective, and High = >2.4 m (8 ft) = fires present major control problems, i.e. torching, crowning, and spotting (Pyne et al., 1996). Fireline intensity classes, which correspond to flame length classes, were calculated using the following equation (Pyne, 1996):

$$I = 259.833(L)^{2.174}$$

where:

I = Fireline Intensity (kW/m)

L= Flame Length (m)

Crown Fire Activity is automatically predicted by FlamMap in three classes, where 1 = Low = No crown fire activity, 2 = Med = Passive crown fire activity or individual tree torching, and 3 = High = Active crown fire. Independent (running) crown fire activity is not modeled in FlamMap. Fire behavior was summarized by class and general vegetation cover type (Fig 9). In all three vegetation types, the majority of the study area is predicted to burn in the high classes for flame length and fireline intensity. For forested areas, crown fire activity is predicted to be "high" (class 3) for the majority of the study area. This is likely due to the fact that our fire behavior predictions were made under 97.5^{th} percentile weather conditions (i.e. severe fire weather).

5.4 Discussion

These regional (countywide) estimates of potential fire behavior seem consistent with the severe fire weather conditions under which they were modeled, with approximately 50 to 80% of the landscape burning in "high" fire severity classes (Figs. 8 and 9). This suggests that under these extreme conditions (97.5^{th} percentile) a majority of the landscape is at risk of fire that is difficult to control (high flame lengths and fireline intensities) and damaging to the forest canopy (high crown fire activity class). The primary goals of fuels treatments are to reduce the risk of high severity, large scale, highly damaging wildfire, as well as the potential for large smoke emissions into the atmosphere. This assessment can be considered an estimate of current fire hazard within the study area prior to any proposed future treatments. Changing the landscape data inputs to simulate treatments and running simulations again will allow us to detect potential changes from treatments. Additionally, these data serve as vital inputs into several other parts of our framework (Fig. 1), including the delineation of firesheds and estimates of potential emissions.

Our baseline fire hazard assessment used national LANDFIRE data for landscape and vegetation characteristics, as this is the only dataset available for the entire county that will support fire behavior analysis. It is important to note that these data, while high resolution (30 m), are generally intended to support regional scale analysis. While Shasta County may be considered "regional", we did note some discrepancies in the LANDFIRE data that may suggest smaller scale analyses are warranted. Specifically, there appeared to be some linear differences in mapped canopy characteristics in the northern part of the county, which could have been due to consolidation of different mapping efforts, or to lag time in updating data for different parts of the county. It would be worth investigating the source of these linear changes in mapped data to make sure we have the most current and accurate representation of the landscape. Additionally, it will be important to track whether these data are updated in the LANDFIRE database, because in an assessment of fuel treatment effects, we will want to isolate change due to treatments, as opposed to change from other sources. This will necessitate using the same base data in both pre- and post- treatment analyses.

6. Conclusions

The information gained from investigating the four topics in this report (i.e. relative fire probabilities, fireshed delineations, fuel classification standards, and baseline fire hazard) is intended to support our general framework for estimating potential changes to fire hazard and smoke emissions due to fuel treatments on the landscape (Fig. 1). This in turn should provide a scientific basis for estimating potential ERCs that can be tied to on-the-ground fuel treatment activities. While development is still ongoing, this work strengthens the foundation for a scientifically sound, contemporary and rigorous model of change that can support the process of carbon accounting. The framework was developed with many criteria in mind. Among these are the following: (1) the framework must make use of the most current models, technology, and information; (2) it must focus on an appropriate scale of analysis; (3) it must be able to account for appropriate variables that may affect its outcomes; (4) it must be scalable, not only spatially but relative to data availability; and (5) it must be spatially explicit in its outputs. Each of the elements addressed in this report can be evaluated in terms of these criteria.

The fire probability mapping methodology shows promise as a way of estimating long-term expected fire return intervals for an area, which is critical if one is to estimate the true value of fuel treatments in one area over another. It uses not just a singular estimate of fire risk (e.g. historical locations), but instead takes into account our best knowledge of the many factors that affect how fire-prone a particular area may be (e.g. long-term fire patterns and a myriad of environmental variables). It is scalable in that we can add spatially explicit data on any number of factors (e.g. road density or proximity to urban centers) and use training data to determine how significant these factors are. It is spatially explicit, but generally limited to the resolution of our input data, particularly climate data. It is, however, well suited to coarse-scale questions of fire return intervals, as opposed to fine-scale fire behavior at the stand level. To some degree, models may be "location specific" such that separate models might need to be developed for very different fire environments.

Our fireshed delineation methodology is a novel way of focusing our analysis on an appropriate scale. It improves on current methods, based on "problem fire" analysis, management constraints, and expert opinion, by adding an ecologically and statistically based element to the process. Though we focused on fuels, weather, topography, fire risk, fire behavior, fire barriers and fire history to delineate our watersheds, the process is flexible enough to allow use of other environmental variables that may help refine or create fireshed boundaries. A primary challenge lies in defining what constitutes a "homogenous" unit to use as the basis for creating firesheds. We chose to start with subwatersheds (HUC12), but other units may be more appropriate, such as forest "stands". However, this type of data may not be available or appropriate for the regional type analysis done here.

The FCCS and fire behavior fuel model formats appear to be the most appropriate for use in the ERC framework. The FCCS and fire behavior fuel model formats feed into the most current fire behavior and emissions models. The FCCS format, with a few fire behavior variables added, allows for a very detailed description of fuel profiles. To the extent that we can apply homogenous fuel profile classifications to particular areas, they are spatially explicit and scalable. We can use data from various sources for these two fuel model formats, including the national LANDFIRE database which includes maps of both for the western United States. For smaller scales, we can use locally collected data to create or classify areas into fuel models. The fire pollutant emissions estimates made for Shasta County demonstrate, at least on a regional scale, how these fuel models can be applied in our ERC framework.

The fire behavior assessment for Shasta County performed here demonstrates how we can create a baseline for assessment of fire hazard change. We used the most widely accepted spatial fire behavior models (Rothermel, 1972; Finney, 2006) to predict fire behavior characteristics on the current landscape under a severe fire weather scenario. We used LANDFIRE data at 30m resolution, though our analysis may not have warranted this high level of specificity. The fire behavior models are able to account for different resolutions of data, and are not necessarily affected by the size of the landscape. Because of the LANDFIRE database, data availability was not an issue, but rather data quality was in question (regarding crown fire characteristics). Using more locally gathered data (as opposed to the remotely sensed LANDFIRE) is possible in this process, and it may be warranted in finer scale analyses or smaller study areas. The models are expandable in that one can create custom fuel models for input, as well as adding supplemental data on canopy characteristics and ground fuels.

Further development of the framework is in progress to quantify treatment effects on vegetation and on fire behavior (both within treatment areas and in shadow areas) using the Forest Vegetation Simulator model (Dixon, 2002). We are continuing to refine the fireshed delineation process, looking at additional spatial multivariate clustering techniques. Fire probability mapping is being refined through additional model validation and sensitivity analyses. We are continuing to explore the use of FCCS and fire behavior fuel models in emissions models, including the BlueSky Framework. In summary, our work demonstrates that an integrated set of quantitative models can make many of the most complex issues inherent in wildfire emissions accounting a tractable problem.

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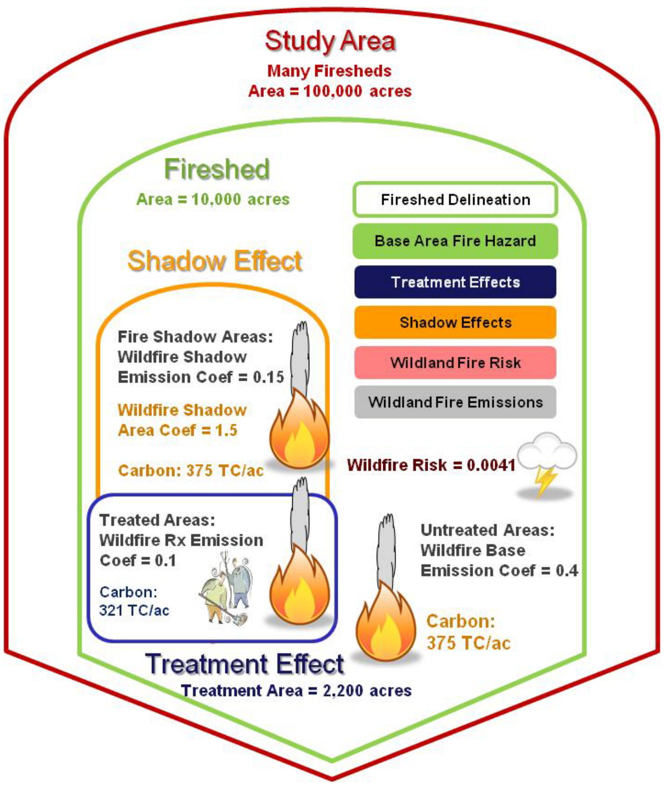
8. Figures and Tables



Fireshed ERC = Pre-Rx CO_2 – Rx CO_2

PRE-Rx CO_2 Estimate

BASE AREA EMISSIONS

= (375 TC/ac * 3.66 CO_2/TC * 10,000 ac * 0.4 * 0.0041)

Rx CO_2 Estimate

BASE AREA EMISSIONS

[375 TC / ac * 3.66 CO_2 / TC * (10,000 ac – 2200 ac – (1.5 * 2200)) * 0.4 * 0.0041]

SHADOW AREA EMISSIONS

+ [375 TC / ac * 3.66 CO_2 / TC * (1.5 * 2200) * 0.15* 0.0041]

TREATMENT AREA EMISSIONS

+ [321 TC / ac * 3.66 CO_2 / TC * 2200 * 0.1 * 0.0041]

Figure 1: Conceptual framework for estimating potential wildland fire emission reduction credits for a particular fireshed. Major elements of the process include fireshed delineation, estimation of base area, treatment area, and shadow area fire hazard and emissions, and estimation of wildfire risk. The fireshed is the major unit of analysis. Treatments are fuels reduction projects such as thinnings or prescribed fire. Fire shadows are areas outside treatments that are affected by treatments in terms of fire hazard or emissions. CO_2 emissions estimates (pre and post treatment) are a function of total stored carbon, CO_2 contained per mass of carbon, size of fireshed, emission coefficient, and wildfire risk.

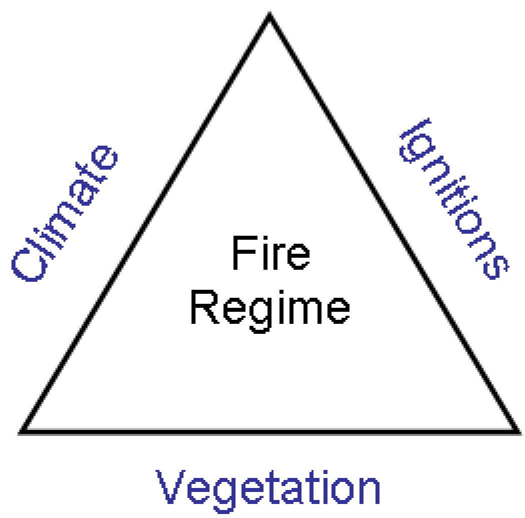
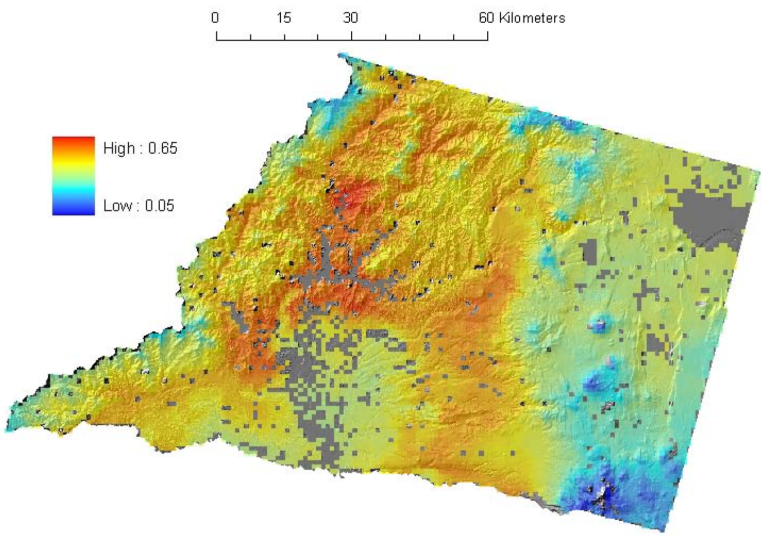


Figure 2: Controls on a fire regime. The vegetation axis incorporates fire-related characteristics of the plant community, such as biomass productivity rates, canopy structure, and chemical flammability characteristics. The climate axis represents atmospheric conditions conducive to combustion, such as how intense and how often hot, dry, windy conditions occur. The ignitions axis captures the spatial and temporal patterns of both human and natural sources of fire. (Modified from Moritz et al. 2005).

a)



b)

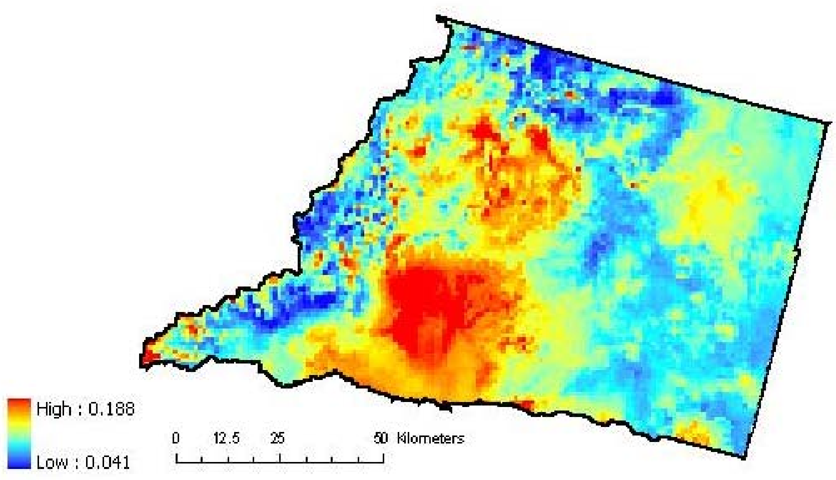


Figure 3: Example of mean (a) and standard deviation (b) of the relative fire occurrence probability of four model scenarios for Shasta County, California. The combination of models included 2 different variable sets (32 variable ensemble and 15 variable ensemble), and 2 different fire size thresholds in each region (1000 acre and 5000 acre). Relative fire occurrence probability values range from 0 to 1.

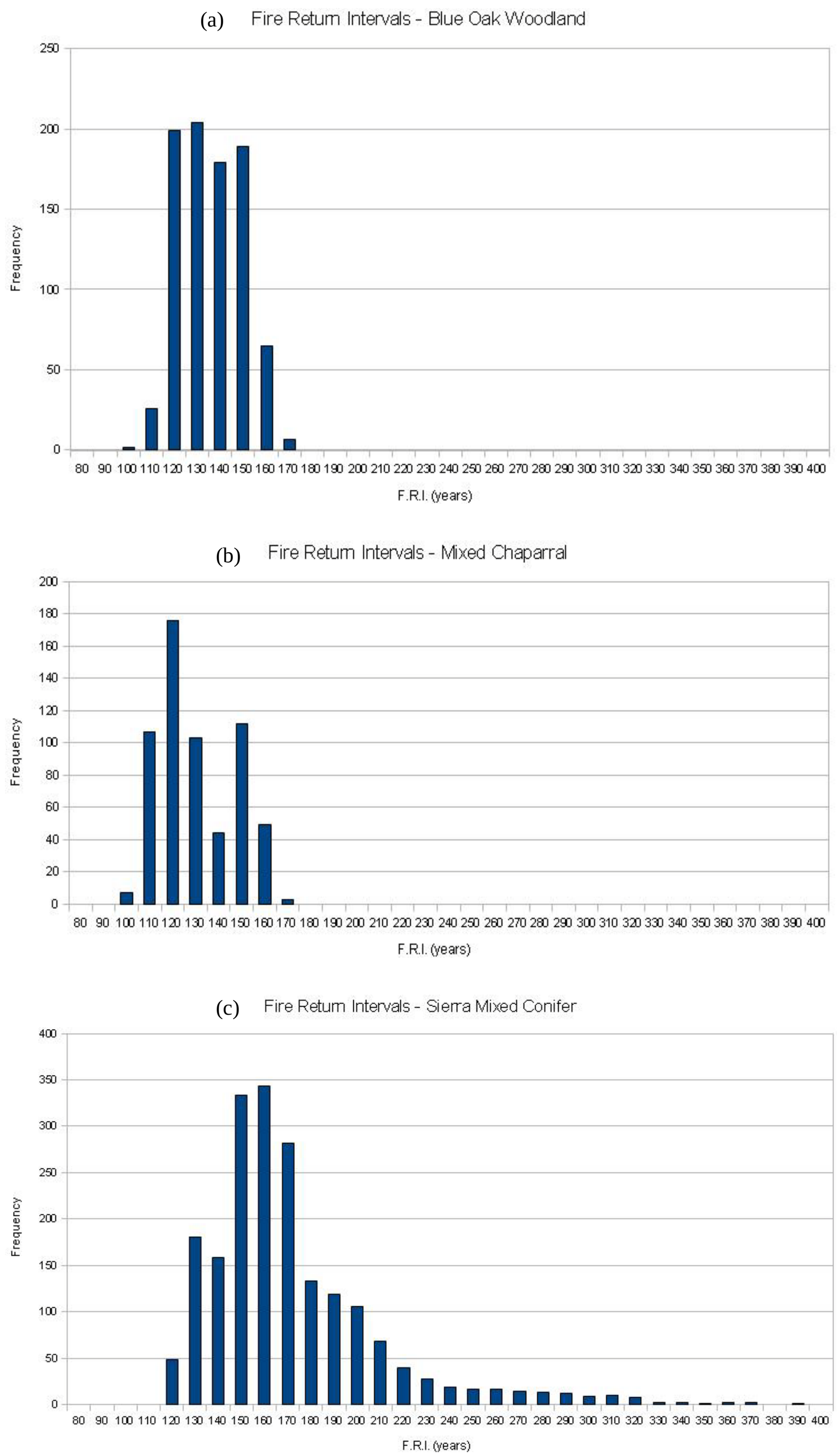


Figure 4: Histograms of fire return intervals by vegetation type: (a) Blue oak woodland, (b) mixed chaparral, and (c) Sierra mixed conifer. Fire return intervals are calculated based on transformation of relative fire probabilities and historical burning rates for Shasta County over 2001-2007 (from example models shown in Fig. 3).

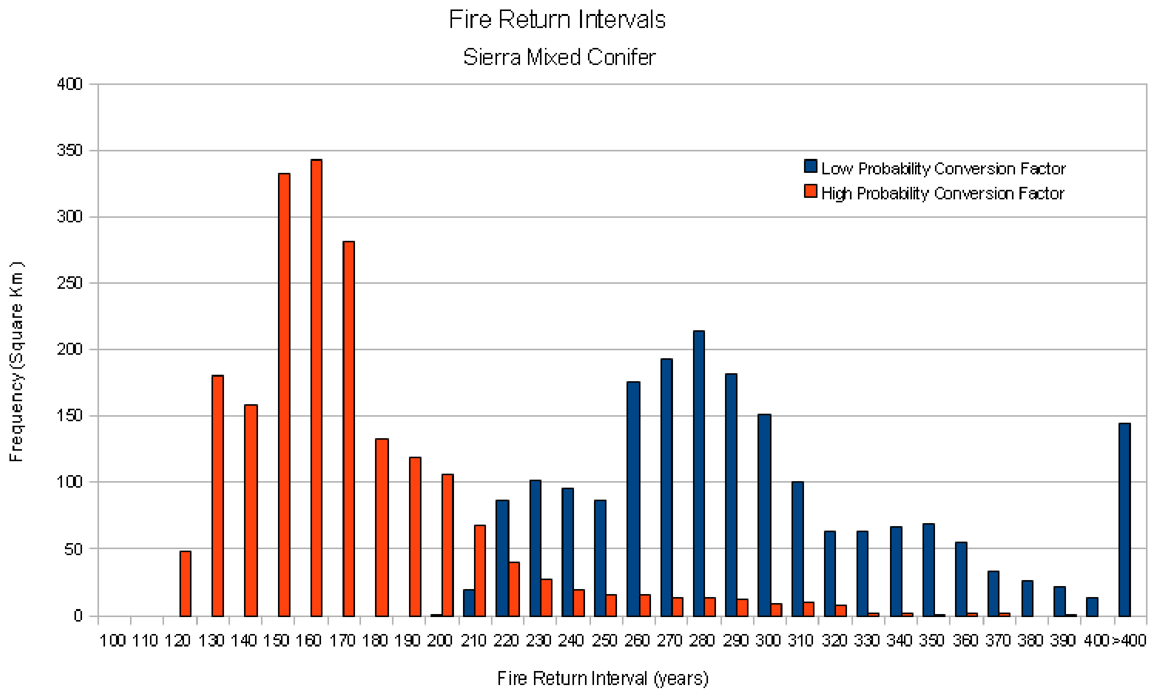


Figure 5. Fire return interval distributions for Sierra Mixed Conifer forest in Shasta County, given different conversion factors for transforming relative mapped fire occurrence probabilities to fire return intervals. The “Low Probability” conversion factor is based on the area burned over the full 1950-2007 period, while the “High Probability” conversion factor is based on area burned during 2001-2007. Here the full 1950-2007 period of record results in much lower fire return intervals (e.g. median = 157 yr, mean = 166 yr) than using the more recent 2001-2007 period (e.g. median = 281 yr, mean = 297 yr).

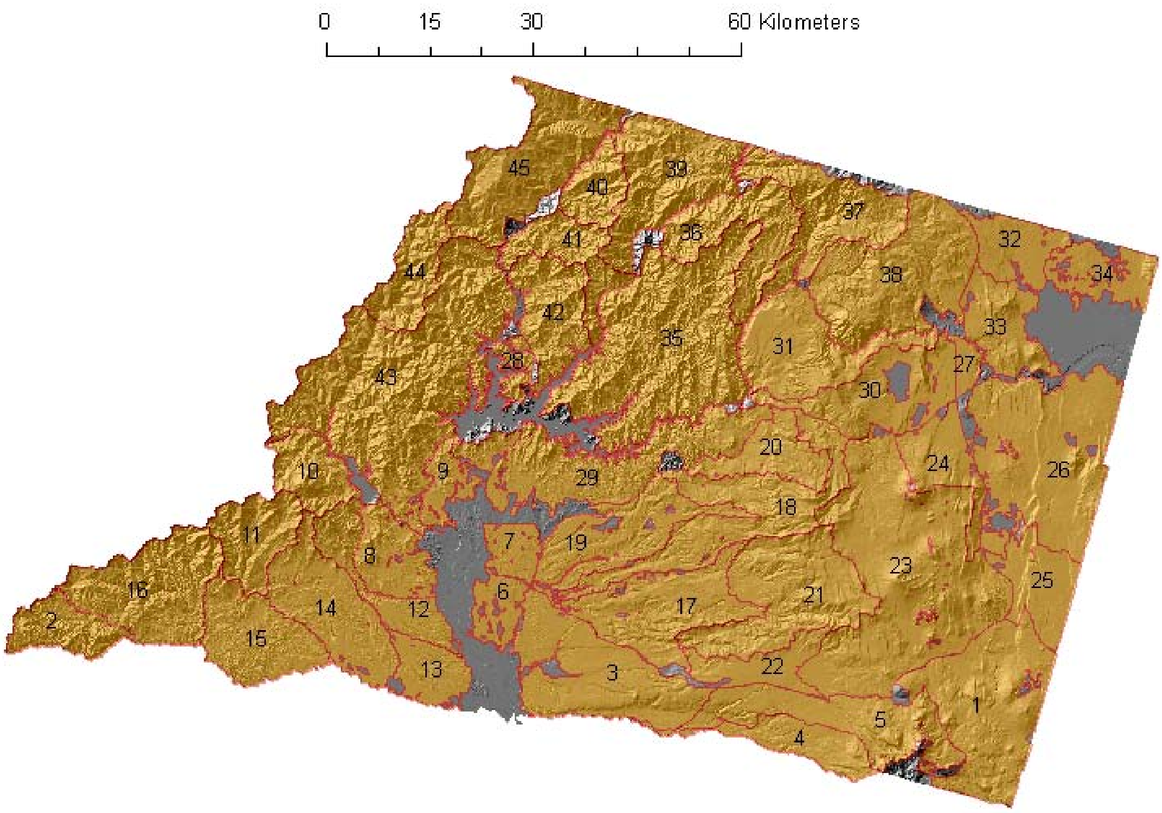


Figure 6: Firesheds delineated for Shasta County, California. Areas not enclosed by a fireshed are non-wildland/non-burnable, i.e. water, urban, agricultural, or barren.

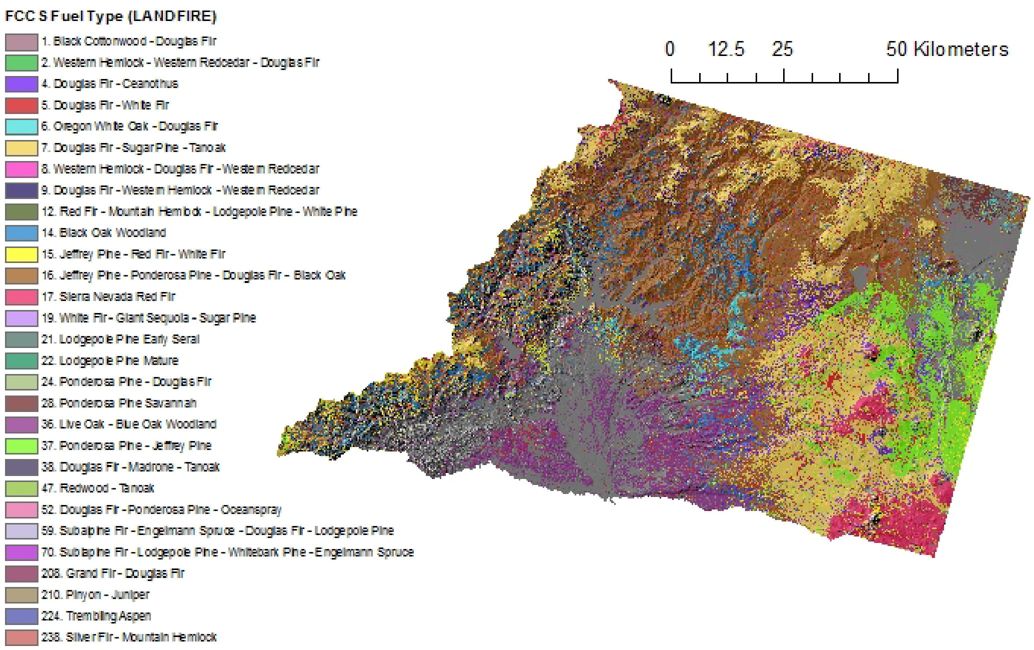


Figure 7: FCCS Fuel Types mapped for forested areas in Shasta County, CA from the National LANDFIRE Database.

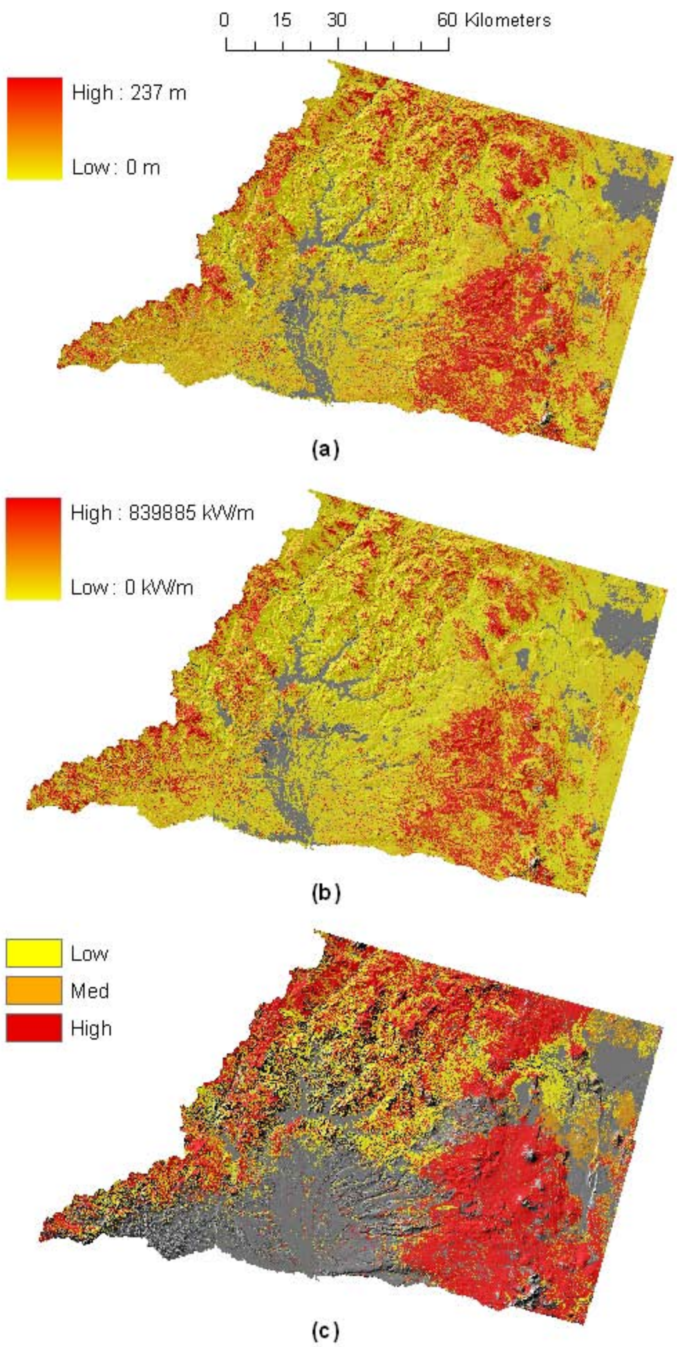


Figure 8: Baseline fire hazard assessment for Shasta County, California. (a) Flame Length (m). (b) Fireline Intensity (kW/m). (c) Crown Fire Activity Class (forested areas only)

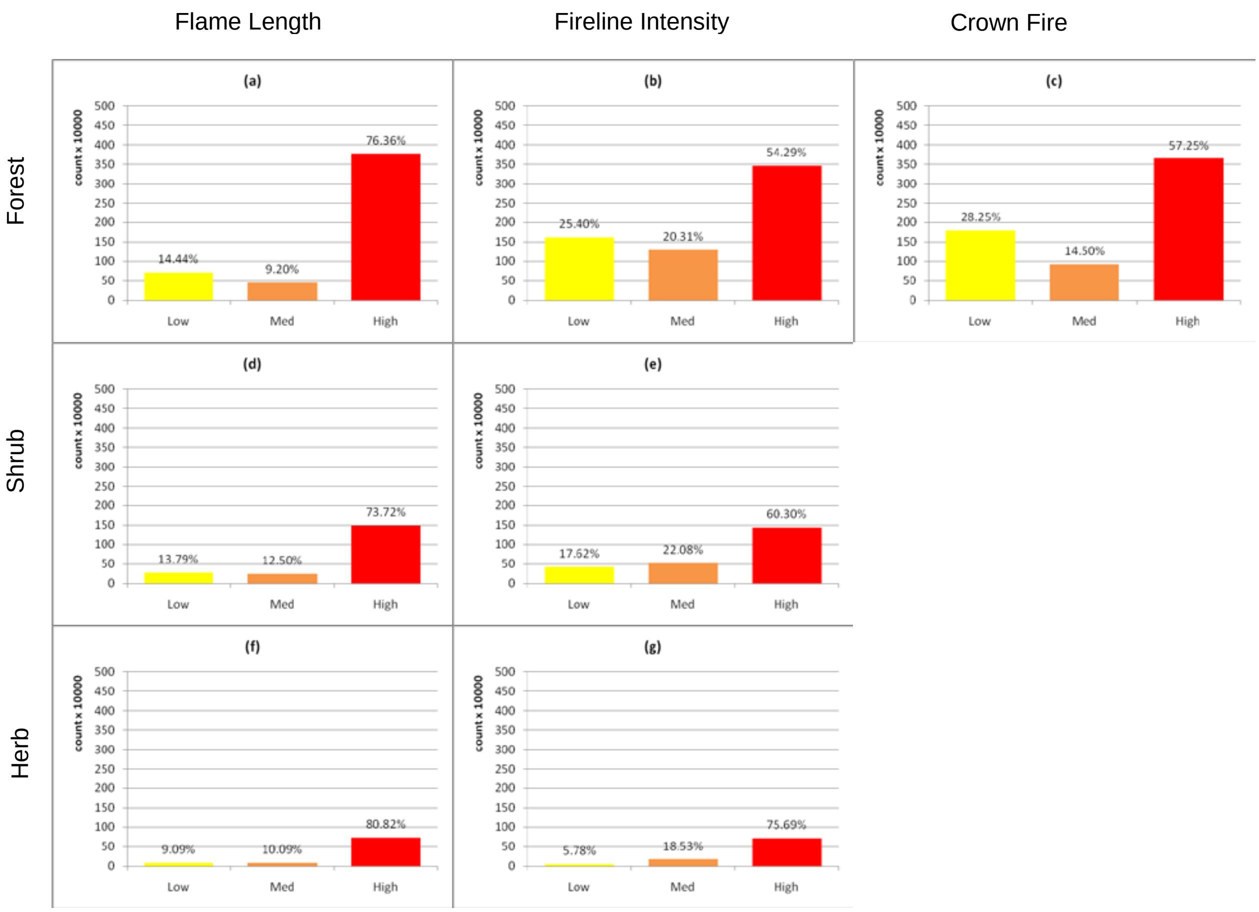


Figure 9: Baseline fire behavior characteristics for Shasta County, California, separated by general vegetation type (NLCD). Flame Length: Low = 0 - 1.2m, Med = 1.2 - 2.4m, High = >2.4m. Fireline Intensity: Low = 0 – 346 kW/m, Med = 346 – 1730 kW/m, High = >1730 kW/m. Crown Fire Activity: Low = surface fire, Med = passive or torching crown fire, High = active crown fire.

Predictor Variable	**Description**	**Strongest Correlations (32)**	**Strongest Correlations (15)**
Balance	Annual water balance (PPT-PET), monthly carryover	ppt_ann (0.98); maxm_ba(0.97)	
Defcapz	Annual Deficit: Water Balance, no monthly carryover	ppt_ann (0.88); maxm_ba(0.85)	**maxm_ba(0.85)**
Elev	Elevation	humann (-0.85); tmaxmea (-0.84)	
Humann	Annual average vapor pressure (absolute humidity)	all humidities (>0.94)	
Humhigh	Highest monthly average vapor pressure	all humidities (>0.94)	
Humlow	Lowest monthly average vapor pressure	all humidities (>0.94)	
Maxm_ba	Maximum monthly water balance	pmaxm_l(0.99); ppt_ann(0.99)	**pmaxm_l(0.99)**
Minm_ba	Minimum monthly water balance	minm_de(1.00); petm_mm (-0.93)	**petm_mm(-0.93)**
Minm_de	Minimum monthly deficit	minm_ba(1.00)	
Mnths_a	Number of months at deficit	ppt_ann(-0.93); maxm_ba(-0.93)	
Pcpfrqa	Annual precipitation frequency	pcpfrqw(0.91)	
Pcpfrqd	Lowest monthly precipitation frequency	pminm_l(0.84);vpdm_mi(-0.83)	**pminm_l(0.84)**
Pcpfrqw	Highest monthly precipitation frequency	pcpfrqa(0.91)	**defcapz(0.82)**
Pet_yea	Annual potential evapotranspiration (PET)	petmin(0.80)	
Petm_mm	Maximum monthly potential evapotranspiration	minmde(-0.93);minmba(-0.93)	**minm_ba(-0.93)**
Pet_min	Minimum monthly potential evapotranspiration	radlow(0.85);pet_yea(0.80)	**radlow(0.85)**
Pmaxm_l	Maximum monthly precipitation	maxmba(0.99);ppt_ann(0.98)	**maxm_ba(0.99)**
Pminm_l	Minimum monthly precipitation	pcpfrqd(0.84)	**pcpfrqd(0.84)**
Ppt_ann	Annual precipitation	maxmba(0.99);pmaxm_l(0.98)	
Radann	Annual radiation	radlow(0.87)	
Radhigh	Maximum monthly radiation	humhigh(-0.77)	**petm_mm(0.64)**
Radlow	Minimum monthly radiation	radann(0.87)	**pet_min(0.85)**
Rangem_	Maximum minus minimum monthly water balance	pmaxm(0.98);ppt_ann(0.97)	
Relativ	Maximum monthly relative humidity	rltvmin(0.68)	**rltvmin(0.68)**
Rltvmin	Minimum monthly relative humidity	minm_de(0.69)	**minm_ba(-0.69)**
Tmax_mi	Maximum minus minimum monthly temperature	tminm_l(-0.59)	
Tmaxm_l	Maximum monthly temperature	tmaxmea(0.91)	**pminm_l(-0.51)**
Tmaxmea	Mean maximum monthly temperature	tmaxm_l(0.91)	
Tminm_l	Minimum monthly temperature	tminmea(0.90)	**pcpfrqd(-0.73)**
Tminmea	Mean minimum monthly temperature	tminm_l(0.90)	
Vpdm_ma	Maximum monthly vapor pressure deficit		
Vpdm_mi	Minimum monthly vapor pressure deficit	tmaxmea(0.83);pcpfrqd(-0.83)	

Table 1: Predictor variables used in Maxent fire probability analysis. Bolded variables are members of the reduced 15-variable set.

Fireshed	NLCD Cover Type	Area (Acres)	Fire Probability	St. Dev.	Windspeed (mph)	St. Dev.	Topographic Roughness Index	St. Dev	Surface Flame Length	St. Dev.	Surface Fire Line Intensity	St. Dev	Crown Fire Activity Class
1	42	85157	0.261	0.054	23.53	3.79	1.019	0.017	27.88	22.88	42526.42	45943.67	3
2	42	24859	0.389	0.061	21.90	4.02	1.081	0.030	20.95	25.18	37142.80	50837.22	1
3	71	73845	0.461	0.050	24.25	1.91	1.006	0.008	7.89	12.00	9219.33	20322.60	1
4	42	25997	0.447	0.103	22.80	2.86	1.015	0.015	37.10	20.38	58395.47	41651.88	3
5	42	56444	0.339	0.140	23.65	3.91	1.029	0.034	30.45	23.58	47855.28	46991.94	3
6	71	14817	0.392	0.018	23.86	0.50	0.999	0.001	3.66	5.77	3995.48	8698.73	1
7	71	13811	0.433	0.014	23.85	0.56	1.000	0.002	2.84	4.96	2493.71	6219.85	1
8	52	27656	0.551	0.045	24.02	2.30	1.021	0.020	7.59	11.42	10513.81	18390.39	1
9	43	21696	0.538	0.058	23.76	2.52	1.026	0.025	9.25	12.01	12346.17	17856.13	1
10	42	25386	0.454	0.065	23.36	6.03	1.080	0.029	22.89	28.42	39622.69	62399.55	3
11	42	31825	0.409	0.061	23.63	5.96	1.086	0.038	21.48	25.82	37844.96	55103.24	1
12	52	29314	0.490	0.046	23.93	3.15	1.031	0.032	11.72	17.65	16694.34	34450.85	1
13	71	21114	0.427	0.024	24.28	0.66	1.002	0.003	5.51	8.36	5938.57	12938.56	1
14	52	53956	0.464	0.041	23.57	1.94	1.013	0.017	7.01	10.56	9992.59	18841.11	1
15	71	45640	0.478	0.030	23.66	1.82	1.025	0.014	4.16	4.23	6489.12	10091.28	1
16	52	62906	0.450	0.056	23.22	4.45	1.084	0.039	12.12	19.04	22309.27	38500.74	1
17	52	58341	0.490	0.040	23.51	2.00	1.015	0.013	11.02	15.37	13855.82	25817.41	1
18	42	68791	0.473	0.071	23.73	2.94	1.022	0.015	23.53	26.01	37999.19	52900.25	3
19	71	48316	0.466	0.055	24.02	1.59	1.012	0.010	6.01	10.77	6777.27	16122.49	1
20	52	27252	0.498	0.077	23.32	2.52	1.020	0.015	16.49	19.29	22852.63	35789.26	1
21	42	72889	0.456	0.073	23.22	3.47	1.029	0.019	39.64	23.23	65215.90	51140.19	3
22	42	23030	0.478	0.032	23.76	2.28	1.005	0.010	38.32	17.69	59289.26	36624.68	3
23	42	159183	0.343	0.051	23.32	3.96	1.017	0.017	38.94	22.66	63242.75	50716.30	3
24	42	27912	0.378	0.031	22.30	3.27	1.016	0.019	21.14	18.47	28548.09	34928.18	3
25	52	31802	0.353	0.038	22.55	2.59	1.009	0.017	8.90	8.70	8312.21	11425.16	2
26	42	105654	0.390	0.029	22.84	2.30	1.008	0.016	7.00	6.99	6055.81	8795.58	2
27	42	6335	0.400	0.014	22.64	1.03	1.004	0.007	2.13	3.55	1334.84	3606.07	1
28	52	9045	0.579	0.016	24.15	3.58	1.058	0.024	5.50	10.96	6261.22	15291.73	1
29	42	70176	0.537	0.044	24.01	2.84	1.037	0.029	6.34	12.09	7902.42	18583.90	1
30	42	47571	0.395	0.044	23.41	3.39	1.016	0.019	11.89	13.35	13755.52	20642.89	2
31	42	53530	0.472	0.049	23.22	4.14	1.036	0.033	20.87	24.60	33088.39	45362.09	1
32	42	25018	0.425	0.007	22.65	1.11	1.001	0.004	14.86	15.03	18262.21	22094.65	2
33	42	31906	0.418	0.015	23.63	3.85	1.021	0.020	9.36	14.56	11660.11	23128.72	1
34	42	25027	0.409	0.014	22.37	2.25	1.003	0.014	4.38	5.24	3220.77	6196.15	2
35	42	133539	0.500	0.030	23.88	5.45	1.106	0.028	14.80	19.44	21026.21	32392.10	1
36	42	45897	0.480	0.050	24.06	5.87	1.099	0.035	30.32	22.44	46920.29	41973.13	3
37	42	53928	0.405	0.084	22.59	5.78	1.081	0.041	25.48	19.45	36513.80	33984.80	3
38	42	83237	0.401	0.054	23.76	4.14	1.041	0.034	31.85	23.73	50593.86	46479.19	3
39	42	60599	0.505	0.043	22.88	6.19	1.108	0.036	24.31	21.93	36168.83	40813.26	3
40	42	20114	0.534	0.028	23.32	6.59	1.108	0.020	20.82	23.43	31915.16	44101.77	1
41	42	29433	0.521	0.036	23.25	6.63	1.123	0.025	14.88	18.81	20581.44	31712.53	1
42	42	37955	0.575	0.039	24.12	5.62	1.093	0.035	9.70	15.55	12673.13	23807.58	1
43	42	163176	0.506	0.051	23.30	5.57	1.101	0.033	12.79	20.19	20239.04	40944.64	1
44	42	29424	0.449	0.061	25.12	5.82	1.096	0.018	34.54	27.91	58900.73	64073.70	3
45	42	67736	0.414	0.102	22.79	6.17	1.073	0.038	22.68	17.55	30692.89	30070.41	3

Table 2: Summary of fireshed attributes for Shasta County, California. NLCD indicates the land cover type code from the National Land Cover Database, 2001. Acres indicates the total number of acres in the fireshed. Fire probability values range between 0 and 1 and listed wind speed values are those expected under near-worst case scenarios. Surface flame length is listed in meters, surface fire line intensity is kW/m. Low, medium and high crown fire activity are classified as 1, 2, and 3 respectively.

Fuel Classification System	Intended Use	Intended Scale	Compatible Models/Systems (Customize fuel models?)	Fuel elements characterized	Mapped Data
Fire Behavior Prediction System (in combination with canopy data)	Surface and crown fire behavior prediction	Site Specific	BehavePlus (Yes), FlamMap (Yes), Farsite (Yes)	Dead and down woody material up to 3" diam. Live herbs and shrubs.	Entire US (LANDFIRE), Various state, local, project-based maps (various mapping methods)
National Fire Danger Rating System	Surface fire danger prediction	Broad	NFDRS (No), FEPS (YES)	Dead and down woody material up to 8" diam. Live herbs and shrubs.	Entire US (WFAS)
Vegetation cover -based classifications (in FOFEM)	Fire effects and emissions prediction	Site Specific	FOFEM (Yes)	All dead and down woody material. Live herbs and shrubs. Litter and Duff. Canopy foliage and 0-1/4" branch wood. Rotten logs.	Entire US (LANDFIRE)
Fuel Characteristic Classification System	Fire emissions prediction	Site Specific	FEPS (Yes), FOFEM(Yes), Consume (Yes)	Trees (over-, mid-, and under-story). Class 1,2, and 3 snags. Primary and secondary shrub layers. Primary and secondary herb layers. All dead and down woody fuels (sound). Rotten woody fuels >3". Sound, rotten and pitchy stumps. Piles. Litter. Lichen. Moss. Upper and lower duff layers. Basal accumulations. Squirrel middens.	Western US (LANDFIRE)

Table 3: Summary of different fuel classification systems.

Preburn Loading (tons/acre)		
Project Total		60.08
Canopy		22.46
Trees (total)		12.54
	Overstory trees	8.28
	Midstory trees	3.77
	Understory trees	0.49
Snags (total)		8.95
	Class 1 snags with foliage	4.56
	Class 1 snags w/o foliage	0.03
	Class 2 snags (wood)	3.38
	Class 3 snags (wood)	0.98
Ladder Fuels		0.97
Shrub		2.66
Primary shrub layer		2.39
Secondary shrub layer		0.27
Nonwoody		0.20
Primary nonwoody layer		0.16
Secondary nonwoody layer		0.04
Woody Fuels		16.67
Sound woody (total)		8.09
	0 to 1/4 inch	0.48
	1/4 to 1 inch	1.59
	1 to 3 inch	1.80
	3 to 9 inch	1.12
	9 to 20 inch	2.10
	> 20 inch	1.00
Rotten wood		8.01
	3 to 9 inch	1.95
	9 to 20 inch	2.72
	> 20 inch	3.34
Stumps (total)		0.57
	Sound	0.02
	Rotten	0.55
	Lightered - pitchy	0.01
Piles		0.00
Litter-Lichen-Moss		1.93
Litter		1.91
Lichen		0.00
Moss		0.02
Ground Fuels		16.17
Duff (total)		16.15
	Upper duff layer	3.86
	Lower duff layer	12.28
Basal Accumulations		0.02
Squirrel middens		0.00

Table 4: Summary of fuel loading (tons/acre) for forested areas in Shasta County, CA from Consume model simulation. Note that the different entries represent the various fuel strata in FCCS fuel beds.

	Emissions (tons/acre)			
Pollutant	**Flaming**	**Smoldering**	**Residual**	**Total**
PM	0.16	0.15	0.19	0.51
PM_{10}	0.1	0.12	0.15	0.37
$PM_{2.5}$	0.1	0.11	0.14	0.35
CO	0.82	1.39	1.8	4.01
CO_2	24.58	11.09	14.24	49.91
CH_4	0.03	0.06	0.08	0.16
NMHC	0.03	0.04	0.05	0.11

Table 5: Pollutant emissions (tons/acre) for forested areas in Shasta County, CA simulated in the Consume model under a very dry weather scenario. PM is particulate matter. PM_{10} and $PM_{2.5}$ are inhalable particulate matter less than 10 and 2.5 microns in size respectively. CO and CO_2 are carbon monoxide and carbon dioxide respectively. CH_4 is methane. NHMC is nonmethane hydrocarbon.

Kings River

Pollutant - tons/acre

	Local Data	LANDFIRE Data	% Difference
PM	0.18	0.20	11.1
PM_{10}	0.10	0.11	10.0
$PM_{2.5}$	0.10	0.11	10.0
CO	0.56	0.62	10.7
CO_2	27.20	30.32	11.5
CH_4	0.03	0.04	33.3
NMHC	0.03	0.04	33.3

Last Chance

Pollutant - tons/acre

	Local Data	LANDFIRE Data	% Difference
PM	0.18	0.27	50.0
PM_{10}	0.10	0.15	50.0
$PM_{2.5}$	0.10	0.14	40.0
CO	0.56	0.82	46.4
CO_2	27.65	40.52	46.5
CH_4	0.03	0.05	66.7
NMHC	0.03	0.05	66.7

Plumas-Lassen

Pollutant - tons/acre

	Local Data	LANDFIRE Data	% Difference
PM	0.10	0.25	150.0
PM_{10}	0.05	0.14	180.0
$PM_{2.5}$	0.05	0.13	160.0
CO	0.29	0.77	165.5
CO_2	14.28	37.50	162.6
CH_4	0.02	0.05	150.0
NMHC	0.02	0.04	100.0

Sagehen

Pollutant - tons/acre

	Local Data	LANDFIRE Data	% Difference
PM	0.07	0.18	157.1
PM_{10}	0.04	0.11	175.0
$PM_{2.5}$	0.04	0.11	175.0
CO	0.29	0.81	179.3
CO_2	10.18	28.62	181.1
CH_4	0.01	0.03	200.0
NMHC	0.01	0.03	200.0

Table 6: Fire pollutant emissions (tons/acre) for four study sites in the Sierra Nevada mountains, California. Emissions estimates are for flaming front and crown fire activity only, not ground fire or post-frontal combustion. PM is particulate matter. PM_{10} and $PM_{2.5}$ are inhalable particulate matter less than 10 and 2.5 microns in size respectively. CO and CO_2 are carbon monoxide and carbon dioxide respectively. CH_4 is methane. NHMC is nonmethane hydrocarbon. Local data estimates are those made with locally collected, field-based data. LANDFIRE data estimates are those made using only the publicly available LANDFIRE data.
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Flame Length		Fireline Intensity		Crown Fire Activity	
Min	0.13	Min.	3.19	1 (Low)	28.25%
Max	237.16	Max.	839885.25	2 (Med)	14.50%
Mean	9.44	Mean	11714.52	3 (High)	57.25%
St. Dev.	13.05	St. Dev.	22917.61		

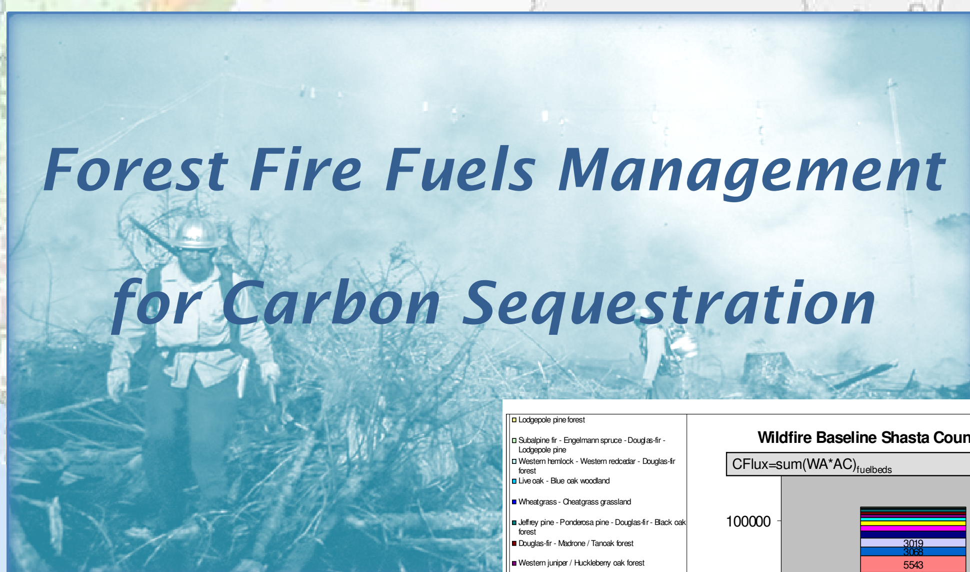
Table 7: Fire behavior characteristics for burnable wildland vegetation in Shasta County, CA. Crown Fire Activity Class is for forested vegetation only.

APPENDIX C:
Draft Protocol for Baseline Fire Emissions

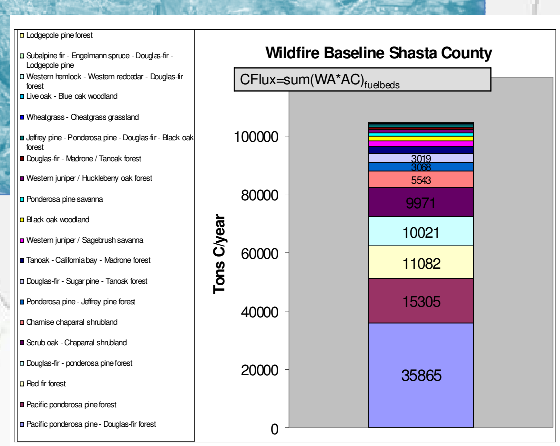
FINAL REPORT

April 19, 2008

DRAFT PROTOCOL FOR BASELINE FIRE EMISSIONS



Forest Fire Fuels Management for Carbon Sequestration



To: WINROCK International

Sandra Brown and John Kadyszewski, Co-Principal Investigators

By: DV (Sam) Sandberg

Sam's FireWorks

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Forest Fire Fuels Management for Carbon Sequestration

I Background

Objective

The objective of this assessment is to conceive a transportable methodology for establishing baseline fire activity and carbon emissions from forest fires and prescribed fires attributable to or affected by fuels management. The intent is to provide a dynamic current and future baseline of expected carbon loss from the un-treated ownerships from which to compare actual or expected future emissions from the treated ownership so that credit for carbon sequestration attributable to the management may be claimed. Context is provided by applying the baseline estimates to a trial demonstration in mixed conifer forests on selected ownership in California. Issues related to the tracking, accounting, and prediction of Carbon offsets are explored and discussed.

The central thesis of this analysis is that it is impossible to directly measure either a baseline or change over time for any area less than many tens of millions of areas. Some form of modeling will be necessary to agree on the expected annual area burned by wildfire or to assess the difference in fire risk over time or as the result of fuels treatment. Wildfire is episodic and rare, with less than a ten percent chance to visit any area within any decade, but certain within centuries. Carbon offsets for fuels treatments will necessarily be gained by demonstration, using agreed-to modeling protocols, that the risk of greenhouse gas (GHG) emissions over time from wildfires plus the sum of emissions from treatments and decomposition, minus the sum of sequestration due to growth, carbon allocation, and wood utilization are expected to be less with treatment than without treatment. The operative word is “expected”, so it is necessary to agree on how to model the effects of fuel treatment on future a) fire risk, b) fire severity, c) ecosystem response, and d) utilization.

This report will focus on treatment of forest fuelbeds and on the influence of altering the physical characteristics of fuelbeds on expected wildfire fire risk (probability of annual occurrence) and severity (GHC emissions). The direct effects of fuel treatments, including prescribed fires, as emitters of GHG’s is easily predicted by using emission models developed for air pollutant emission inventories. (Anderson et al 2004). Effects on decomposition rates, ecosystem response, and utilization are being addressed by others.

Two modeling approaches are possible to establish the current baseline (untreated) risk of fire: 1) calculating a baseline by adjusting from a large reference area to a smaller project area based on comparisons of the risk-causing biophysical characteristics of the two areas and calculating expected treatment effects by a similar comparison of before- and after-treatment fire risk, or 2) employ an intensive, site specific, deterministic fire behavior modeling for the current landscape and alternative futures by utilizing traditional fire management decision support tools such as FLAMMAP (Stratton 2004); This analysis will employ first modeling alternative, relying heavily on the Fuel Characteristic Classification System (FCCS) by Ottmar and others (2007). We believe it has the advantage over the 2nd by being more transportable, scale-independent, and less dependent on subjective expert judgment as an input.

Authority

This assessment is made by David Sandberg, sole proprietor of *Sam's FireWorks*, under contract with Winrock International and with contributions from USDA Forest Service Research. The work is done under the auspices of West Coast Regional Carbon Sequestration Partnership (WESTCARB), led by the California Energy Commission, one of 7 US Department of Energy regional partnerships with the goal of determining the best approaches to capture and permanently store greenhouse gases contributing to climate change. These government/industry partnerships are working to develop technologies, approaches and infrastructure for carbon capture, storage, and sequestration in both terrestrial and geologic systems.

Winrock International is leading WESTCARB terrestrial sequestration efforts. Terrestrial pilots are initially taking place in Shasta County, California and Lake County, Oregon, though opportunities will also be identified in Washington and Arizona. Activities include afforestation of rangelands, improved management of forest fuels to reduce emissions from wildfires, biomass energy, and conservation-based forest management. Overall objectives are to quantify emission reductions/sequestration attributable to each activity; gather information on costs and benefits to landowners; design measurement, monitoring and verification methods; evaluate the practicality of existing reporting protocols to capture verifiable reductions at reasonable cost to landowners and carbon credit buyers; explore questions of market validation for terrestrial activities; and evaluate environmental benefits.

The USDA Forest Service Pacific Northwest Research Station - Pacific Wildland Fire Sciences Laboratory/FERA Team is a key partner in this effort. David Sandberg, a private consultant and scientist emeritus representing FERA, has three decades of experience in air pollutant emissions inventory from fires and in characterizing fuelbeds, fuel consumption, and carbon emissions from fires; and is attempting to apply that experience toward the estimation of carbon baselines and project benefits for forests and fuels management.

Carbon offsets to motivate sequestration

Carbon offsetting is the act of mitigating greenhouse gas emissions by increasing carbon sequestration. Healthy forests sequester carbon as they grow biomass in durable pools such as tree boles and roots, so tree planting to replace shorter-lived vegetation is the most well-known example of a management practice that offsets emissions. Most newly-established temperate or tropical forest ecosystems continue to accumulate carbon for several decades to several centuries, depending on species composition, until they become "carbon-neutral" when mortality and decomposition rates approximately equals photosynthetic rate. Boreal forests are an exception, because the slow rate of decomposition promotes underground carbon storage that can extend sequestration for millennia. Thereafter, the system no longer sequesters carbon at a higher rate than the grassland or scrubland it replaced but it represents the one-time creation of a carbon store represented by total biomass (living and dead; above and below ground) as long as it remains a mature forest.

Harvesting live trees and utilizing the biomass in durable products such as construction materials delays decomposition for many decades and, if the harvested trees are replaced with new growing stock, sustains the forests' ability to accumulate carbon. So the true measure of the carbon store from managed forests would include the carbon sequestered in all wood products. If biomass is removed and converted to energy that reduces consumption of fossil fuels, an offset is accomplished by replacing many thousands of years of carbon formation while maintaining active sequestration by the remaining live biomass.

Fire plays an important role in determining the composition, productivity, and sustainability of most wildland ecosystems. Because fire is only one of many interacting ecological processes, managing fire to reduce carbon emissions is not as simple as preventing or suppressing fires. In fact, fire can either increase or decrease the emission of greenhouse gases over a decade or longer period by influencing other pathways of carbon sequestration and biogenic emissions.

Most wildland ecosystems, with the notable exceptions of boreal and bog ecosystems, do not forever sequester carbon from the atmosphere. Rather, they store carbon in structures during a grand period of growth and development that may last a few years (in grasslands) to a many decades (temperate forests) before mortality and decomposition roughly equals growth and the system becomes carbon neutral. Depending on climate (i.e. moisture and temperature regimes), the biomass directly consumed in mild to moderately severe fires would have decomposed and emitted roughly the same amount of greenhouse gases over those time periods as fire. Fire, by producing some long-lasting charcoal from woody debris and by charring large down logs and stumps, can even slightly reduce future decomposition rates. But all in all, the greatest effect of fire in stable temperate systems in to advance the timing of carbon emissions by a decade or two without substantially changing the carbon balance over time.

The measure of the effect of fires on carbon sequestration rates and storage depends almost entirely on the effect of fire on the health and structure of the mature forest that results after fire, rather than on the emissions or vegetation mortality from fire. Forest fires, in an over-simplistic view, are an anathema to carbon sequestration because they "destroy" forests, consume biomass and sequestered carbon, and emit greenhouse gases. It has been repeatedly proposed that preventing or suppressing forest fires could be credited as a carbon offset. In a few cases, it is true that severe forest fires do consume a significant fraction of living biomass or convert an ecosystem from a forest to a system that supports less standing biomass or even a system with a less productive system that for centuries will store carbon at a slower rate. Or, in boreal systems, create a warmer microclimate where below-ground carbon storage is lost. But the overwhelming fraction of biomass consumed in forest fires is from the accumulation of forest floor and dead fuels that would have otherwise released carbon dioxide as it decomposed over the next decade or two. So the actual effect of forest fires is to advance the release of those emissions by a few years. Tree mortality caused by fire is rapidly replaced in roughly equal measure by regeneration and growth of younger trees or by concentration of growth on the remaining large trees. Less severe fires, such as low-intensity fires in fire-dependent ecosystems of the Western United States, typically improve forest health and eliminate competing undergrowth, effectively transferring carbon stores from shorter-lived species to the boles and roots of trees.

Fuels management, for the purpose of reducing the frequency, size and severity of wildfires and a practice that may also yield useable biomass, has increased dramatically in the past decade on public lands. The increase in costly and destructive "mega-fires" generally attributed to climate change and decades of fuels buildup resulting from prior fire suppression has provided the incentive to invest heavily in restoring forest structure and fuel loading to sustainable levels. Dead biomass loading is almost always either generated through forest stand management or is consumed by fire by prescribed-burn treatments. In any case, fuels management advances either the short-term decomposition or the consumption of biomass in comparison to the unmanaged condition. Whether the advanced emissions or decomposition are offset by increased sequestration depends largely on two secondary effects of fuels management: 1) was the long term health (i.e. sequestration) of the forest ecosystem improved? and 2) was the eventual occurrence of wildfire or other forest disturbance either delayed or made less severe?

Accountability systems for GHG emission baselines

Widely accepted principles have been published for accountability systems for Project Baseline Scenarios for Greenhouse gas emissions (World Resources Institute 2005), In a sense parallel to the development of emission reduction systems for air pollutants over the past four decades, accountability systems based on these principles apply most readily to industrial and transportation sources for which a reasonably constant pattern of emissions can be inventoried and used as a baseline from which to measure future reductions. The obvious and standard methodology is to measure emissions, or inventory parameters thought to be reliable parameters to estimate emissions, over a period of years and simply project the average GHG emissions forward as a constant baseline for comparison to future inventories. Unlike air pollution baseline emissions, however, a GHG emission baseline is a forward-looking and hypothetical estimate of "what would have happened in the future" in the absence of the opportunity to mitigate climate change by offsetting emissions.

GHG emission baselines for Wildland Fire

The emissions baseline for wildfires is the area (acres) that would burn in the absence of a carbon project multiplied by the fuel loading (tons/acre) multiplied by the proportion of fuel consumed by fire (tons/tons) greenhouse gas emissions, or "GHG emission factor" (tons/tons) from each ton of fuel. Simplistically,

$$WGHG_{wildfire\ emissons}^{annual\ basline} = WA_{wilfire\ \ area}^{annual\ baseline} \times WF_{fuel\ load} \times WC_{\%Consumed} \times EF_{CO2}$$

Where

$$WA_{wilfire\ \ area}^{annual\ baseline} = PA_{project\ area} \times W\%_{wilfire\ \ area\ burned}^{annual}$$

Emission Factors, EF, for greenhouse gases are the most certain term in the equation. Forest fuels almost uniformly contain about 50% carbon (although rotten material can be as low as 35-40% carbon). About 95% of the carbon is released as carbon dioxide and a small quantity released as methane, carbon monoxide, or other greenhouse gases; so it is reasonable to apply an emission factor of about 1835 tons of CO2 per ton of fuel consumed. About 1-2% of the carbon in biomass is left behind as charcoal, sequestered for centuries in that form.

Fuel Consumed, WC, by fires can also be predicted with considerable accuracy on the basis of fuel moisture content at the time of burning. Several fuel consumption models have been published and are in routine use by fire managers.

Fuel load, WF, can range from a fraction of a ton per acre in grasslands to 100 or more tons in forests. Although highly variable, it is measurable directly in the field or estimated from vegetation cover, bioclimatic region, and qualitative description of the biophysical environment using the Fuel Characteristic Classification System, FCCS (Ottmar et al 2007). Forest fuelbeds are complex mixtures dead woody debris on the forest floor, plus a surface layer of moss, lichens, and recently fallen litter, a deeper layer of partially decomposed ground fuels that may burn under dry conditions, low non-woody vegetation, and shrubs (Riccardi and others 2007). In severe wildfires, tree branches and canopies are also significant components of the available fuel (Sandberg and others 2007a). Modeling biomass consumption, GHG emissions, or decomposition cannot be done with one measure of fuel load, but requires the combination of several algorithms that consider the entire fuelbed complex.

The natural (i.e. in the absence of fire management) fire return interval, i.e the inverse of fire risk, both depends upon and expresses itself in the vegetation cover type, and ranges from a year or three in some grasslands to centuries in some forest types. In much of the fire-dependent conifer ecosystems of the West, natural fire return interval would be on the order of 10-25 years, meaning that 4-10 percent of the forest lands would be visited by fire each year. But fires in the Western United States now burn about one-half of one percent per year, suggesting that fire control is approximately 90 percent effective at reducing area burned.

Wildfires are quasi-random, episodic events subject to influence to some extent by fuels management but also to a myriad of intrinsic ecosystem characteristics, weather conditions, ignition probabilities, and the influence of prevention and suppression activities. Consequently, it is extremely difficult to predict what would happen in the absence of fuels management or to assess the marginal effect of increased fuels management. Expected wildfire area burned, WA, is nearly impossible to measure directly.

Trends in wildfire area burned are difficult to establish because of the extreme inter-annual variability. It is simply impossible to measure the difference in fire frequency on any area smaller than a very large bio-region because any local trend is washed out by chance. Attempts have been made to measure the trend in area burned in the United States or other large regions such as Alaska or boreal Canada and even on those large areas the trends are difficult to establish. Nielson and Lenihan (2004) observed a very modest downward trend between 1960 and 1985 in the contiguous United States and a sharp increase (432 thousand acres per year) between 1991 and 2003 that could be due to climate change and or fuel buildup (figure 1). The data were used to tune their simulation model of area burned, which suggests that fire management has excluded 7/8 of natural fire risk.

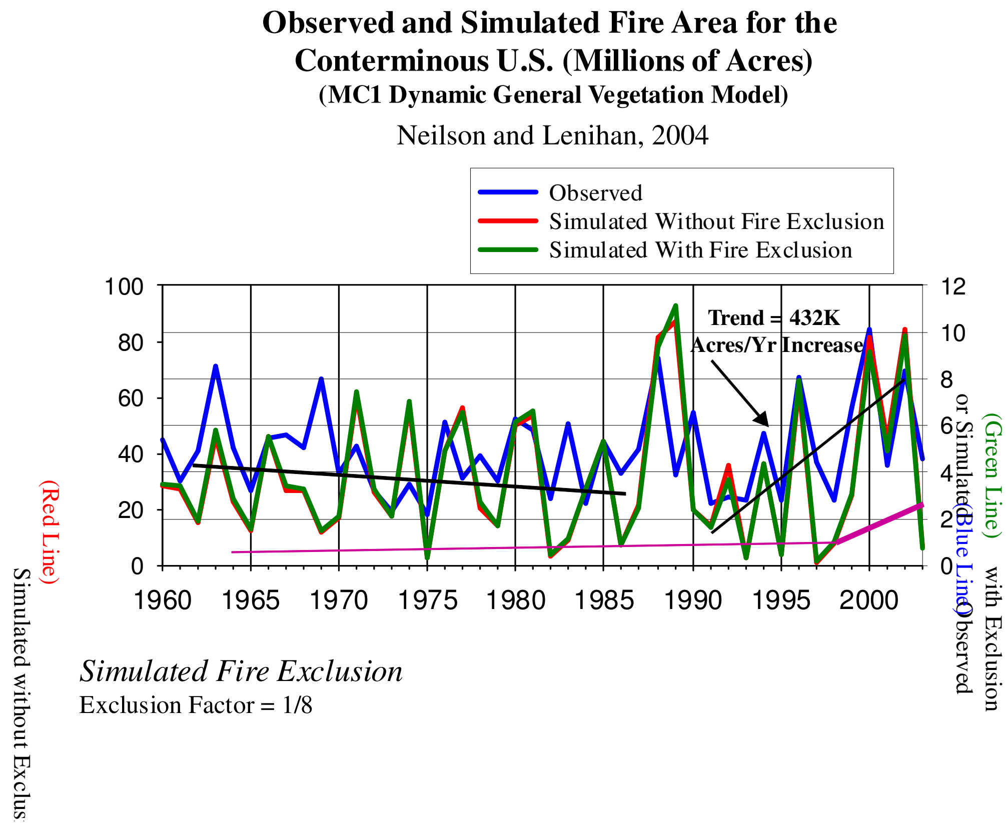


Figure 1. Increase in burned area observed and simulated by Neilson and Lenihan (2004)

Fuels Management, Fire Occurrence, and Fire Severity

Land management agencies and land owners in the United States spend several hundred million dollars per year treating forest fuels to reduce fire occurrence and severity. The effect on area burned is uncertain in part because total area burned and the number of very large fires continues to trend upwards, probably due to climatic change. It is taken on faith that the upwards trend would be even greater in the absence of fuels management, but quantitative proof has been elusive.

Obviously it is easier to suppress fires where fuel loadings and fuel continuity have been altered by fuel treatment, and the severity (biomass consumed and environmental impacts) of those fires is lowered. It is possible to accurately predict the change in fire behavior, biomass consumption, carbon flux, and air pollutant emissions per unit area that result from fuel treatment, but attempts to quantify reduction in burned area have been frustrating.

Central to our approach is our conclusion that annual area burned by wildfire cannot be reliably observed on any small area, i.e. smaller than a state or bio-region. It would be even more impossible to measure the change in fire area burned over any period of time shorter than several decades. So, there is no hope of establishing an area burned (or carbon flux) baseline on a project area smaller than tens of millions of acres or a period of less than 30 years. The standard practice of measuring carbon flux or the level of activity for a greenhouse gas emitting activity and re-measuring carbon flux at intervals of 5-10 years is not a useful model for evaluating the effectiveness of fire or fuels management efforts.

Instead, some form of modeling must be employed to calculate a baseline for wildfire area burned and carbon flux, and the same form of modeling will be necessary to predict or re-calculate burned area and carbon flux in future decades with and without fuel treatment. That modeling could be done by deterministically simulating fire behavior under assumed weather, fuels, and management scenarios on every “fireshed” in a project area. Federal land management agencies are currently attempting to demonstrate that type of modeling in several areas including parts of the Sierra Nevada region of California.

An alternative approach is presented here that will be to establish a Large-Area historic baseline for wildland fire area burned, and then to adjust the baseline to the smaller Project Area based on differences due to such factors as a) Inflation of wildfire area burned over time, b Vegetation cover distribution, and c) Fuelbed characteristics. It may be possible in the future to also adjust for regional differences in d) Fire Weather, e) Ownership and management, and f) Social and ecological context.

II. DRAFT PROTOCOL for establishing GHG emission project baselines for Wildland Fire Carbon emissions from wildland fire

Step 1—Establish a Historic Large-Area (Reference Area) Burned Area Baseline:

$HFRisk_{ref}$ = Historic Annual Area Burned (in Large Reference Area, A/yr)/Large Reference Area (A)

a) Select a reference area, such as a State, Eco-region, Climate Zone, or other large area that includes the Project Area that has a reliable long history (20+years) of fire occurrence records, including fire size.
b) Compute a 10-year (or other period of between 5 and 20 years) running average of annual burned area. Compute the coefficient of variation of the average area burned, which will represent the minimum standard error of the absolute baseline area burned estimate.
c) Try different combinations of alternate Large Areas and history time periods to attain a satisfactory (or most accurate) historic baseline.

Step 2—Inflate Large-Area Baseline to account for wildfire increases

$$TimeHFR_{ref} = HFRisk_{ref} \times 1.007^{(analysisyear - historicbaselineyear)}, where$$

$TimeHFR_{ref}$ = Time-inflated historic fire risk (1/yr)

1.007=Default annual area-burned inflation factor

a) Inflate wildfire burned-area baseline to current year and future years using annual inflation rate of 0.5-0.9%, or other more applicable value, if known.
b) Adjust the wildfire risk, using other management and sociological factors, if quantifiable.

Step 3—Compare Large-Area Baseline to Project Area Fuelbed or Vegetation Cover:

$$PArea_{i.ref} = Area_{i.ref} \div \sum_{i=1}^{n} Area_{i.ref}$$

a) Determine the area covered by FCCS fuelbed or vegetation cover type, for which historical data or an algorithm exists that enables one to establish the relative fire risk for each fuelbed or type.
b) Using the FCCS mapping capability (McKenzie et al 2007) or other spatial classification of fuelbed or vegetation classification, determine the proportion of area covered by each class in candidate Large (reference) Areas.
c) Using the same classification, determine the proportion of Project Area covered by each class in the Project Area.

$$PArea_{i.project} = Area_{i.project} \div \sum_{i=1}^{n} Area_{i.project}$$

$PArea$ *is the proportion of the total area in either the Large Area* (ref) *or Project Area* $(project)$ *covered by FCCS Fuelbed* i.

$Area_{i.ref}$ = Area of FCCS Fuelbed i or Vegetation Type i in Reference Area

$Area_{i.proj}$ = Area of FCCS Fuelbed i or Vegetation Type i in Project Area

Step 4—calculate fire risk by vegetation or fuelbed type in the Project Area

a) Differentiate fire risk for each fuelbed or vegetation cover type using expert judgment based on published guidelines, or employ an algorithm based on fuelbed structure.
b) There are no published algorithms that assign a Relative Fire Risk by fuel or vegetation type, but we offer the following as an example of several that have been proposed: (this subject deserves much more investigation)

   a. Hypothesis 2, h2:
   $RFR_i = {}^{1}/_{RFRI_i}$
   $RFRI_i = 2.0 + 2.3C_{surface.i}$

   RFR_i = Relative fire risk for fuelbed i
   (Probability of burning per year, 1/yr)
   $RFRI_i$ =Relative Fire Return Interval (frequency of expected fire, yr)
   $C_{surface\ fuel}$ = Carbon store (fuel load/2) in surface fuel strata (ton/A)
   i = FCCS fuelbed identifier (Ottmar, 2007) or substitute classification.

c) Establish a table of regional-area adjusted fire risk (fire return interval or expected percent annual area burned) such that the product of fire risk multiplied by proportion of area covered for each fuelbed type in the Large Area equals the wildfire burned-area baseline.

Adjusted Fuelbed Annual Fire Risk, $AFR_i = Adj \times RFR_i$,

$$where: Adj = TimeHFR_{ref} \div \sum_{i=1}^{numberoffuelbeds} (RFR_i \times Area_{i.ref})$$

Step 5—Calculate carbon flux (C released per area burned) for each fuelbed or vegetation type.

a) Utilize a recognized fuel consumption model such as CONSUME, FOFEM, FEPS, or FCCS at the moisture scenario appropriate for wildfire to compute carbon flux for each FCCS Fuelbed or type.

$$CFlux_{i.wildfire} = f\,(fuel.moisture.scenario)_{wildfire}$$

Step 6—Calculate baseline carbon flux (C released per year) for Project Area

a) Multiply carbon flux by adjusted area burned for each Fuelbed, then sum.

$$\text{Project Baseline Carbon Flux} = BCFlux_{project.wildfire} = \sum_{i=1}^{number.of.fuelbeds} (AFR_i \times CFlux_{i.wildfire})$$

III. TRIAL APPLICATION DRAFT PROTOCOL for establishing GHG emission project baselines for SHASTA COUNTY, California

Step 1—Establish a Large-Area Baseline:

Despite extreme variability, there is little choice but to rely on the historical record as starting point for establishing a GCG emissions from wildfires. In order to obtain a reasonable sample of annual burned area one must choose a large enough area and long enough record to be reliable, in most cases larger (and more diverse) than the project area. There are several sources of historical fire records covering large areas. All are secondary compilations of individual fire reports from public agencies. The fire reports have their own accuracy problems, but are the only source currently available. Remote sensing by satellite is slowly replacing individual fire reports as a source of area-burned monitoring, but remains unreliable other than for very large fires.

We explored several possible large area baselines based on Statewide (California and Oregon) fire occurrence records as well as a number of vegetation or fuel classification systems. Few states have as complete or accurate records of wildfires as California. California also shares with Washington and Oregon the best record keeping systems for prescribed fires.   In addition to statewide records, there are data bases established to assess fires by ecoregion and land cover types (figure 2).

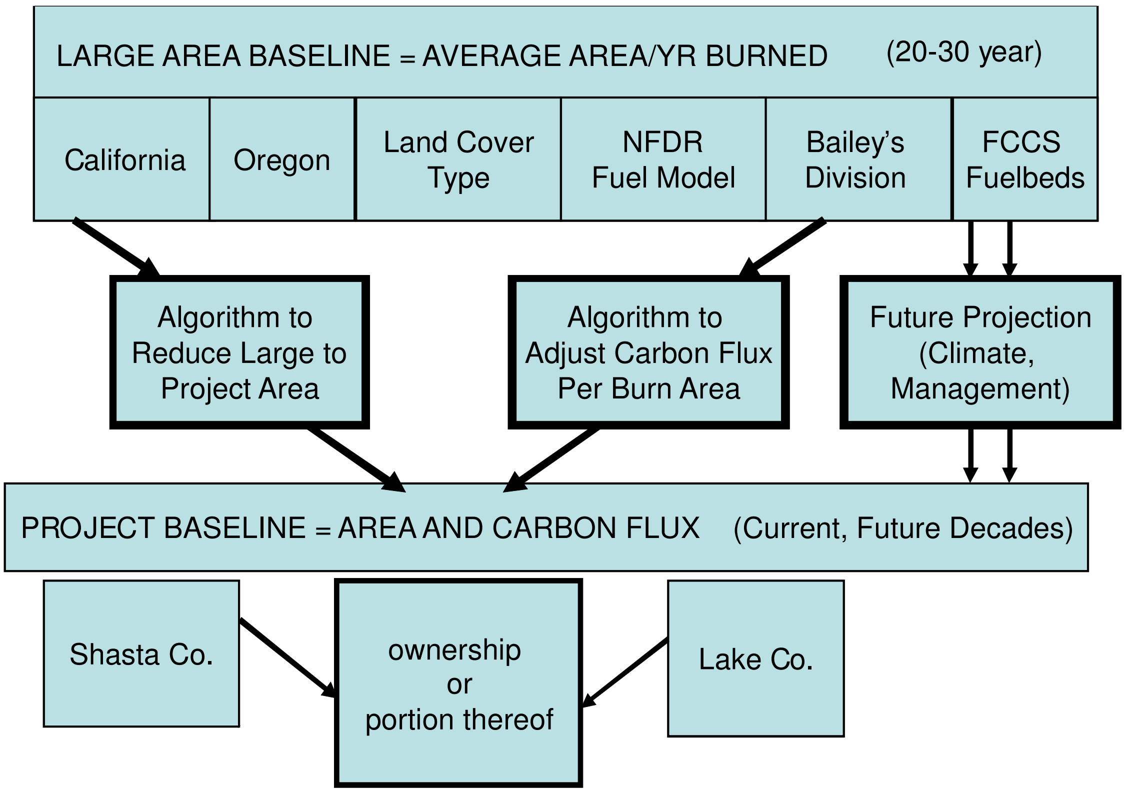
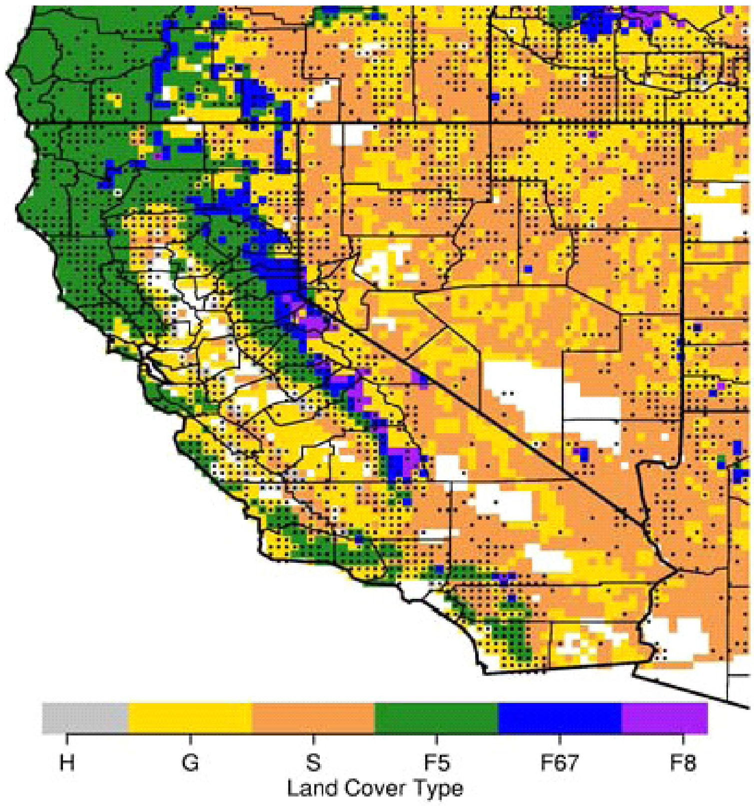
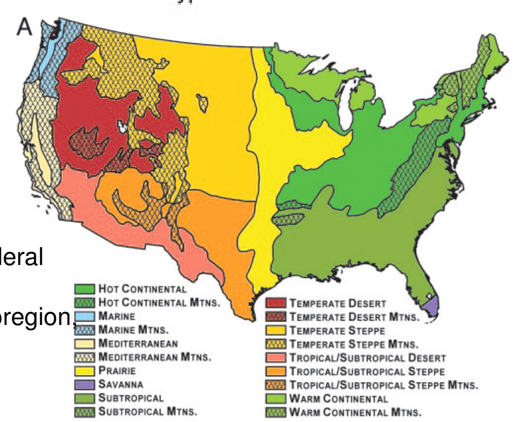


Figure 2. Adjusting large area baseline to project area

Several assessments have been made of the historical fire record in California and in eco-regions that include California and Southern Oregon by the California Climate Center (Westerling and Bryant 2006) , the Desert Research Institute (Brown 2002, Malamud et al 2006) and CFRAP (CDF 2003, Brown et al 2006). Malamud and others (ibid) examined 30 years of federal fire data to establish an expected area burned by Bailey's eco-region (figure 3).

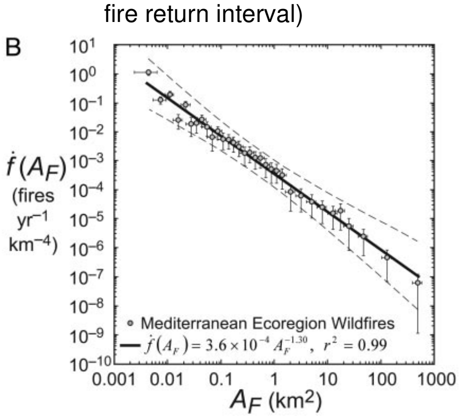
Westerling, Bryant 2006





DRI-CEFA (Brown 2002; 30 year federal data)

Malamud et al 2005; (Bailey's ecoregion fire return interval)



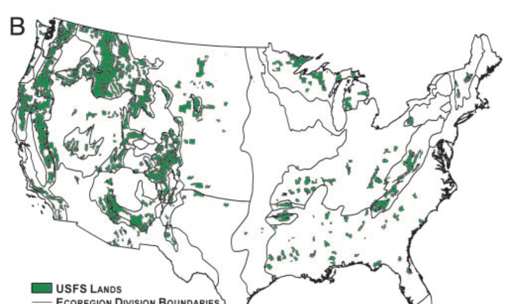


Figure 3. Fire return interval established for Bailey's eco-regions using 30 years of federal fire reports.

Establishing a baseline for wildfire activity has a very weak anchor point in the historical record. It is difficult enough to establish an average or a trend for wildfire area burned annually (or even buy decade) on a national Scale, but almost impossible on any smaller scale. The states of California, Alaska, Montana, Oregon, and Colorado have each recently dominated the area burned in one calendar year; and each have exceeded their previous record for area burned within the past decade. About the most that can be said is that: over the past 20 years in the State of California, or in the mountainous western United States, about 0.3-0.7 percent per year has burned over in an average year, as in figure 4. The two eco-regions that best represent the Sierra Nevada and Southern Oregon project area have experiences .34 and .52 percent per year burned area.

	1	2	1	2
	Area (ac)	Area (ac)	Percent	Percent
Year	Public	Private	Public	Private
1985	1,863	367	0.070	0.019
1986	129	393	0.005	0.021
1987	83,344	4,272	3.116	0.224
1988	1,976	4,881	0.074	0.256
1989	400	379	0.015	0.020
1990	4,505	15,175	0.168	0.795
1991	314	818	0.012	0.043
1992	5,132	41,741	0.192	2.188
1993	81	1,013	0.003	0.053
1994	5,241	1,001	0.196	0.052
1995	103	0	0.004	0.000
1996	7,342	392	0.275	0.021
1997	79	39	0.003	0.002
1998	3,836	1,020	0.143	0.053
1999	13,670	5,547	0.511	0.291
2000	20,959	4,757	0.784	0.249
2001	16,906	4,345	0.632	0.228
2002	19,895	2,272	0.744	0.119
2003	1,988	3,016	0.074	0.158
2004	2,809	1,799	0.105	0.094
Total 20 years	190,573	93,228		
Total 10 years	87,588	23,188		

%AreaBurned/yr

(CFRAP, Brown et al)

	Annual percentage Public	Private
1985-1994	0.385	0.367
1986-1995	0.378	0.365
1987-1996	0.405	0.365
1988-1997	0.094	0.343
1989-1998	0.101	0.323
1990-1999	0.151	0.350
1991-2000	0.212	0.295
1992-2001	0.274	0.314
1993-2002	0.329	0.107
1994-2003	0.337	0.117
1995-2004	0.328	0.122

Malamud M261	.52
Malamud 260	.34
Cal (WRAP)	.58
Cal (FF+)	.70

Figure 4. Large-Area Baseline wildfire burned area (from Brown et al 2006) compared to California wildfire area burned (CDF) and Malamud (2005) area burned in two ecosystem domains.

The simplest baseline area burned would be to project a future where percent of the project area were expected to burn each year would remain constant (represented by the past 30 years)

$HFRisk_{ref}$ = Historic Annual Area Burned (in Large Reference Area, A/yr)/Large Reference Area (A)

$$HFRI_{MalamudM261} = 0.52\% / yr$$

Step 2—Inflate Large-Area Baseline to account for wildfire increases

In addition to being extremely variable year to year, wildfires occurrence does not regress over the decades to a historical average. As the climate warms and fire seasons become longer, the area burned by wildfires in the United States is trending upwards at a rate of a few hundred thousand acres per year.   One estimate, by Neilson and Lenihan (2004) (see figure 1), is that wildfire area burned in the contiguous United States will grow at about 430 thousand acres per year, or an annual inflation rate of 0.7 %/year. Westerling and Bryant (2006) used a completely different analysis to predict similar inflation (0.5 %/yr) based on scenarios from General Circulation Models (figure 5), and Wilkenson (2002) predicts about an 0.9%/yr increase.

CCI: Climate Change Area Inflation (%/yr) = 1.007   ?

Westerling, Bryant 2006

Figure 6. Standardized annual expected number of 1/8 degree x month voxels with at least one large fire (> 200 ha, or > 494 acres) 1951–2100 for A2 and B1 emissions scenarios and GFDL and PCM global climate models. Bold lines are the result of smoothing with Friedman's supersmoother (Friedman 1984) with a span of 0.3.

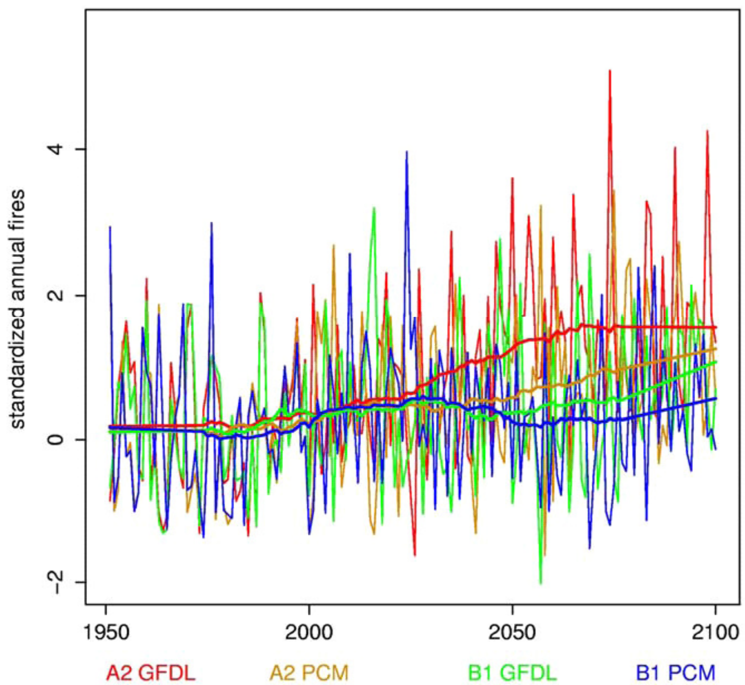


Figure 5. Predicted increase and annual variability in California wildfire burned area by Westerling (2006)

We should consider inflating historic estimates and future baselines by that amount, for example, for 2008 and 2058 baselines:

$TimeHFR_i = HFRI_i \times yrs^{aif}$, *where*

$TimeHFR_i =$ Time-inflated historic fire risk (1/yr)

$yrs =$ years between refernce period and analysis period

$aif =$ annual area-burned inflation factor (default $aif = 1.007$)

$$TimeHFR_{M\,261.2008} = 0.52 \times 1.007^{20} = .60\% / yr, and$$

$$TimeHFR_{M\,261.2058} = 0.52 \times 1.007^{70} = .85\% / yr, and$$

Step 3—Relate Large-Area Baseline to Project Area Vegetation Cover:

a) Using the FCCS mapping capability (McKenzie et al 2007) or other spatial classification of fuelbed or vegetation classification, determine the proportion of area covered by each class in candidate Large (reference) Areas.
b) Using the same classification, determine the proportion of Project Area covered by each class

$$PArea_{i.ref} = Area_{i.ref} \div \sum_{i=1}^{n} Area_{i.ref}$$

$$PArea_{i.project} = Area_{i.project} \div \sum_{i=1}^{n} Area_{i.project}$$

PArea is the proportion of the total area in either the Large Area (ref) or Project Area (project) covered by FCCS Fuelbed i.

Available fuel loading for many vegetation types is uniquely available by accessing the Fuel Characteristic Classification System, or FCCS (Ottmar and others 2007). The system enables land managers and scientists to create and catalogue fuel measurements taken in the field or to choose from a limited library of a few hundred “canned” FCCS fuelbeds selected on the basis of vegetation cover type and Bailey’s eco-region province. Those FCCS fuelbeds have been mapped for the contiguous United States on the basis of remotely-sensed vegetation cover (McKenzie et al 2007; figure 6),

Figure 6. National map of FCCS fuelbeds (McKenzie et al 2007)

and those authors have contributed a breakdown of FCCS fuelbed coverage of the Large Areas (i.e. California, Oregon, and Provinces 260, M261, and 340) and County (Lake Co. OR and Shasta Co. CA) areas considered in this project (figure 7).

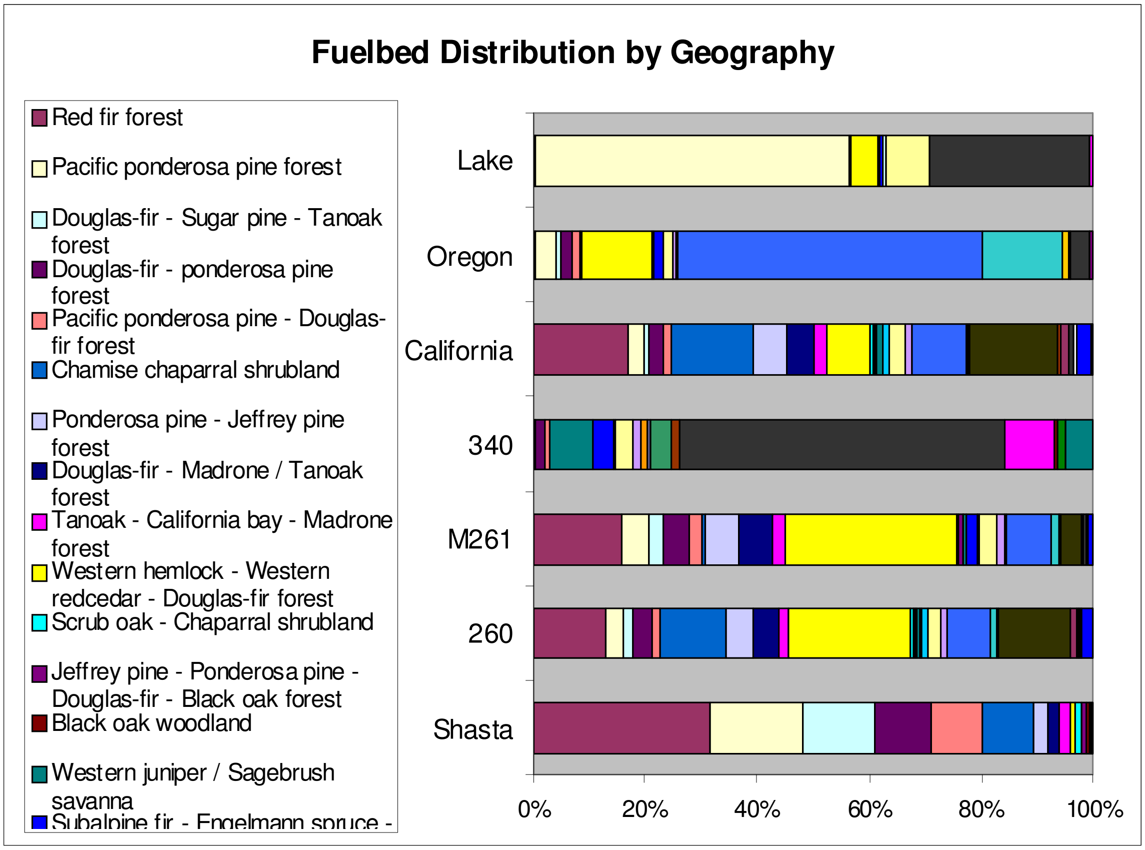


Figure 7 FCCS Fuelbed distribution in Large Area baseline references and in Project Area counties, contributed by McKenzie et. al.

Visual comparison of fuelbed distributions in Shasta or Lake County to any of the Large Area baseline references in figure 6 makes it obvious that some adjustment should be made to the large-area estimates of wildfire area burned and the estimate of biomass available for consumption in a wildfire.

Step 4—calculate fire risk by vegetation or fuelbed type in the Project Area

Adjusting the expected Fire Return Interval (FRI) from the Large Area to the Project area is more problematic. Let me specify up front that there is no published literature that can adjust the FRI based on measured physical attributes of a fuelbed or vegetation structure.   While it is clear that fuelbeds such as “wheatgrass” will have a very short FRI relative to “red fir forest”, there is no generally accepted algorithm for calculating either on the basis of fuel characteristics.   So all we can do now is form hypotheses and see if they look reasonable.

The Project Area will almost differ from the Large Area in two significant ways, unless the distribution of vegetation cover is identical in the two areas because both 1) the Fire return interval (and percentage of area burned per year) and 2) the fuel loading are strong expressions of vegetation cover. In general, the natural fire return interval is very short (on the order of 1-3 years) for grasslands, intermediate (10-50 years) for shrub lands and pine forests, and longer (100+ years) for other coniferous forest lands. The natural fire return interval for many vegetation, not to be confused with return interval for lands under management, is extensively available in the literature.

Conversely, the shorter fire-return interval vegetation types typically have less available fuel loading (i.e. fuel load that would burn in a fire than the longer-interval types. Does that mean, as sometimes assumed, that the two factors offset? That over any long period of time, the product of accumulated available fuel loading and probability of fire each year is constant? No, because ecosystems with a longer fire return interval sequester a greater proportion of carbon in structures that are unavailable for consumption by fire. So, the longer Fire Return Interval ecosystems types can be expected to yield less carbon as a result of fire on an average annual basis.

a) Differentiate fire risk for each fuelbed or vegetation cover type using expert judgment based on published guidelines, or employ an algorithm based on fuelbed structure.
b) There are no published algorithms that assign a Relative Fire Risk by fuel or vegetation type, but we offer the following as an example of several that have been proposed:

   a. Hypothesis 2, h2:

$$RFR_i = {}^{1}/_{RFRI_i}$$

$$RFRI_i = 2.0 + 2.3C_{surface.i}$$

RFR_i = Relative fire risk for fuelbed *i*
(Probability of burning per year, 1/yr)

FRI h2: One hypothesis (h2) is that one can differentiate the likelihood of fire during any time period by measuring the buildup of surface fuels, such that risk is roughly inverse to the fuel loading in the surface (i.e. litter, down woody, herbaceous, and shrub vegetation) fuelbed strata. The FCCS system accounts for biomass allocation (Sandberg and others 2007) in such a way that we can calculate that proportion for each FCCS fuelbed. There are alternative hypotheses, but this one results in an expected FRI ranging from 2 to 108 years, as shown in figure 8. These expected, but not regionally adjusted natural fire return interval are not in conflict with the rage of FRI's reported in the ecological literature. Chamise-chaparral fuelbeds, for example, would have an approximate natural fire return interval of 25 years, while wheatgrass would burn every 2 years.

This is only one hypothesis of many possible hypotheses that relate physical fuelbed characteristics to fire risk or historical fire return interval. It has never been tried before. But it is reasonable that any algorithm based on the allocation of carbon to grasses and other flash fuels increasing fire risk and on the allocation of carbon to coarse fuels and canopy fuels will have some value in explaining the variation in fire return intervals among ecosystems.

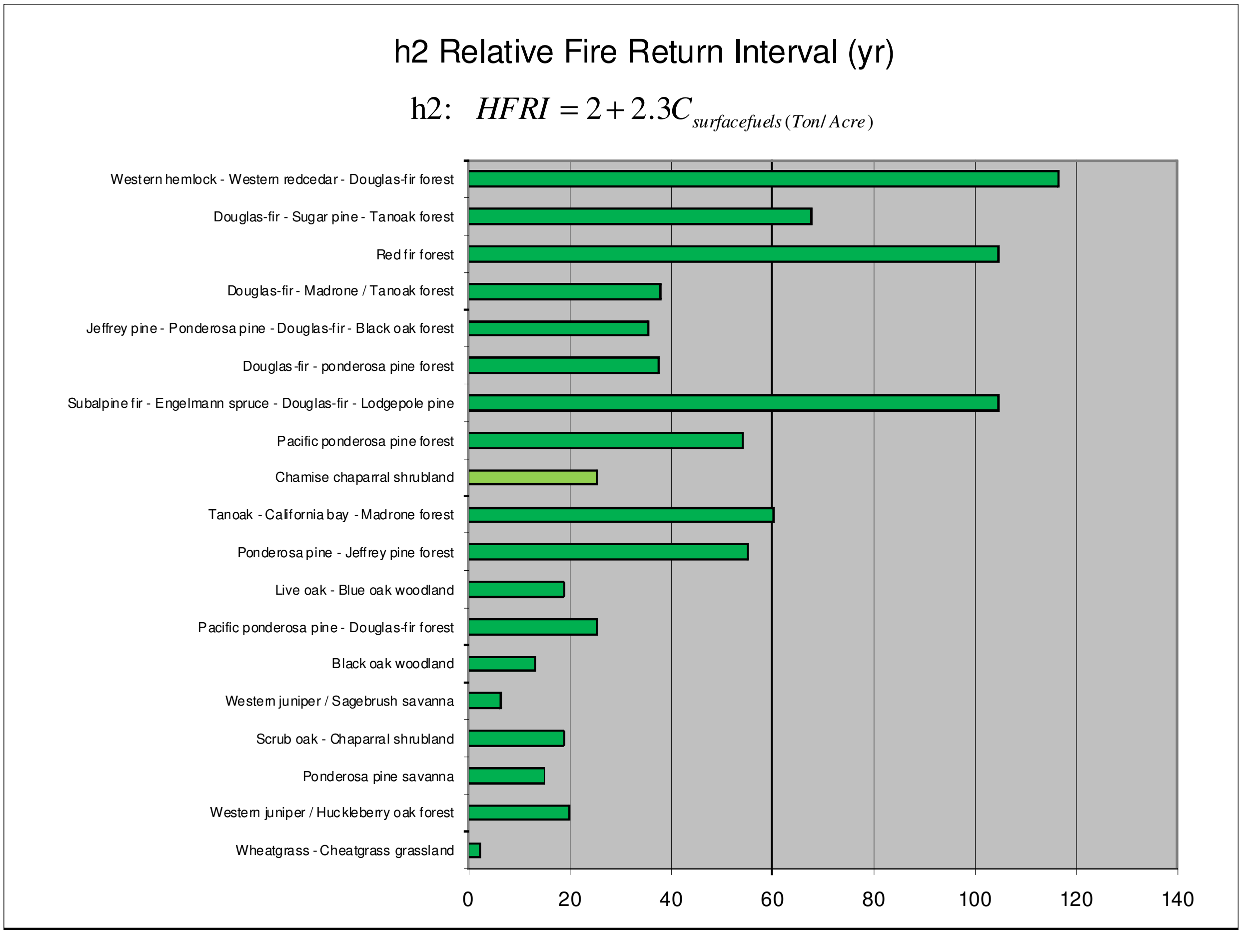


Figure 8. Relative Fire Return Interval (inverse of the annual probability of wildfire on any area) based on the hypothesis that fire return interval is directly proportional to the carbon (C) storage in the surface fuels.

Relative Fire Return Interval, RFRI, is an rough approximation of the natural fire return interval for each Fuelbed. RFRI must be adjusted regionally, by normalization, to the observed historic (or time-inflated) Large Area baseline area burned in order to calculate an expected area burned for the Project Area. At this point, I assume the Project Area will be the entire of Shasta County, although the same procedure would be used for any size project.

As a test, I normalized the relative values by constraining the sum of the products of 1/RFHI x Fuelbed Area for each fuelbed to the observed 30-year average area burned in the Large (reference) Area (figure 9). As validation, I used three Large Area reference areas to test h1 and multiplied the expected (i.e. baseline) area burned by the wildfire carbon flux for each FCCS fuelbed (from figure 8). There is a variance of about 20% among the three estimates which I accept as a reasonable, if not perfect, validation. Perfect validation would result in identical estimates of expected area burned regardless of the Large Area used as reference.

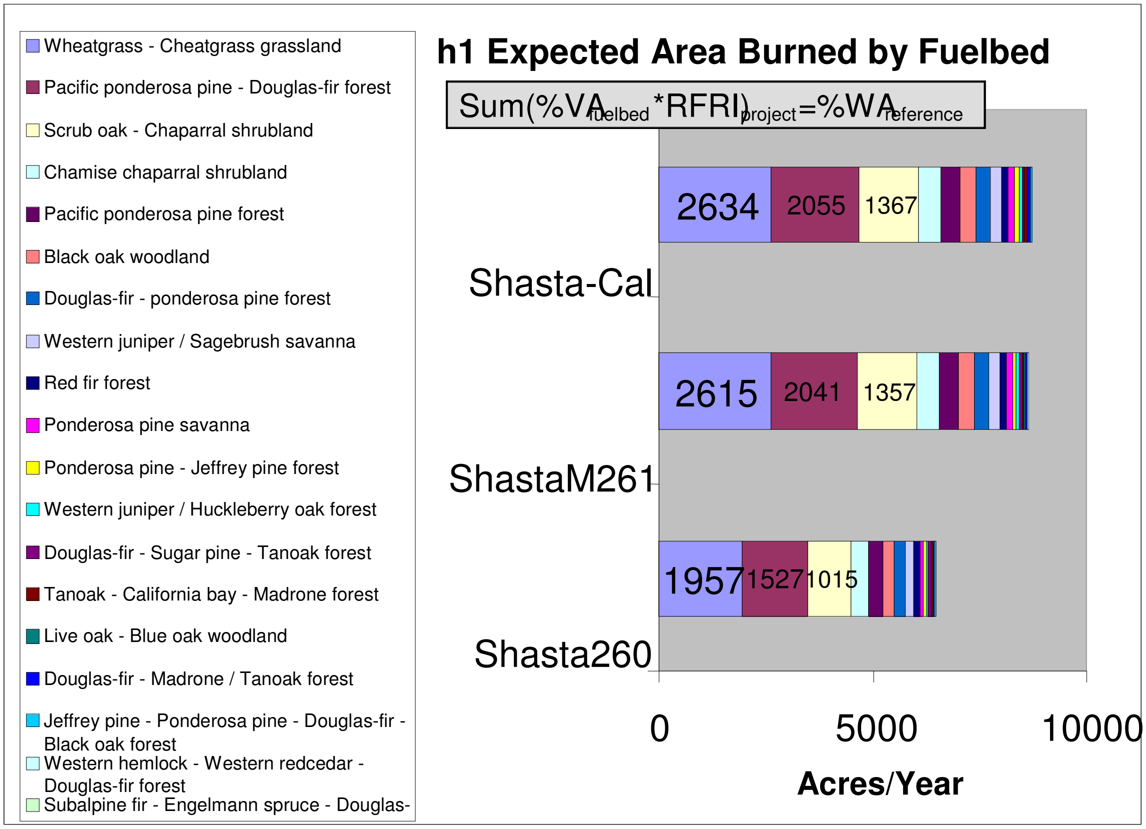


Figure 9. Expected (historic baseline) area burned annually by in Shasta County CA by FCCS, normalized on the basis of Relative Fire Return Interval, to the area burned in California and in two Provinces (M261 and 260) of Bailey's ecoregion classification. Wheatgrass –cheatgrass fuelbeds account for the largest contribution to wildfire baseline burned area.

I accepted Bailey’s Province M261 as the most representative Large Area for the Project Area, based on the relative similarity of vegetation cover, and adjusted the h1 Relative Fire Return Interval for each FCCS Fuelbed in that Province (from figure 8) and forced (i.e. normalized) the sum of products to yield the observed historic fire burned area in that province. The calculated fire risk (inverse of fire return interval) for each Fuelbed (figure 10). As expected, the adjusted annual fire risk is greatest for grasslands (3.6%/yr) and lowest for coastal and high elevation coniferous forests (.07-.08% /yr) . Mid-elevation forest lands (where timber management is most often practiced) are estimated to have an average fire risk of 0.07% (Red fir) to 0.29% (Ponderosa pine-Douglas-fir).

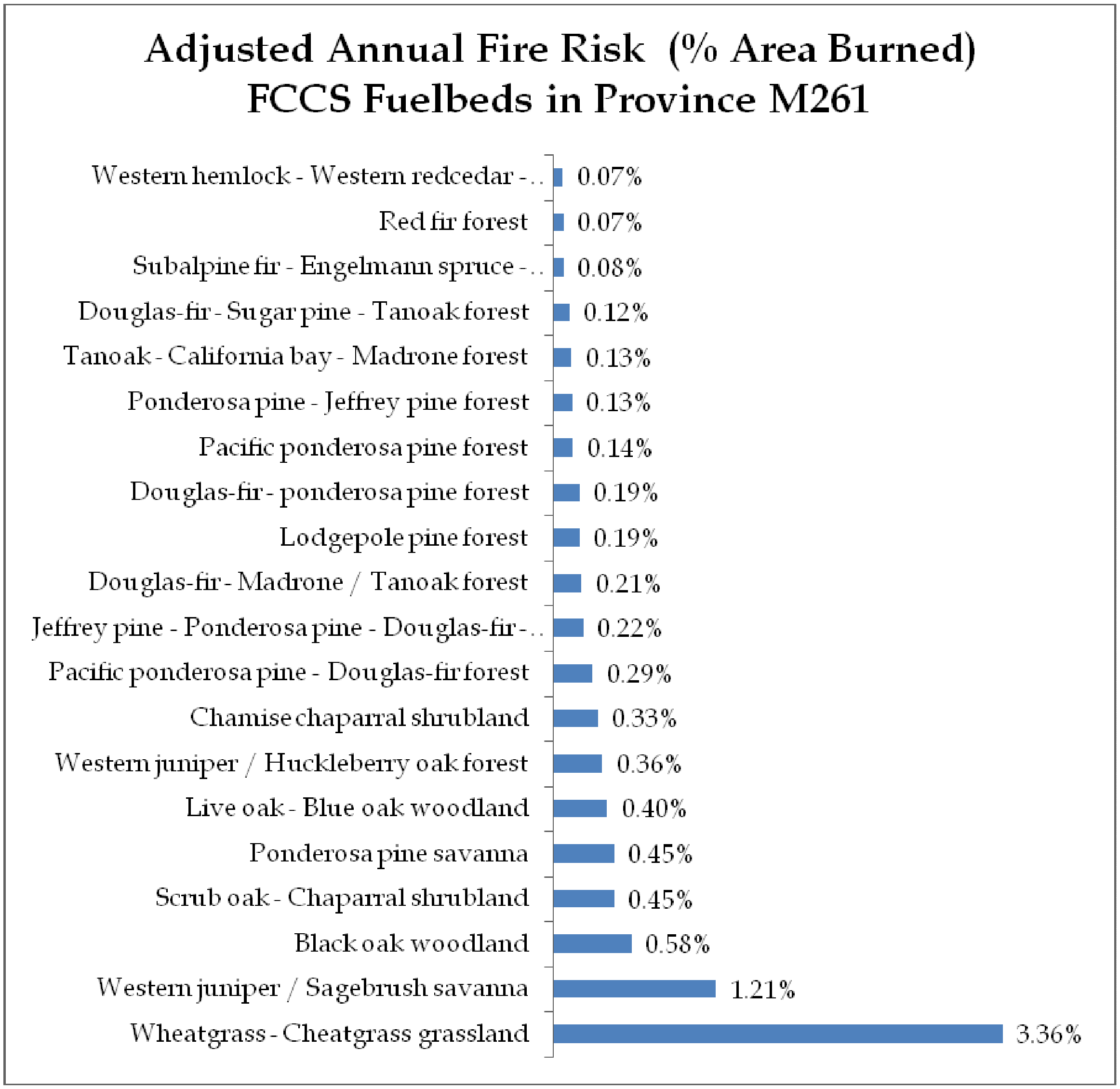


Figure 10 Historic annual fire risk for FCCS fuelbeds in ecosystem province M261. The individual fire risk are assumed to be the same for any Project Area (including Shasta County) in the Province

There are other ways to approach a calculation of baseline area burned. Under a separate subcontract with Winrock, scientists at the University of California, Berkeley (UCB) compiled a detailed fire history in Northern California using a vegetation classification system independent of Bailey's classification and FCCS. The two baseline estimates are illustrated in figure 11. There is no crosswalk currently that allows detailed comparison of the results other than to make a couple of gross observations 1) the UCB estimates an annual area burned in Shasta County to be about 10,000 acres while the h2/FCCS method estimates 8700 acres, and 2) a greater share of the estimate in the h2/FCCS is in grasslands. Shasta County covers 2472470 Acres, so the two methods yield an annual fire risk of 0.041 (UCB) and 0.035 (FCCS).

Comparison of Shasta County Baseline Area burned estimates from UCB (10021) andFCCS(8701) Acres/year. It would be useful, but take a few days of effort, to assign an FCCS fuelbed to each vegetation type in the UCB analysis. The two bars on the Sandberg data reflect baselines derived from the California and M261 ecoregion-wide fire histories.

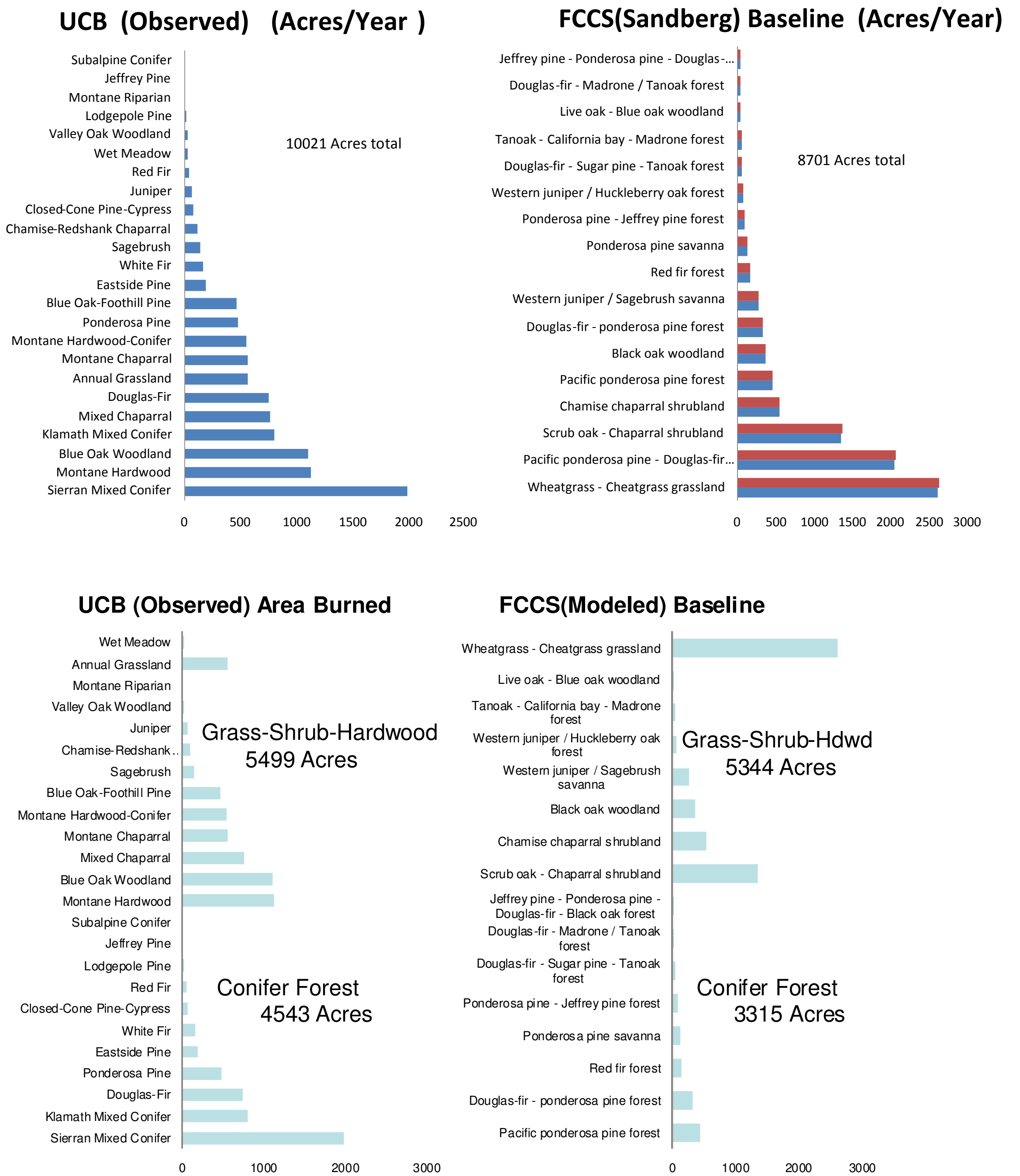


Figure 11 . Comparison of expected (historic baseline) area burned annually by in Shasta County CA using the University of California (observed) and the FCCS (modeled) methods. , Fuelbeds and vegetation classes grouped by life form.

Step 5—Calculate carbon flux (C released per area burned) for each vegetation of fuelbed type.

Each of the FCCS fuelbeds imputed to the geographic areas in figure 6 have a distinct fuel loading. FCCS includes measured values for each size class (0.1-hr, 1-hr, 10-hr, 100-hr, and 1000-hr) and category (foliage, nonwoody vegetation, shrub, woody, litter, and duff) in each fuelbed. Several fuel consumption models, with fuel moisture profiles as inputs, are available to estimate biomass consumption from any FCCS fuelbed or directly measured fuelbed profile. I ran one of these models, i.e. model now integral to FCCS software, to calculate total fuel consumption (expressed at tons/acre carbon flux) at three fuel moisture profiles based on the 1000-hr moisture content (figure 12). The lowest fuel moisture would be representative of wildfire conditions, while the two other moisture scenarios span the typical range of prescribed fires. Several other models are available whose use would be justified, including CONSUME (Ottmar et al 2005), FOFEM (Reinhardt et al 2001), and FEPS (Anderson et al 2004).

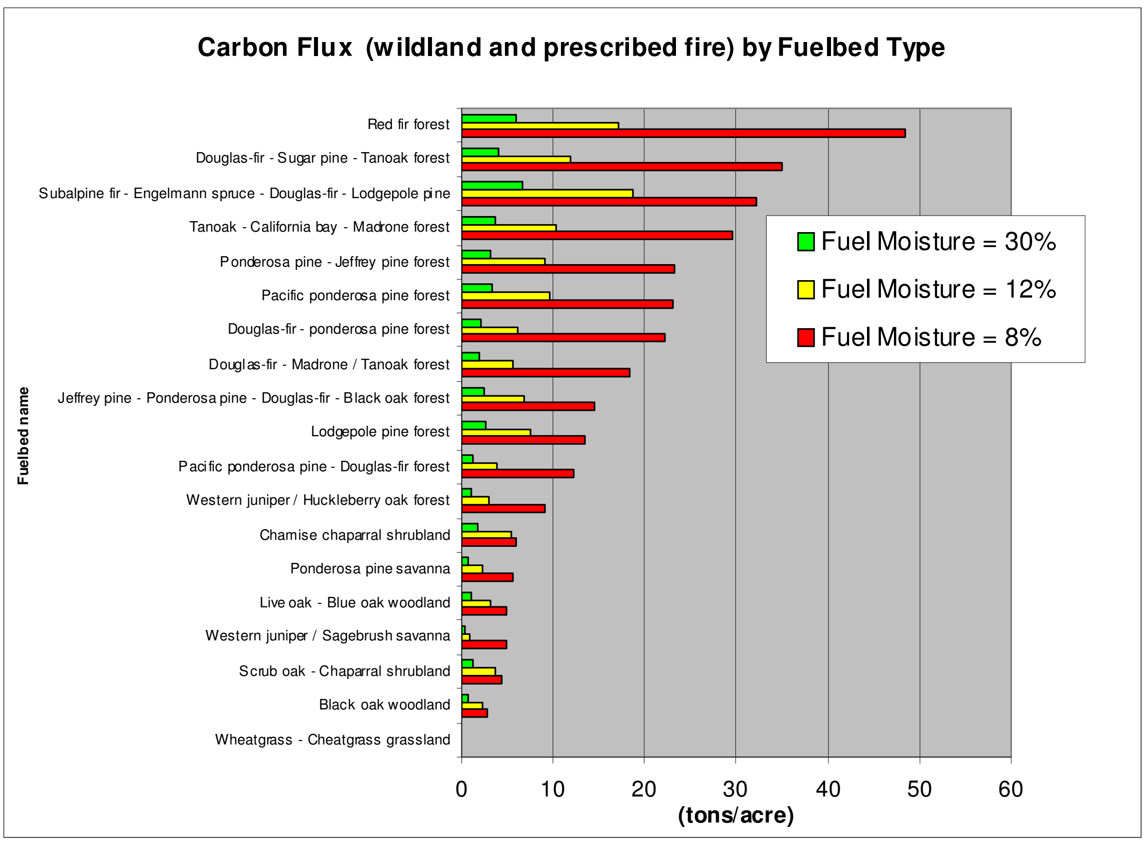


Figure 12. Carbon Flux (tons/acre C) for FCCS fuelbeds in Oregon/California at three 1000-hr moisture content profiles. The "8%" moisture profile represents an average wildfire; 12% and 30% represents a range in fluxes expected from prescribed fire in each fuelbed.

Step 6—Calcualte historic baseline carbon flux (C released per year) for Project Area

a) Multiply carbon flux by adjusted area burned for each Fuelbed, then sum.

$$\text{Project Baseline Carbon Flux} = BCFlux_{project.wildfire} = \sum_{i=1}^{number.of.fuelbeds} (AFR_i \times CFlux_{i.wildfire})$$

Finally, the expected (historic baseline) annual area burned for Shasta—M261 (figure 11) was multiplied by the expected carbon flux from wildfires (figure 12) for each FCCS fuelbed to yield a historic baseline annual carbon flux for Shasta County (figure 13). Although a grass fuelbed (Wheatgrass-cheatgrass) is the greatest contributor of annual expected burned area (2600 acres), the type contributes only 300 tons per year to the carbon flux baseline. There are 11 Conifer-forest FCCS fuelbeds identified in Shasta county that contribute a total of 81000 tons per year to the Carbon flux. Shrub and deciduous forest fuelbeds contribute another 20100 tons per year to a total carbon flux of 104,443 tons C per year.

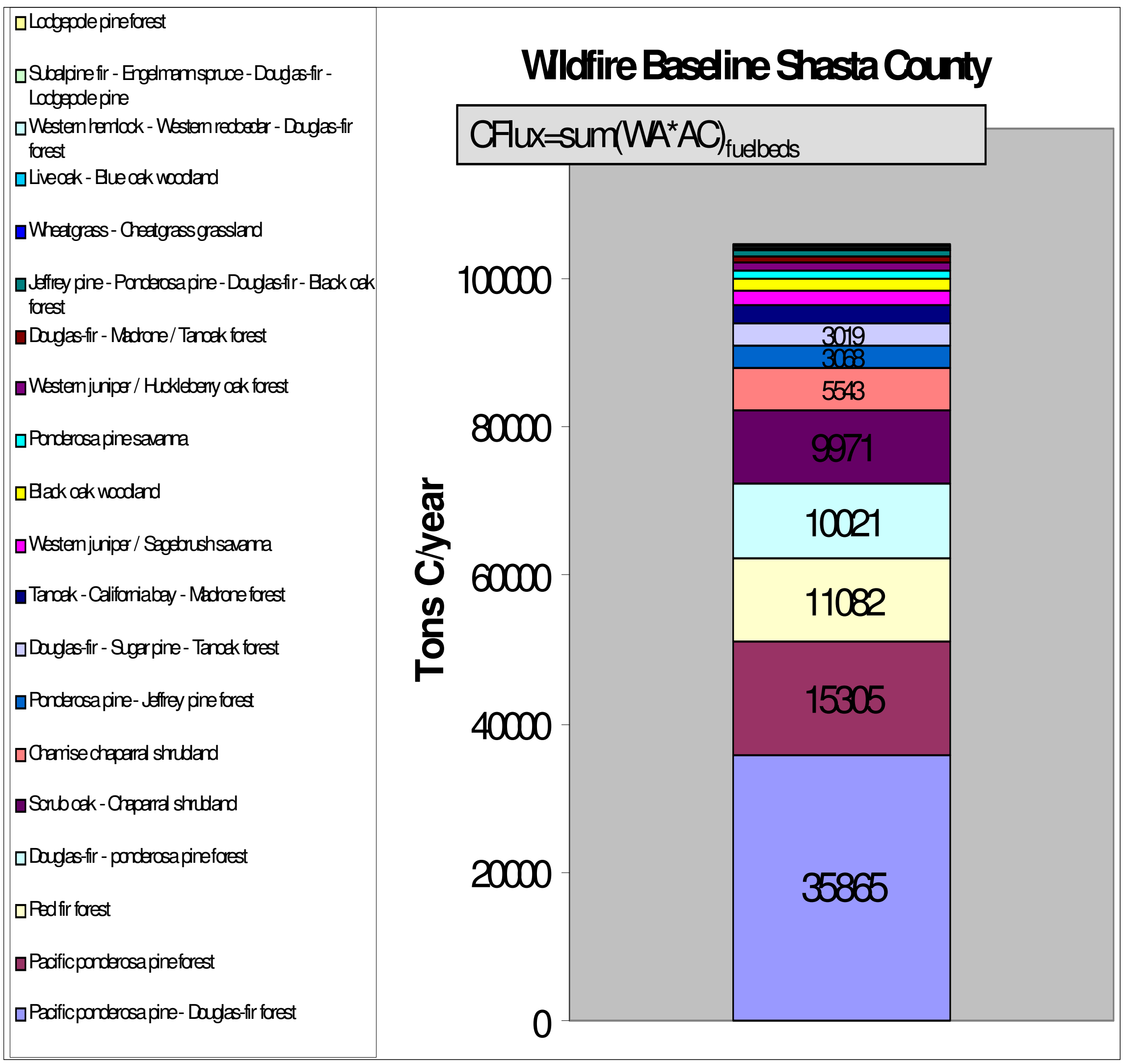


Figure 13. Historic wildfire carbon flux in Shasta County by FCCS Fuelbed type, i.e. the expected annual area burned by the wildfire carbon yield from each fuelbed present in the county. The greatest contribution to the baseline carbon flux are 4 coniferous forest types (Ponderosa pine-Douglas-fir, Ponderosa pine, Red fir, and Douglas-fir-Ponderosa pine). Total historic baseline wildfire carbon flux is 104,443 Tons per year.

Steps 4 and 6 in this test case were based on the Historic Fire Risk rather than a time adjusted risk (Step 2) Returning to the issue of the observed and predicted inflation of annual wildfire area burned, one could apply an factor of 1.007/year to the carbon flux in figure 13. Assuming that no increase in area carbon flux (tons/acre) occurs simultaneously, the 104 thousand tons per year can be expected to have increased to at least 120 thousand tons per year by 2008 and to 170,000 tons by 2058.

IV. SUMMARY and CONCLUSION: Draft protocol for establishing GHG emission project baselines for Wildland Fire Carbon emissions from wildland fire.

- Establishing Project baselines and measuring offsets for fuel management to reduce wildland fire greenhouse gas emissions must rely on modeling. Direct measurement is an unreliable baseline because of the episodic nature and extreme annual variability of fires.
- The baseline for wildfires is not a historic baseline, but is what would have occurred in the absence of fuel treatment in a future also affected by climate change, vegetation land use patterns, and cultural trends. The annual fire risk in most of the United States is increasing at between 0.5% and 0.9% per year.
- The same methodology and assumptions must be used both for establishing a baseline and for measuring the success of mitigating treatments, because any methodology used is likely to be less accurate than the magnitude of the offsets measured. The selected methodology must be precise enough to detect change and be repeatable by different analysts at different times.
- The draft protocol described in this report is based on quantitative algorithms that require no subjective or expert input. However, the assignment of relative risk based on vegetation or fuelbed characteristics is speculative. The example provided is based on an unpublished and narrowly-validated algorithm for that step. This represents a promising avenue for additional research.
- This analysis is intended to be fully transportable and can be used with a minimum of intensive data inputs. All information used for the baseline calculation exists in the public domain. Results could be improved with some specific site data characterizing the fire environment including better fuels, topographic, weather, and management influences.
- Alternatives to this approach include accomplishing a data-intensive and expert-system driven "fireshed" analysis under trial by several federal land management agencies. It is unknown whether that approach will provide adequate precision or repeatability, but it may prove a better alternative where its expense is justified.

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VI. WORK LEFT UNDONE

Establishing a baseline is an essential but an early step in establishing protocols for measuring offsets for forest fuels management, and the proposed methodology presented here is still imperfect. But the modeling framework used to measure baseline emissions can be extended to predict future baselines as well as the impacts of fuel treatments on wildfire and prescribed fire emissions. Next on the agenda:

1. LIFE-CYCLE FLUX ANALYSIS.: Develop the protocols to represent long term forest life-cycle analysis of carbon fluxes from under natural and alternative management scenarios.

Challenging addition work should be done to fully express baseline emissions from managed forests in order to represent the integral of all natural and anthropogenic sources of GHG emissions and sequestration over a forest life cycle (figure 14)

- 100-year, harvest cycle, or biological rotation baseline scenarios accounting for natural and management processes
    - Decomposition
    - Fuel accretion
    - Risk of non-fire disturbance (insects, windthrow, etc)
    - Succesional Change in forest structure (allocation to trees, shrubs, herbaceous, ground fuels)
    - Intermediate harvest
    - Fuel Treatments
    - Prescribed fire
    - Silvicultural treatments
- Recalculation of fire risk resulting from each process at each time interval

2. FUELBED-BASED FIRE RISK QUANTIFICATION: Improve on Step 4: Correlate annual fire risk to physical fuelbed characteristics.

Published statistical correlation between fuelbed characteristics and fire risk is absolutely essential to provide an automated, objective prediction of the effects of fuelbed changes on fire risk. This project provided a proof of concept that biomass production rates and the relative allocation of carbon by ecosystems into various fuelbed strata is useful for predicting natural fire return intervals and annual fire risk.

3. TREATMENT "SHADOW" EFFECT: Develop a simple, automated method for assigning an area-effect multiple for reduction in fire risk.

Spatial patterns of fuelbeds, including treated and untreated areas can be analyzed analytically or statistically to provide measures of percolation or resistance to fire spread. Fire behavior potentials (Sandberg and others

2007) provide a measure of fire spread and extreme fire behavior based on fuelbed characteristics that could be developed into a simple and automated default for the multiplying "shadow" effect of fuel treatments. The US Forest Service intensive "Fire-Shed" analysis is a data rich and expert-judgment based methodology that can be applied in some specific high value cases with good results, but is too subjective and area-limited to be widely transported.

4. INTEGRATION AND APPLICATION: Fuel Characterization Classification System and Consume; R5 Life-Cycle Analysis and SPLATS, Winrock policy development; California

The Winrock-lead contribution to the West Coast Regional Carbon Sequestration Partnership is a groundbreaking demonstration effort involving several agencies, institutions, and private entities. Many advances have been made in a healthy collaborative environment, but there has been no true coalescence into a clear team effort with clear expected application and outcome. The opportunity presents itself in California to apply specific local projects and Statewide programmatic strategies whose value in carbon offsets are measured by jointly developed and accepted set of protocols.

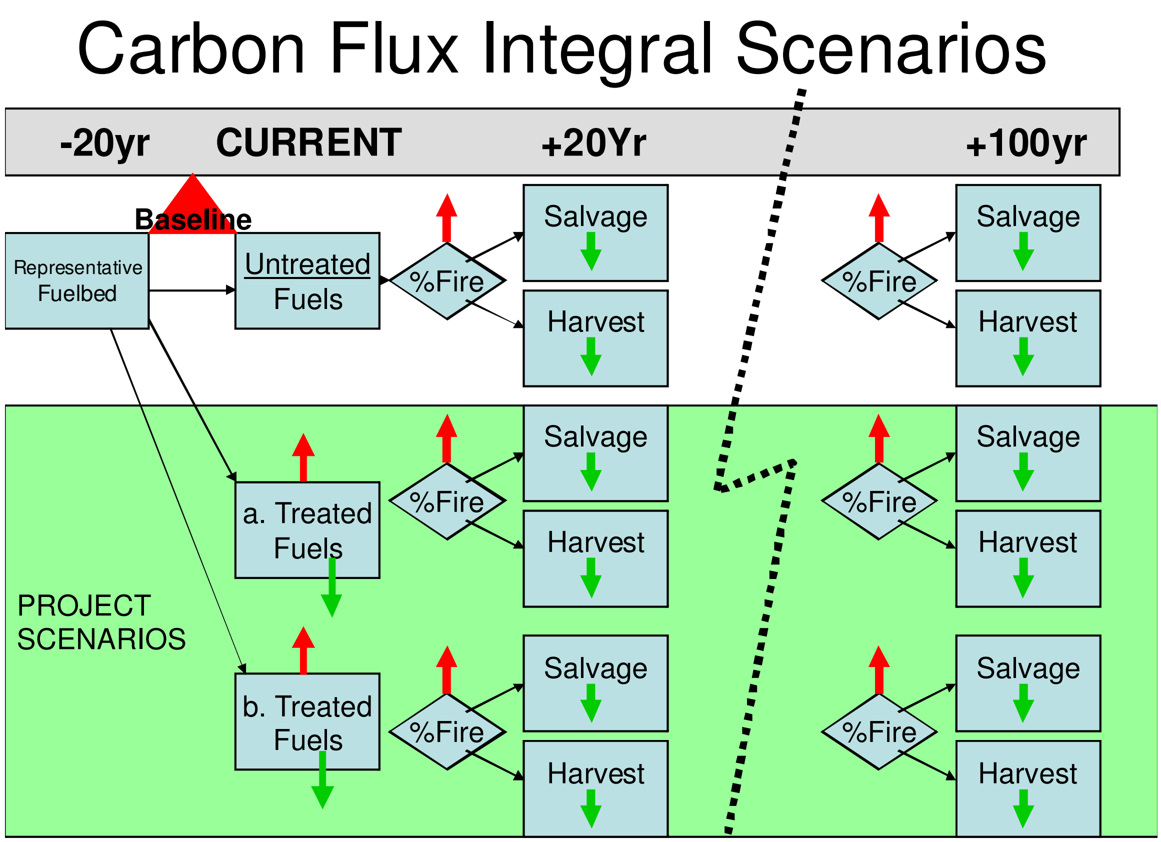

Figure 14. Carbon flux in managed forests consists of several management entries, vegetation succession, and natural events that each have an effect on fire risk as well as emitting or sequestering carbon.

APPENDIX D:
Rates of Decomposition of Woody Debris In WestCarb Region (Northern CA and Southern OR)

APPENDIX D

A.

RATES OF DECOMPOSITION OF WOODY DEBRIS IN WESTCARB REGION (Northern CA and Southern OR)

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April, 2007

RATES OF DECOMPOSITION OF WOODY DEBRIS IN WESTCARB REGION (Northern CA and Southern OR)

Introduction

This report was requested in support of methodology for determining carbon credits for improved fuel management. As specified in the statement of work, the report contains literature review and analysis of data on rates of decomposition of woody debris of species and sizes typically found in the mixed conifer forest type of northern CA and southern OR.

The key for understanding and managing woody debris in forest ecosystems is an understanding of the rate this material decomposes. Given this information one can plan the silvicultural, fuel treatment and other practices required to maintain dead wood at desired levels. Unfortunately decomposition rates have been determined for very few species and in a limited number of locations and site conditions. In the Pacific Northwest, the main species that have been reported are Douglas-fir and western hemlock (Graham 1982, Grier 1978, Means et al 1985, Sollins et al 1987). Other species such as lodgepole pine have also been published (Fahey 1983, Busse 1994), but most species remain without this level of examination. Preliminary data on 17 species occurring in the western United States (five locations in Oregon, one in California, one in Colorado, and one in Washington) has been posted on the web at http://www.fsl.orst.edu/lter/pubs/webdocs/reports/decomp/cwd_decomp_web.htm . These data sources and unpublished results from a branch decomposition experiment form the basis of this report. While none of the study sites are within the boundaries of WestCarb project pilot studies, eleven of the sites described in Appendix 1 are near enough to provide relevant decomposition data.

Methods and Sources of Data

The source of the data used in this report was taken from the peer-reviewed literature and from a preliminary report on decomposition rates for 17 species growing in the western Unitied States. Data on wood decomposition was obtained from eleven different sites with different climatic characteristics across the Western US (Table 1). The general approach used at each of the sites differed (Table 2). The three methods used (i.e., chronosequences, time series, and decomposition vectors) are defined below. Each estimate method has a level of uncertainty associated with it.

Chronosequence Approach

The chronosequence approach was used at Frasier, Sequoia, Olympic, Medicine Bow, and Central Oregon to determine decomposition rates from logs in which the sampling occurred only once. In a chronosequence one ages many pieces in various states of decay and examines how a parameter such as density changes through time. This is a substitution of space for time, and while not as precise as a time series experiment (where individual pieces are followed through time) it provides a good first approximation of decomposition rates (Harmon et al. 1998). The uncertainty with this method is intermediate.

Table 1. Climatic characteristics for each site.

	Mean annual temperature		Mean annual precipitation	
Site	Degrees C	Degrees F	mm	Inches
Cascade Head Experimental Forest (CHEF), OR	10	50	2489	98
Fraser Experimental Forest (FEF), CO	0.5	34	737	29
H.J. Andrews Experimental Forest (HJAF), OR	10	49	2500	98
H.J. Andrews Experimental Forest (FRIS), OR[a]	6.7	44	2221	87
Klamath Ranger District (KRD), OR	4	40	1054	42
Pringle Falls Experimental Forest (PFEF), OR	7	45	813	32
Sequoia National Park (SQNP), CA	8	46	1255	49
Wind River Experimental Forest (WREF), WA	8.7	47	2467	97
Warm Springs Reservation (WSR), OR	8.3	47	1778	70
Olympic National Park (ONP), WA	10	50	4000	157.5
Medicine Bow National Forests (MBNF), WY	5	41	600	24
Central Oregon			280	11

[a] FRIS plot in upper elevation.

Table 2. The type of measurements made at each study site.

Location	Type of measurement	Number of Measurements
CHEF	Decay classes, decomposition vector	2 times
FEF	Chronosequence	2 times
HJAF	Time series	5-9 times depending on sp.
FRIS	Chronosequence	1 time
KRD	Chronosequence	1 time
PFEF	Time series	3 times
SQNP	Decay classes, decomposition vector, chronosequence for Abco	2 times
WSR	Time series	1 time
WREF	Decay classes, decomposition vector	2 times
ONP	Chronosequence	1 time
MBNF	Chronosequence	1 time
Central OR	Chronosequence	1 time

Time Series

In a time series a cohort of fresh logs is placed out and individual pieces are followed through time (Harmon et al .1998). Typically a log is sampled once, after a planned interval expires. As different logs are sampled over time the trend in decomposition is revealed. It is more accurate than the chronosequence approach, but takes a lot more time to examine the full range of changes. This method was used at H. J. Andrews, and Pringle Falls. This method has the lowest uncertainty.

Decomposition Vectors
The final method used to study decomposition rates is the decomposition vector method which involves resampling pieces after a set period of time (Harmon et al. 2000). If the age of the piece being sampled can be determined it represents a combination of the chronosequence and time series methods. It is also possible to make estimates of decomposition rate for decay classes. This method allows one to quickly and accurately determine changes in both density and volume over the full range of decay conditions. We used this method at Cascade Head, Fraser, and Sequoia. This method has high certainty when the age of the pieces is known, but the lowest uncertainty when decay classes are resampled.

Methods used to determine density of coarse woody debris
Aside from determining the age of a piece, the key measurement to determine decomposition rates is density of the bark and wood. Density is expressed as a dry mass divided by green volume in most cases, although density can be determined in alternative ways. Pieces are subsampled with a chainsaw to remove cross-sections along the stem. Key characteristics such as presence of leaves, twigs, branches, bark, cross-sectional shape, wood hardness, and strength are typically recorded to help assign the piece to a decay class. Volume is determined either by displacement in water or a particulate solid (e.g., millet seed), taking a known volume using a core, or by measuring external dimensions. While volumes determined by external dimensions are less accurate, they can take quite rapidly in the field on very large volumes and have been the most frequently used.

Mass of samples is typically determined by drying in an oven, often at temperatures ranging between 55 and 75 ˚C until mass remains constant. This can take a extended period of time of weeks for even small cross-sections. To speed up drying times, smaller subsamples are often used. This entails weighing the entire sample and then subsampling for moisture determination. The ratio of oven dried mass to the fresh mass of the subsample is used to convert the fresh mass to dry mass of the entire sample.

In addition to determining the density it is important to determine the volume lost during decomposition. While some of this loss is due to fragmentation, some of it is due to the total respiration of some parts of logs (e.g, sapwood and stem tops). In cases where this correction has not been made the density can be overestimated and the mass loss underestimated (Harmon et al. 1987).

Decomposition rates for small diameter wood
This experiment was conducted in Pringle Falls. Fresh branchwood and twigs of four different size classes (1, 4, 8, and 15 cm) were cut into short lengths, weighed, tagged and placed on the forest floor. The original dry weight was estimated by subsampling fresh pieces. A small subsample was taken from each piece, but they were pooled to provide an average moisture content for a species and size class.

Statisitical analysis
The primary statistical analyses used for the chronosequence and time series data was linear regression. To calculate the decomposition rate constant, the estimated age of the logs was used as the independent variable and the density of the log (adjusted for fragmentation losses) was used as dependent variable. The form of the regression equation used to calculate the decomposition rate constant was:

$\ln(\text{Density}_t) = \ln(\text{Density}_0) - k\,t,$

where ln is the natural logarithm of Density_t or $\text{Density}_{0,}$ the density at time t and 0, respectively and k which is the decomposition rate constant.

In the case of time series without enough sample times for regression analysis (N<3) and decomposition vector samples we used a modification of the regression equation:

$-k = (\ln[\text{Density}_t/\text{Density}_{t-i}])/i$

where Density_t or $\text{Density}_{t-1,}$ the density at time t and the initial sampling time t-i, respectively and i is the interval between samples. The values of k calculated were then averaged to estimate the overall species rate of decomposition. The k estimated for each decay class was weighted by the relative residence time of the decay class.

To estimate the decomposition rate of fine woody detritus we calculated the ratio of decomposition rates for pieces of a given diameter by the decomposition rate for pieces with a diameter of 30 cm. One can estimate the decomposition rate of any species by multiplying this ratio by the decomposition rate of coarse woody detritus.

Results

A comparison of decomposition rates derived from the different methods indicates that for three of the best studied species (*Abies, Pseudotsuga*, and *Tsuga*) the rates are generally similar (Table 3). In contrast *Thuja* at HJAF and *Abies*, *Calocedrus*, and *Pinus lambertiana* at SQNP in which the regression estimate of decomposition rate was about half that of the decomposition vector approach. For some species, this difference was caused by the small sample size used in the regression. However for the better sampled species (*Abies* and *Thuja*) it is likely caused by a nonlinear decomposition pattern. In the case of a steady loss of mass the two methods should give identical methods. However, when decomposition accelerates and then slows, the regression method may fail to detect the period of rapid mass loss. This indicates that average rates of decomposition need to be taken as an approximation and a non-linear model with a changing decomposition rate may be required.

Table 3. Best estimate of decomposition rates using all methods.

Site	Species	*k*	Uncertainty
CHEF	Alru	0.055	medium
CHEF	Pisi	0.023	medium
CHEF	Tshe	0.023	medium
FEF	Abla	0.035	medium
FEF	Pico	0.023	medium
FEF	Pien	0.028	high
FRIS	Abpr	0.023	medium
HJAF	Abam	0.051	low
HJAF	Alru	0.083	low
HJAF	Psme	0.007-0.016	medium
HJAF	Thpl	0.007	low
HJAF	Tshe	0.008-0.026	medium
KRD	Abco	0.035	medium
KRD	Abma	0.043	medium
PFEF	Abgr	0.038	medium
PFEF	Pico	0.042	medium
PFEF	Pimo	0.035	medium
PFEF	Pipo	0.011	high
SQNP	Abco	0.051	medium
SQNP	Cade	0.02	high
SQNP	Pije	0.042	medium
SQNP	Pila	0.036	high
WREF	Psme	0.014	medium
WREF	Tshe	0.018	medium
WSR	Abpr	0.030	medium
ONP	Pisi	0.011	medium
ONP	Tshe	0.010	medium
MBNF	Pico	0.012	medium
Central OR	Pico	0.027	medium

Based on all the likely estimates (reasonable sample size, preference for regression estimates) of decomposition rates it would appear that the decomposition rate of tree boles can range and order of magnitude between 0.007 to 0.083 year^{-1}. The two highest rates were for *Alnus*, which was consistent at the two sites it was examined (0.087 and 0.089 year^{-1}). *Abies* at SQNP was estimated to have rates as high as 0.087 year$^{-1,}$ but a long-term average is more likely to be 0.044 year^{-1}. This would mean that the range for conifers is most likely to be from 0.007 to 0.044 year^{-1}.

The rates of decomposition estimated generally correspond to the general classes of decay resistance developed in forest products analysis. Conifer genera with very low decay resistance such as *Abies* had decomposition rates ranging from 0.035 to 0.051 year^{-1}. However, for other genera with low decay resistance, there was considerable variation with *Picea* ranging between 0.018 to 0.028 year^{-1} and yellow pines ranging between 0.011 and 0.023 year^{-1}, and *Tsuga* being 0.026 year^{-1}. The high range in yellow pines is likely caused by and underestimation with *Pinus ponderosa*. *Pseudotsuga* and white pine species, which have moderate decay resistance had decomposition rates ranging between 0.014 and 0.035 $year^{-1}$. The two genera with high decay resistance (*Thuja* and *Calocedrus*) had decomposition rates ranging between 0.007 and 0.02 $year^{-1}$.

Decomposition rates for small diameter fuels are faster than for CWD (Figure 1). A 1-hour fuel decays about 10 times faster than a 10,000-hour fuel (Table 4). The relationship between fuel size classes and decomposition rate is hyperbolic (i..e., 1/time) indicating that it requires longer to decomposition larger fuels.

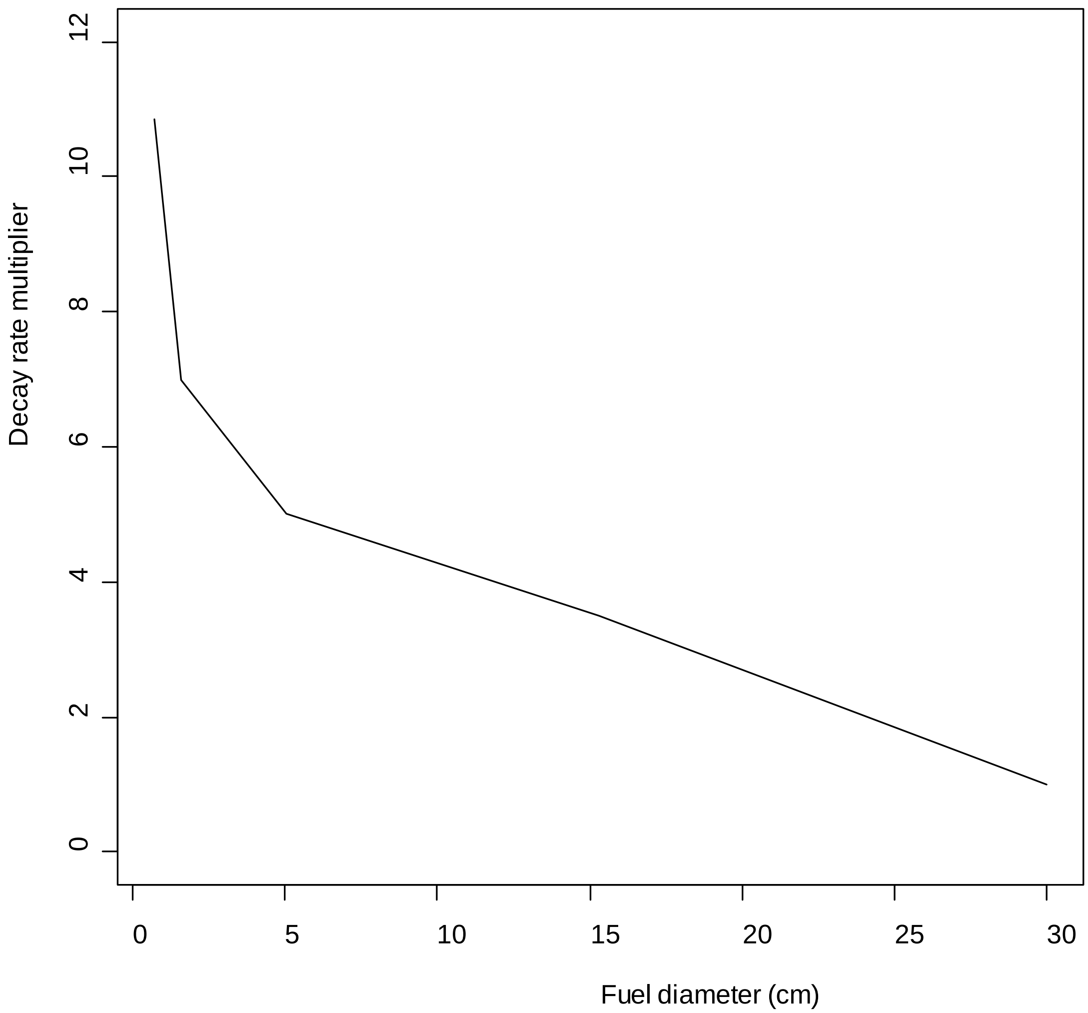

Table 4. Decomposition rate multiplier for time-lag fuels small size woody debris.

Fuel class	Diameter range	Decomposition rate multiplier
1 hour	$D < 7$ mm	10.85
10 hour	7 mm< D < 25 mm	7.00
100 hour	25 mm < D < 76 mm	5.02
1000 hour	76 mm< D< 23 cm	3.50
10,000 hour	23 cm < D*	1

* value for a CWD of 30 cm *D*

Uncertainty in decomposition rate estimates

The data presented in this report were not collected from the pilot study area and that introduces uncertainty in the decomposition rate values. While the species might be the same, the environment is unlikely to be the same. There is little understanding how temperature and precipitation interact to control decomposition rates. Temperature increases decomposition rates in theory, but it also increases evaporation rates and reduces moisture available to decomposers. Given that moisture in the pilot study area is likely lower than the study areas found in the review, it is possible decomposition rates are lower than estimated from the literature.

The effect of size is not completely understood. There is a lack of data on fine wood decomposition (despite its importance as a fire fuel). In part it is due to the fact that fine wood decomposition rates are highly influenced by the position of the piece relative to the forest floor. Pieces on the forest floor are more likely to decompose faster than those suspended above the forest floor. As our preliminary numbers are for pieces on the forest floor these estimates are likely to be high if the decomposition rates of pieces are suspended is being predicted.

All the decomposition rates reported have been for downed wood. Given the dry nature of the pilot study area it is likely that suspended or standing dead wood decomposition rates will be extremely low relative to that of downed wood.

The effects of burning on decomposition rates are not known. Fire is likely to slow decomposition, but this may only be true for wood that is in the intermediate stages of decomposition (Harmon 2001). Fire charred trees are typically attractive to wood boring insects and many species specialize in finding fire-killed trees. Wood fully colonized by decomposers is also likely to be little affected by charring, although increasing albedo is likely to heat the wood and lead to faster biological activity. Charring is most likely to slow decomposition in woody pieces that have the decayed portions fully removed by fire, thus eliminating the normal colonization sequence.

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Appendix 1. *Description of study sites*

Cascade Head Experimental Forest (CHEF), Oregon
Cascade Head is located on the north-central coast of Oregon, 8 km north of Lincoln City. It lies entirely within the Hebo Ranger District of the Siuslaw National Forest. The site is in the Oregon Coast Range region and the forests are representative of the Sitka spruce-western hemlock (*Picea sitchensis-Tsuga heterophylla*) and Douglas-fir (*Pseudotsuga menziesii*) zones of the region. Soils, derived primarily from tuffaceous siltstones, are fine textured, moderately well drained, and deep (up to 100+ cm). Because of the Pacific Ocean influence, CHEF has a moderate and very wet climate. Mean annual temperature is 10˚C (50 F) with minimal seasonal variation. Average yearly rainfall is 2489 mm (98 in.), although fog drip through the forest canopy can add 500 mm or more precipitation a year.

Fraser Experimental Forest (FEF), Colorado
Fraser Experimental Forest is located in the heart of the central Rocky Mountains, about 50 air miles from Denver. FEF includes subalpine forests typical of the area, with Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) predominating at higher elevations and lodgepole pine (*Pinus contorta var. latifolia*) predominating at lower elevations and on drier upper slopes. Soils are generally derived from gneiss and schist and typically contain angular gravel and stone with very little silt or clay. These soils are very permeable and can store considerable water during snowmelt. Climate varies strongly with elevation. Overall, the climate is cool and humid with long, cold winters and short, cool summers. Mean annual temperature at the Fraser Forest headquarters is 0.5°C (34 F) and mean annual precipitation over the entire FEF is 737 mm (29 inches).

H. J. Andrews Experimental Forest (HJAF and FRIS), Oregon
H. J. Andrews Experimental Forest is located approximately 5 miles east of Blue River, Oregon, within the Willamette National Forest. The HJAF plots are primarily located in lower elevation forests that are dominated by Douglas-fir, western hemlock, and western redcedar (*Thuja plicata*). The FRIS plot is located in upper elevation forest that contains noble fir (*Abies procera*), pacific silver fir (*Abies amabilis*), Douglas-fir, and western hemlock. Throughout the experimental forest soils are mainly Inceptisols (some undoubably Andisols) with local areas of Alfisols and Spodosols. The maritime climate has wet, mild winters and dry, cool summers. The average temperature at lower elevation is 9.5°C (49 F) and the average precipitation is 2500 mm (98 inches). The average temperature at higher elevation is 6.7°C (44 F) and the average precipitation is 2221 mm (87 inches).

Klamath Ranger District, Winema National Forest (KRD), Oregon

The Klamath Ranger District of the Winema National Forest is located in south-central Oregon, 35 miles northwest of Klamath Falls and south of Crater Lake National Park. Elevations on this Ranger District range from 1,277 to 2,430 m (4,200 feet to 8,000 feet). The topography is mountainous and dissected. Conifer forests are the dominant vegetation, and fall within the mixed conifer, white fir (*Abies concolor*), Shasta red fir (*Abies magnifica*), and mountain hemlock (*Tsuga mertensiana*) zones of Franklin and Dyrness (1973). Mixtures of white fir, ponderosa pine (*Pinus ponderosa*), and Douglas-fir occur at the lowest elevations and red fir, mountain hemlock, western white pine (*Pinus monticola*) and lodgepole pine occur at the highest elevations (Hopkins 1979). Soils are generally well-drained, gravelly and cobbly fine sandy loams to loam, with 10-75% coarse fragments (Carlson 1979). The climate is characterized by cold, snowy winters and warm, dry summers (Carlson 1979). The mean annual temperature is 4.4°C (40 F). Mean annual precipitation is 1054 mm (41.5 inches).

Pringle Falls Experimental Forest (PFEF), Oregon

Pringle Falls Experimental Forest is located in central Oregon, about 6 miles west of LaPine, within the Deschutes National Forest. The forests are characteristic of low elevation forests within the High Cascades physiographic province and are comprised of ponderosa pine, lodgepole pine, and higher elevation mixed conifer. Soils are derived from aerially deposited Mount Mazama pumice and ash with only a thin weathered surface layer. Most of the soil profile is undeveloped, with low organic matter content and high porosity. The climate at PFEF is continental, and most precipitation occurs as snowfall. Annual precipitation averages 813 mm (32 inches) and the average temperature is 7°C (45 F).

Sequoia National Park (SQNP), California

Sequoia National Park is located in the Sierra Nevada mountain range of East-Central California within Tulare and Fresno Counties. The sample plots for this study were located in the Giant Forest region of the park. Vegetation in this region is typical for midelevation mixed conifer forests in the Sierra Nevada. The forests of this area are dominated by white fir, red fir (*Abies magnifica*), incense cedar (*Calocedrus decurrens*), sugar pine (*Pinus lambertiana*), Jeffrey pine (*Pinus jeffreyi*), and giant sequoia (*Sequoiadendron giganteum*). Soils are primarily Pachic Xerumbrepts, derived from granodiorite. The climate of this area is Mediterranean, with wet, snowy winters and long, dry summers. The mean annual precipitation is 1255 mm (49 inches), with approximately half occurring as snow. The mean annual temperature is 8°C (46 F).

Wind River Experimental Forest (WREF), Washington

The Wind River Experimental Forest is near Carson, Washington in the Gifford Pinchot National Forest. The forest is classified as a western hemlock/salal (*Gaultheria shallon*) cover type, and is estimated to be ~500 years old. Dominant tree species are Douglas-fir and western hemlock. Dominant understory shrub species are vine maple (*Acer* *circinatum*), salal, and dwarf Oregon grape (*Berberis nervosa*). Soils are of the Stabler series, coarse textured and developed on 2 to 3 meters of volcanic ejecta over basalt bedrock. Texture ranges from shotty loam to clay with coarse particles in the top 1 m averaging 3% of the soil volume. The climate is characteristic of a temperate winter-wet, summer-dry climate. Annual precipitation totals 2467 mm with less than 10% occurring between June and September. Mean annual temperature is 8.7°C.

Warm Springs Reservation (WSR), Oregon

The Warm Springs reservation plots are located in north central Oregon, approximately 8 miles from the town of Government Camp and bordering the Mt. Hood National Forest. The forests are characteristic of mid to high elevation forests within the High Cascades physiographic province and are comprised of Douglas-fir, western hemlock, noble fir, pacific silver fir, and higher elevation mixed conifer. The climate is characterized by cold, snowy winters and warm, dry summers. The mean annual temperature is 8.3°C (47 F). Mean annual precipitation is 1778 mm (70 inches).

Olympic National Park (ONP), Washington

The Olympic National Park is located in the Olympic Peninsula, WA. The study area was located 5 km inside the National Park along the south fork of the Hoh River on the west side of the peninsula. Forests in this area consist of massive, widely spaced Sitka spruce and western hemlock with scattered bigleaf maple trees and large vine maple shrubs. The climate of the region is characterized by winter rains and summer drought. There may be intermittent snowpacks in this area during the winter. Precipitation exceeds 250 cm per year (Graham and Cromack 1982).

Medicine Bow National Forest (MBNF), Wyoming

The Medicine Bow-Routt National Forests extend from north central Colorado to central Wyoming. The study sites were located in Wyoming about 50 km west of Laramie. The climate of the Forests ranges from semi-arid at low elevations to cold and humid in the high country. Mean annual precipitation is about 600 mm, mostly in the form of snow from October to May. Large annual variation in precipitation (over two fold) is a characteristic of the study site. In July the mean daily maximum temperature is 20°C and the mean minimum is 4°C. Forests are dominated by *Pinus contorta*.

Central Oregon

The study area was located on the high lava plains of Central Oregon, about 30 km east of LaPine. The average elevation is 1670 m asl, and the landscape is gently rolling, with scattered volcanic cones and buttes. Most of the precipitation falls in the form of snow during November through April. Forests are dominated by lodgepole pine with an understory dominated by bitterbrush (*Purshia tridentata*) and western needle grass (*Stipa occidentalis*).

APPENDIX D.

B.

MODELING STUDY OF CARBON DYNAMICS

FOR SELECTED TREATMENTS OF FOREST FUELS IN SOUTHERN OR

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Introduction

This report was prepared to present the results of a simulation study of forest carbon dynamics with and without different fuel treatments (stand thinning) and for different wild fire severities. As planned for TASK 4, the STANDCARB 2.0 model was used to examine changes in carbon stores over time for these scenarios:

> control and 2 different levels of thinning (high and low intensity)
>
> regeneration after wild fire (3 levels of burning severity for the above fuel treatments)

Additional scenarios were also examined to assist in the analysis of the impact of thinning and wild fire on carbon stores and on forest fuels. The report includes the description of methods and assumptions used to frame the model simulations, results of simulation runs and their analysis, and preliminary conclusions at the end.

Methods and Assumptions

STANDCARB Model

STANDCARB 2.0 is a simulation model that accounts for the regeneration, growth, death, decomposition, and disturbance of forest stands (Harmon and Marks 2002). The pools of carbon accounted for in this model include live (separated into various parts such as leaves, branches, stems, and roots), dead (all the types of live parts that have died), and stable (soil) pools. The model has been parameterized for the major tree species in the PNW and used for analysis of the impact of forest management activities on carbon stores in forest ecosystems (e.g., Cohen et al. 1996, Harmon and Marks 2002, Krankina and Harmon 2006).

The model can be set up to assess the effects of different types of forest disturbance on carbon pools. The timing and the impact of disturbance can be defined by the user. The default definitions of burning severity in STANDCARB for the four vegetation layers (Herbs, Shrubs, Lower trees, and Upper trees) include: percent killed which represents the amount of biomass for each layer killed by fire, percent burned is the proportion of killed biomass that is incinerated, and percent charcoal is the proportion of killed biomass that is converted to charcoal (Table 1).

Table 1. Definition of burning severity in STANDCARB

Fire severity	Layer	% killed aboveground	%killed belowground	% burned aboveground	% burned belowground	% charcoal aboveground	% charcoal belowground
High	Herb	100	100	99.5	50	0.5	2.0
High	Shrub	100	100	99	5	1.0	2.0
High	LTree	100	100	10	5	2.0	1.0
High	UTree	100	100	5	2	4.0	1.0
Medium	Herb	90	90	99	25	1.0	1.5
Medium	Shrub	75	75	75	5	1.0	1.0
Medium	LTree	90	90	7	2	1.5	0.0
Medium	UTree	50	50	2	1	1.0	0.0
Low	Herb	80	80	99.5	0	0.5	0.5
Low	Shrub	50	50	50	0	0.5	0.5
Low	LTree	80	80	5	0	1.0	0.5
Low	UTree	5	5	1	0	2.0	0.5

The proportion of different dead biomass pools **left on site** following wild fires of low, medium, and high severity is shown in Table 2, along with the "fuel weighting factor" parameter which defines the likely contribution of various fuels to fire severity. The level of burn severity is based on the amount of fuels present (unless the user prescribes a specific burn severity).

Table 2. Proportion of different dead biomass pools left on site following wild fires

Pool	Light Burn	Medium Burn	Hot Burn	Fuel Weighting Factor
Dead Foliage	75	50	0	0.65
Dead Fine Root	100	75	50	0.213
Snag SapWood	100	85	70	0.3
Log SapWood	95	75	50	0.65
Snag HeartWood	100	95	80	0.2
Log HeartWood	100	90	70	0.413
Dead Branch	75	50	0	0.75
Dead Coarse Root	100	100	70	0.138
Stable Soil	100	100	100	0
Stable foliage	100	50	25	0.713
Stable wood	100	50	25	0.713
Charcoal	10	5	0	0.2
Herb	n/a	n/a	n/a	0.325
Shrub	n/a	n/a	n/a	0.675
Lower Trees	n/a	n/a	n/a	0.8

For the dead pools, the proportions of burned mass (percentages) that is transformed into charcoal are presented in Table 3.

Table 3. Percent of burned mass that is transformed into charcoal

Pool	Light Burn	Medium Burn	Hot Burn
Dead Foliage	2	3	0
Dead Fine Root	1	2	0
Snag Sapwood	1	1.7	2.5
Log Sapwood	2	3.5	5
Snag Heartwood	0	0	1.2
Log Heartwood	0	0.4	1.5
Dead Branch	5	10	1
Dead Coarse Root	0.5	1	2
Stable Soil	0	0	0
Stable foliage	2	3	1
Stable wood	2	3	1

Charcoal in STANDCARB is composed of two pools. The first is the surface charcoal pool, which represents charcoal input from live, dead, and stable pools when there is a wild fire. These pools are subject to loss from wild fires and can be transferred to the second pool which is buried charcoal. The latter is not subject to loss via fires and has a very low decomposition rate (essentially zero).

The model outputs the stores of carbon in all pools. For purposes of WestCarb Project we created two additional outputs: (1) total harvest which is the sum of all biomass removals by thinning for a given scenario and defined time interval and (2) "fuel levels" which we calculated using the "fuel weighting factor" above and grouped into the following five categories:

Fine fuels= Dead foliage + Dead Branches

Coarse woody fuels = Snagsapwood + Snagheartwood + Logsapwood + Logheartwood

Belowground fuels=Fine roots + Coarse roots + Stablefoliage + Stablewood

Live fuels = Herbs + Shrub leaf + Shrub branch + Lower trees leaf + Lower trees branch

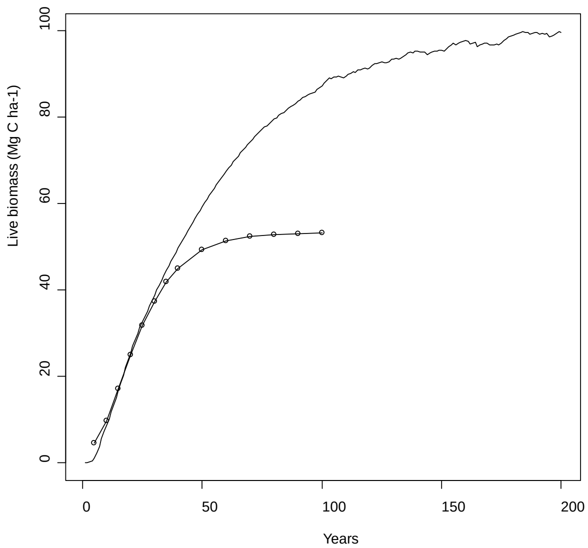
Charcoal.

Model calibration.
To approximate the growth patterns of major forest types in Southern Oregon we calibrated the model to make the output consistent with FIA data. We generated the reference data using the Carbon Online Estimator (COLE, http://ncasi.uml.edu/COLE/), which is an online package that was developed under a cooperative agreement between NCASI and the USDA Forest Service, RWU-4104 in Durham, NH. We retrieved data from USDA Forest Inventory and Analysis plots current as of March 18, 2005 for Klamath and Lake Counties in Oregon. Even though the Lake County is the primary

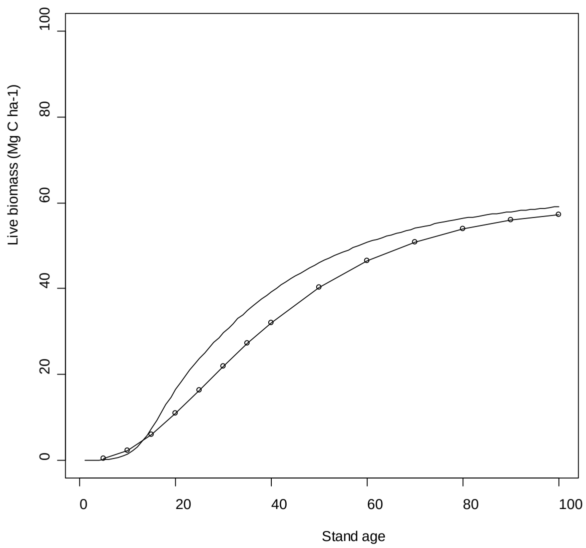
focus we felt that pooling data from 2 adjacent counties would increase the number of plots and produce more robust reference data. The full COLE report for two counties is appended.

Only forest types represented by >20 plots were analyzed by the COLE report; those forest types include Ponderosa pine (155 plots), Fir/Spruce/Mountain Hemlock Group (27 plots), White Fir (28 plots), Lodgepole pine (100 plots). Ponderosa pine Lodgepole pine types were selected for the modeling and analysis.

While the report provided information on a full set of forest carbon pools, we focused the calibration on live tree carbon which is expected to be the most accurate of all reported pools. The chronosequence of live tree biomass shows little or no accumulation beyond stand age class 70-80 years (Figure 1 and Appendix-Table 3) for Ponderosa Pine while for Lodgepole pine accumulation continues through age 100 years. The lack of biomass accumulation in older stands of Ponderosa pine is likely an artifact of chronosequence method as it reflects the impact of thinning and also the selective removal of high-biomass stands from the older age cohort by past clearcut harvests. This impact can be expected to be greater in more productive and valuable Ponderosa pine type than in Lodgepole pine. Thus for Ponderosa pine we used the values from age classes 5-50 as a basis for model calibration, while for lodgepole pine the entire chronosequence of biomass accumulation with age of forest stands matched closely the model output (Figure 1).



Live biomass (Mg C ha-1)
0
20
40
60
80
100
0
50
100
150
200
Years



Live biomass (Mg C ha-1)
0
20
40
60
80
100
0
20
40
60
80
100
Stand age

	50%			x	x

The effects of fire were simulated using the same starting point as for thinning scenarios and the model was run for 1000 years for the following wild fire scenario matrix:

		Frequency			
		0	20 yrs	100yrs	200yrs
Severity	No	x			
	Low		x	x	
	Moderate			x	
	High			x	x

While the model is best suited to simulate long-term impacts of different disturbance regimes we recognize the need to examine shorter-term effects, and produced a set of outputs that focus on short-term simulation results as well.

In the combined thinning and wild fire model runs we used a subset of thinning scenarios including one scenario with aggressive thinning (50% thinning every 25 years) and two moderate thinning scenarios (35% and 20% every 25 years). The timing of fires was selected randomly to average a 100 year fire return interval. We assumed that thinning reduces wild fire severity and not the frequency of fires (Sam Sandberg, pers. comm.). The scenario with no thinning and high burning severity was used as a control against which scenarios with thinning were compared. In a separate round of simulations we allowed the model to define the burning severity based on the amount of fuel present at the site. To assure meaningful averages of resulting carbon stores the scenarios were run to year 1400.

Results

Thinning scenarios

Model calibration resulted in reasonable agreement for the calibration ages between COLE live tree biomass estimates based on FIA data and those simulated by STANDCARB for two selected forest types: Ponderosa Pine and Lodgepole Pine (Figure 1). Because forest floor and organic soil are reported as constant values in COLE report we did not consider those in the calibration exercise. Dead wood carbon pool also shows reasonable agreement between the simulations and data. While there is no precise match between reference data and calibrated model output we feel we were able to achieve realistic results. Because the overall approach is to estimate the effects in relative rather than absolute terms the differences between the simulation results and the reference data appear insignificant.

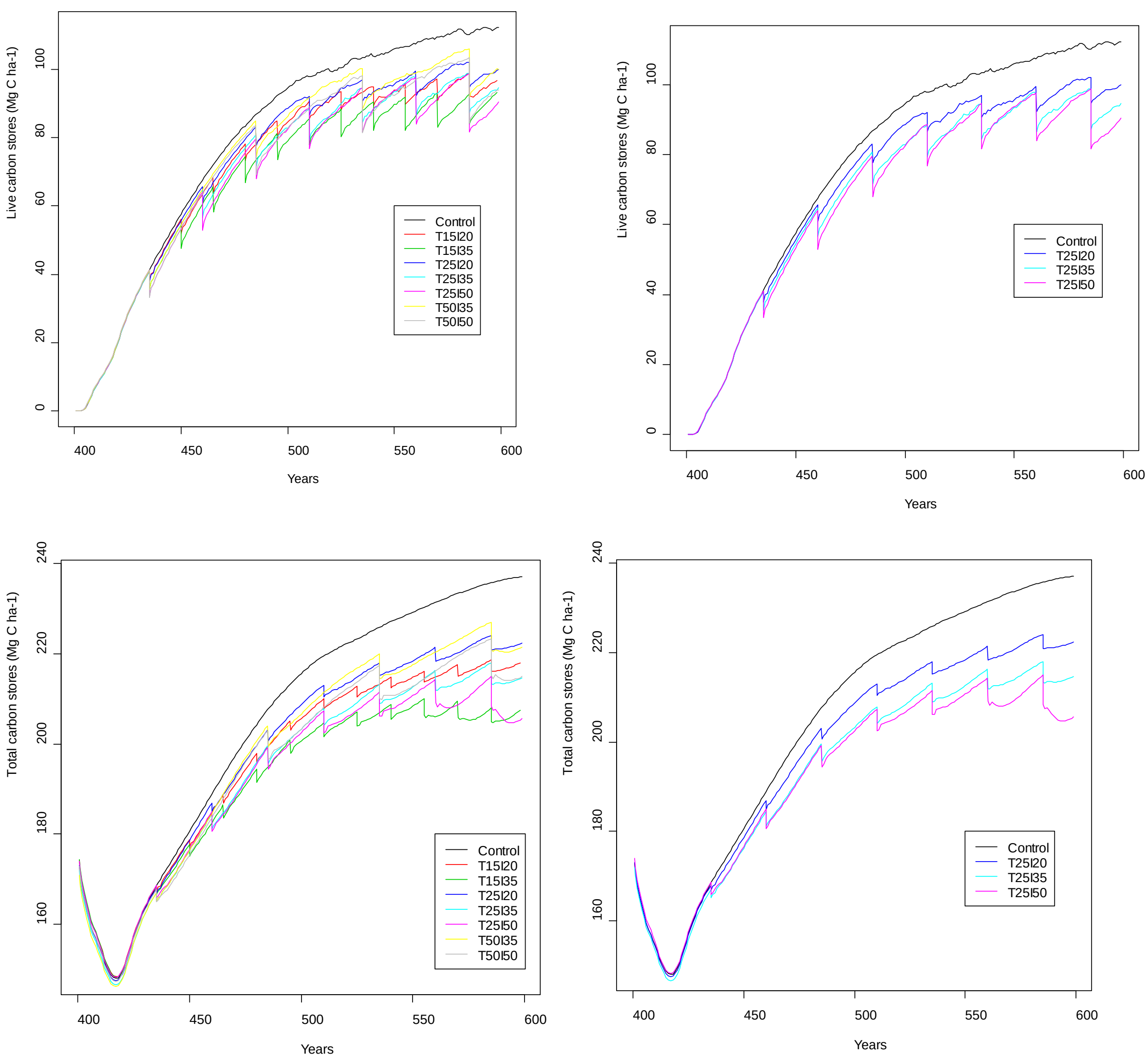


Figure 2. Effect of thinning on live (top) and total (bottom) biomass stores in Ponderosa Pine forest type (Legend: T is thinning frequency in years; I is thinning

intensity in percent of stem wood harvested, color-coding of individual scenarios shown on graphs).

Model outputs for Ponderosa Pine (Figure 2) suggest that at year 600 of the simulation (or after 165 years of application of aggressive thinning e.g., 35% removal every 15 years or 50% removal every 25 years) carbon stores in live biomass and total biomass stores declined by about 20 and 30 MgC/ha, respectively. This loss of carbon stores represents 15-20% of the business as usual scenario (control). Moderate scenarios resulted in smaller losses of carbon at the end of the simulation, but live biomass declined at least by 12 MgC/ha and total carbon stored by 15 MgC/ha. The overall pattern of impact was similar for Lodgepole Pine, but because of lower productivity the losses of carbon were lower in absolute terms (but represented a similar percentage of live and total carbon store on site; graphs not shown).

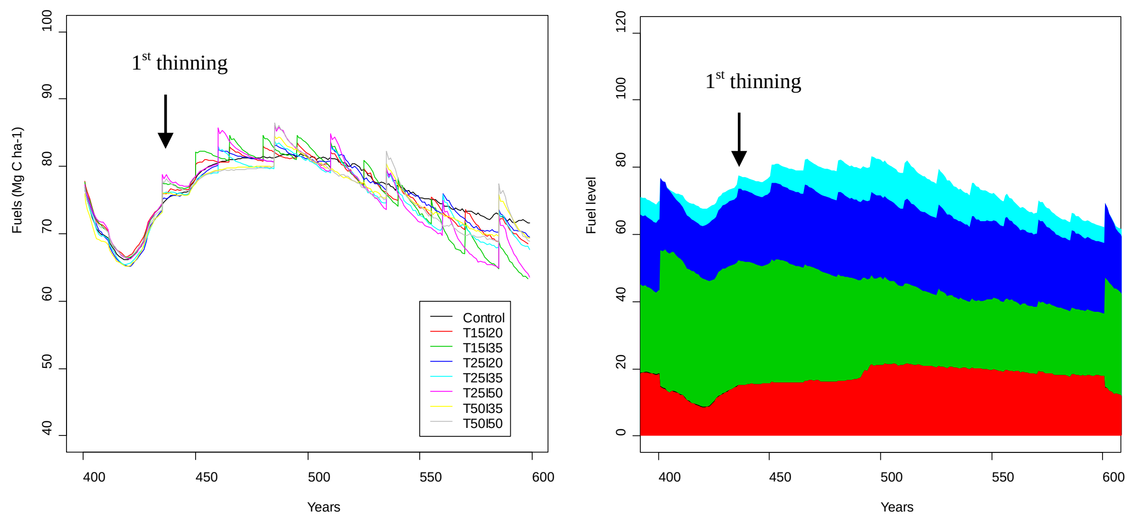


Figure 3. Effect of thinning on forest fuel level over time in Ponderosa Pine forest type: changes in total fuel loads for all scenarios (left) and changes in fuel composition for 35% thinning every 15 years (right; light blue - live fuels; blue - fine fuels; green - coarse woody fuels; red - belowground fuels).

All thinning scenarios in both forest types initially increase the amount of fuels on site (i.e., 50-80 years after the start of thinning regime), but over long term these treatments tend to cause a small reduction of fuel levels. Specifically, aggressive thinning in Ponderosa Pine reduced forest fuel level by up to 8 MgC/ha (or 12%) by the end of simulation. Thinning caused fluctuations in the amount and composition of fuels and fine fuels fluctuated the most: there is a sharp increase in fine fuels as the slash is left on site followed by reduction as this material rapidly decomposes. The proportion of live fuels increases over time as the canopy opens and allows understory vegetation to accumulate more biomass.

On average over the 165 years of applying these thinning treatments the losses of live biomass ranged from 7 to 15 MgC/ha compared to the no-thin scenario. The effect of thinning on the average fuel levels was small being about 1 MgC/ha or 1.3% of the forest fuel level in no-thin scenario (control). This average reflects the initial increase in fuel level and subsequent decline primarily due to the reduced level of coarse woody fuels towards the end of the simulation.

Carbon removed by harvest was by far the greatest effect of thinning and the greatest difference among thinning scenarios. The total amount of carbon moved off site with harvested biomass ranged from 42 to 87 MgC/ha in Ponderosa Pine and 32 to 68 MgC/ha in Lodgepole Pine indicating significant potential for biomass fuels offsets.

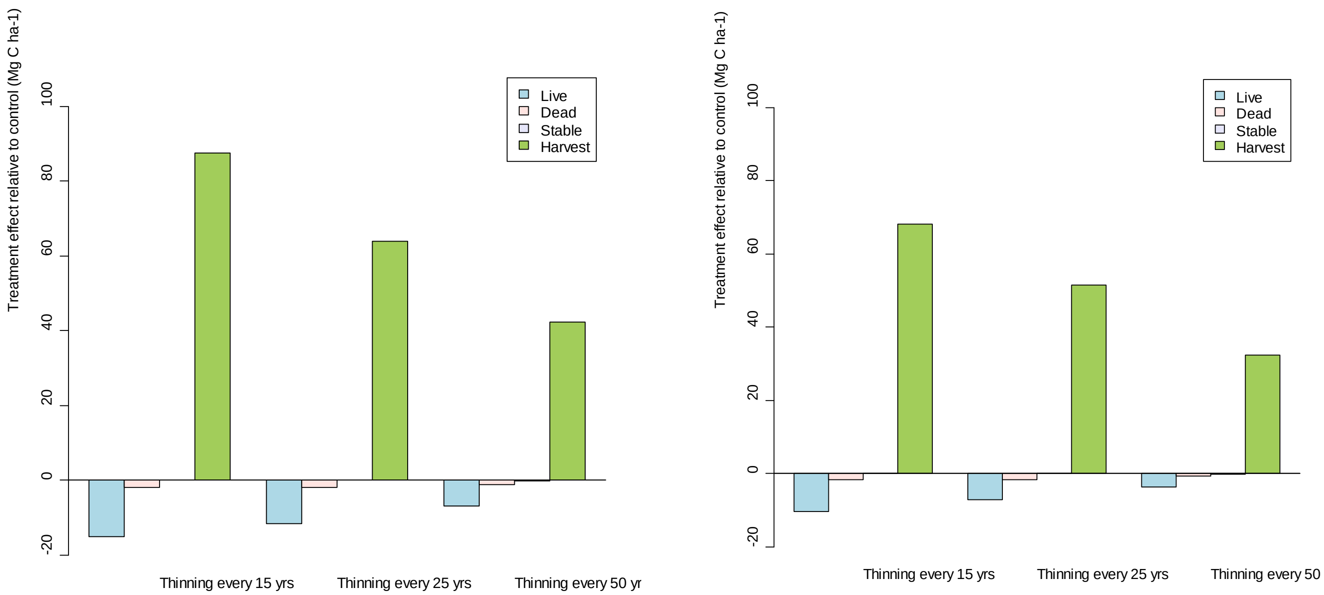
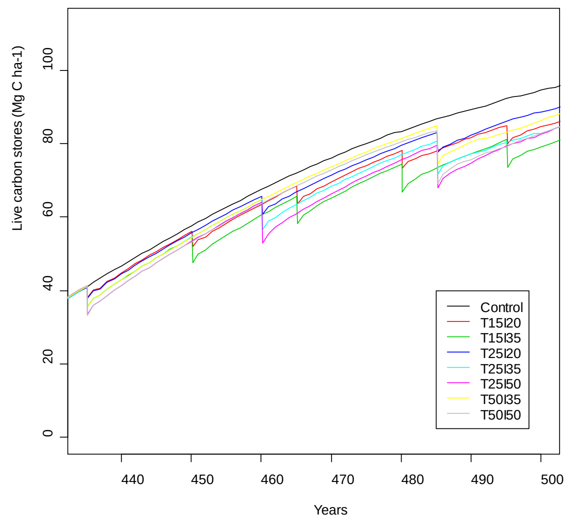


Figure 4. Summary of Thinning Effects in Ponderosa Pine (left) and Lodgepole Pine (right) over 165 years: comparison with control



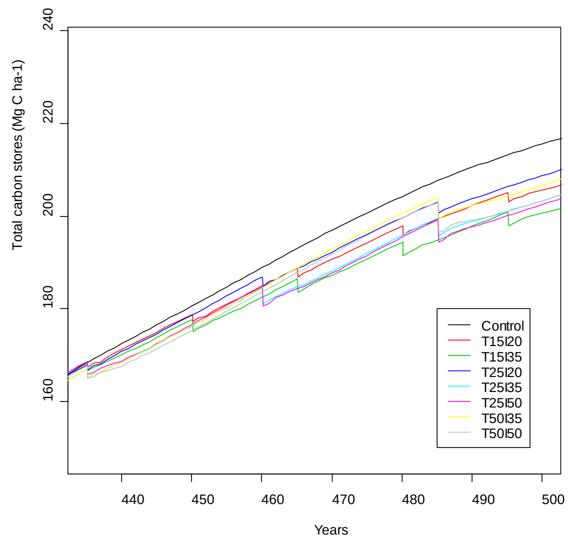


Figure 5. Short-term effect of thinning on live and total biomass stores in Ponderosa Pine forest type.

Carbon pools undergo significant short-term changes (in the year of thinning and during the first few years following thinning): it takes 4-6 years to recover the pre-harvest levels of live and total biomass, but in comparison to the control the stores of carbon in live trees and the total stores do not recover before the next round of thinning. Due to the input of slash the fuel level is the highest immediately following thinning; then it declines gradually as the slash decomposes (Figure 3). While these losses are partially offset by accumulating live fuels, the overall fuel level is the lowest prior to the next thinning.

Fire scenarios

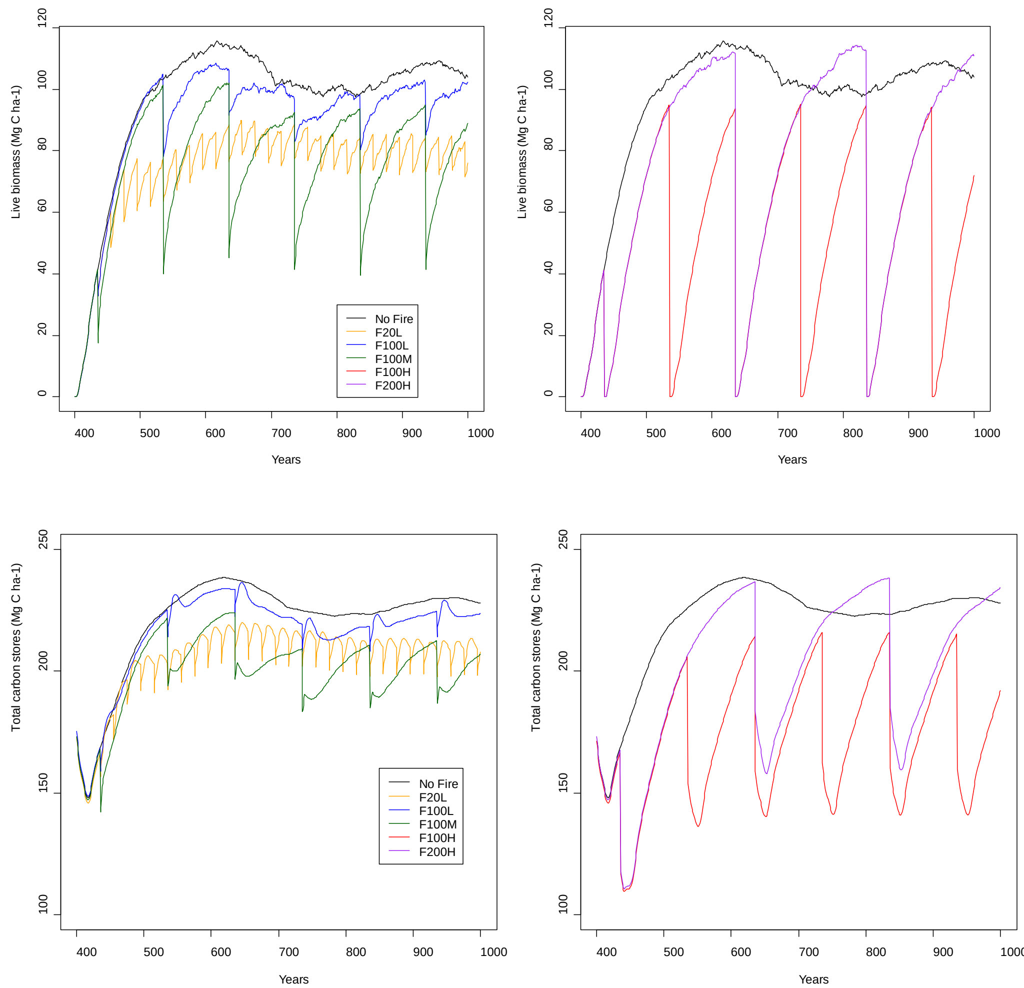


Figure 6. Effect of wild fire on live and total biomass stores in Ponderosa Pine forest type (Legend: F is Frequency; L, M, H are Low, Medium, and High Severity; for example:
F20L = Frequency 20 years, fire severity Low).

Wild fires caused greater fluctuations in the amount of C stored on site than did thinnings. On average wild fires reduced live and total carbon stores. The long-term average reduction in live stores caused by fire in Ponderosa Pine ranged from 8 to 53 MgC/ha, the reduction in total C stores on site was between 17 and 50 MgC/ha. Among the examined fire scenarios, high severity fire every 100 years made the greatest impact and low severity fire every 100 years – the smallest for both forest types.

Wild fires had relatively small impacts on long-term averages of fuel levels: low and medium severity fires had virtually no effect in Ponderosa Pine forest type, while high-severity fires increased fuel levels slightly (by 4-7 MgC/ha or 6-10%). A fire regime with low-severity frequent fire is expected to reduce fuel loads, and while in our simulations this regime did reduce the long-term average fuel level slightly in Lodgepole Pine forest type, it did actually increase it by 2.5 MgC/ha compared to no-burn scenario in Ponderosa

Pine forest type. The increase occurred in fine and belowground fuels (duff), while the live fuels were significantly lower compared to no-burn scenario (by 2 MgC/ha or 40% of the control).

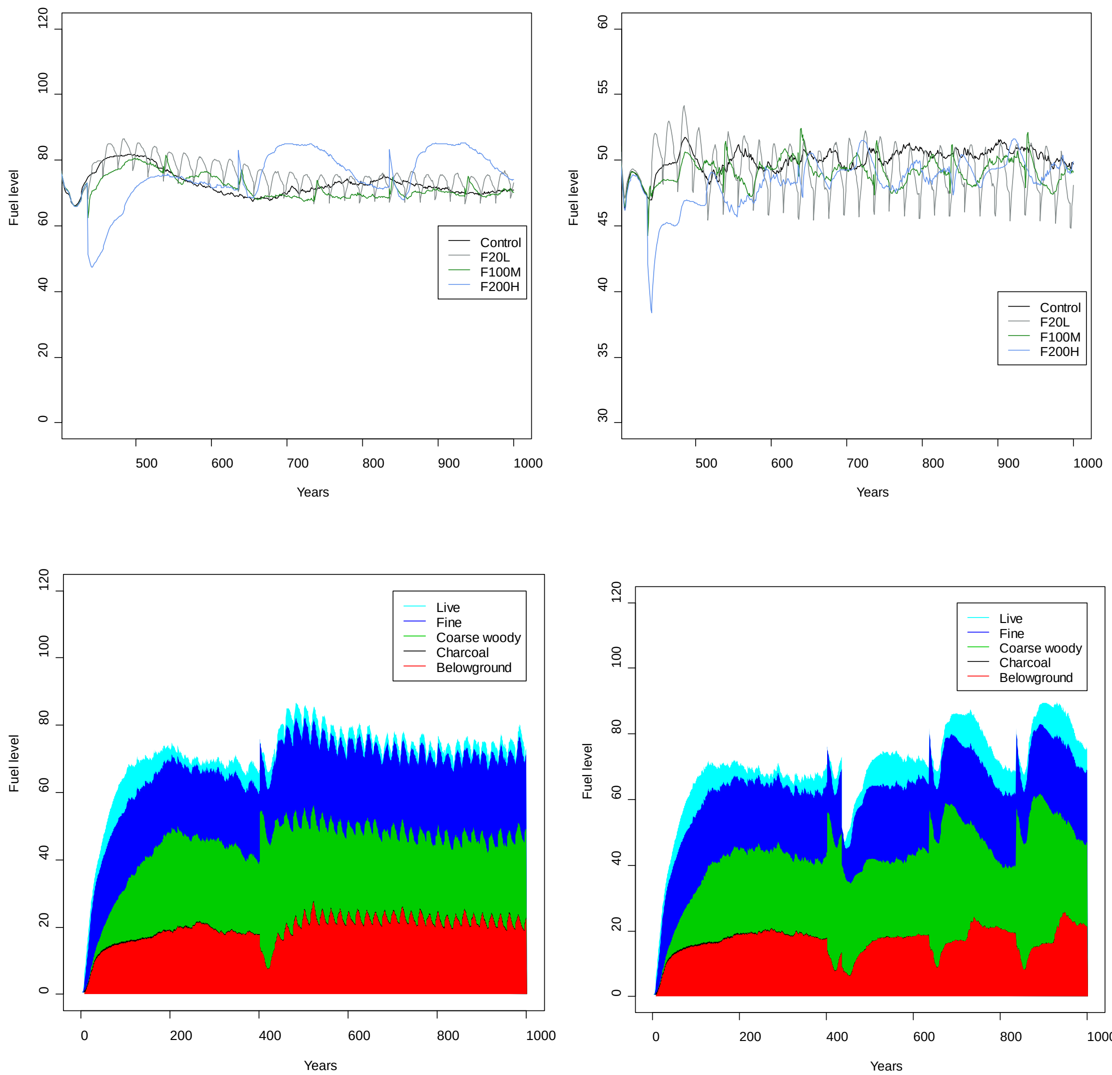


Figure 7. Effect of different wild fire scenarios on fuel stores (Ponderosa Pine – upper left, Lodgepole Pine - upper right) and composition in Ponderosa pine (light severity fires every 20 years – lower left, high severity fires every 200 years - lower right).

Short-term impacts are highly variable and are quite different from effects on long-term averages. For example, the first burn was simulated to occur in a relatively young and low-biomass forest and in case of a high-intensity burn a significant proportion of fuels was consumed by fire which also reduced fuel production for several years while the site regenerated. This lead to greatly reduced fuel levels for several years (in fact, the first wild fire temporarily reduced fuel to the lowest level found in all simulation results). However, fuel level increased following a high severity burn of a 200-year-old, high biomass forest. In this case, the initial pulse of added fuel came from the large mass of live trees as they were killed by wild fire and there was an additional increase in fuel level several years after the fire as snags began to fall and live fuels accumulated.

Combined thinning and fire scenarios

In combined model runs we first assumed that aggressive thinning reduced wild fire severity to low level while moderate thinning resulted in moderate level of fire severity. In the second round of simulations we allowed the STANDCARB model to define the burning severity based on the level of fuel present at the site.

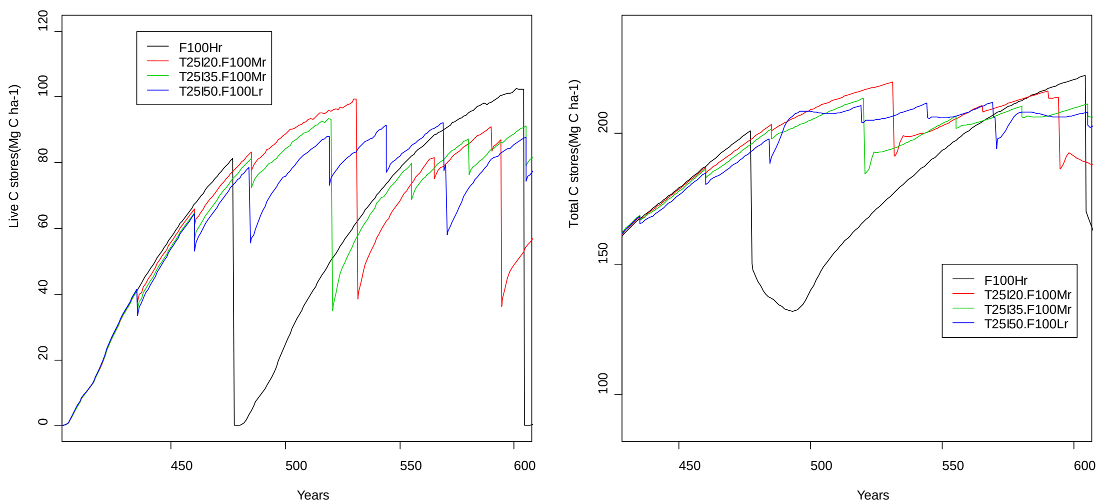


Figure 8. Combined effect of wild fire and thinning on live and total biomass stores in Ponderosa Pine forest type.

Our simulations indicated that wild fire had a much stronger impact than thinning on carbon stores in Ponderosa Pine forest type. The no-thinning scenario with high severity fire resulted in the lowest average carbon stores (Table 4). Note that both live and total stores for this scenario are lower than for all other scenarios while the dead pool is higher. Compared to this (burn/no-thin) scenario, the total fuel levels were lower in all thinning scenarios but there was there was virtually no difference among them. This result appears to call into question the potential for greater reduction of fuel levels (and consequently burning severity) by aggressively thinning rather than by moderate thinning schedules.

In Lodgepole pine forest type the difference between the impact of thinning and wild fire was small: minor increase in live biomass in thinning scenarios was offset by reduction in dead stores so that the overall impact of thinning treatment on total carbon store was virtually zero and the level of fuels was not different from control.

Table 4. Long-term average carbon stores (MgC/ha) for thinning + wild fire scenarios. In all scenarios the interval between thinnings is 25 years and the average wild fire return interval is 100 years.

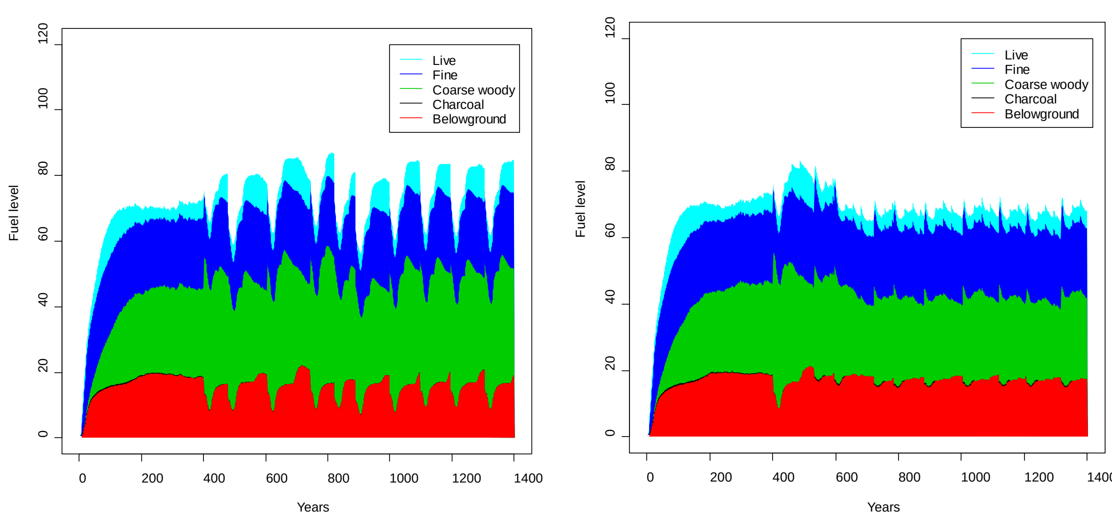
Ponderosa Pine

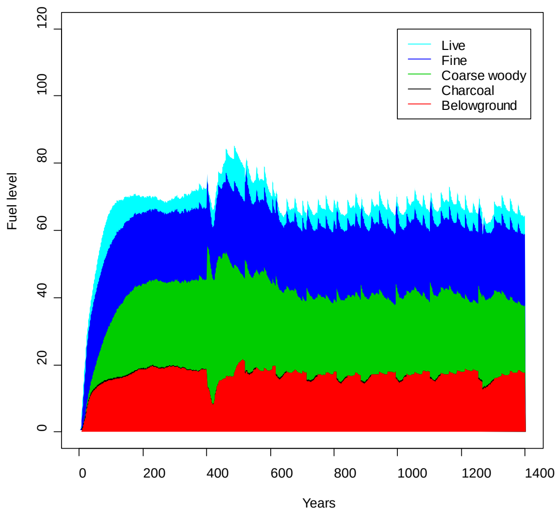
	No thinning, high-severity fire (baseline)	Thinning 20%, moderate fire	Thinning 35%, moderate fire	Thinning 50%, low-intensity fire
Live	54.99	73.57	70.87	80.01
Dead	74.69	67.25	65.77	63.89
Stable	49.65	54.00	53.88	56.19
Total	179.33	194.81	190.52	200.09
Fuel levels	75.50	69.80	69.06	69.39

Lodgepole pine

	No thinning, high-severity fire (baseline)	Thinning 20%, moderate fire	Thinning 35%, moderate fire	Thinning 50%, low-intensity fire
Live	28.37	31.02	29.86	32.29
Dead	31.94	29.69	28.83	27.48
Stable	12.17	11.76	11.77	12.33
Total	72.49	72.48	70.46	72.10
Fuel levels	29.15	29.33	28.77	28.69

Thus, relative to the baseline scenario (a high-severity wild fire averaging every 100 years), thinning can be expected to increase long-term averages of total C stores on site by about 10-20 MgC/ha for Ponderosa Pine. For Lodge-pole pine thinning does not significantly change the total amount of C stores compared to wild fire as live biomass takes longer to recover between thinning treatments in this low productivity forest type. This result reflects the working assumption that aggressive thinning reduced fire severity to low level while moderate thinning results in moderate level of fire severity.





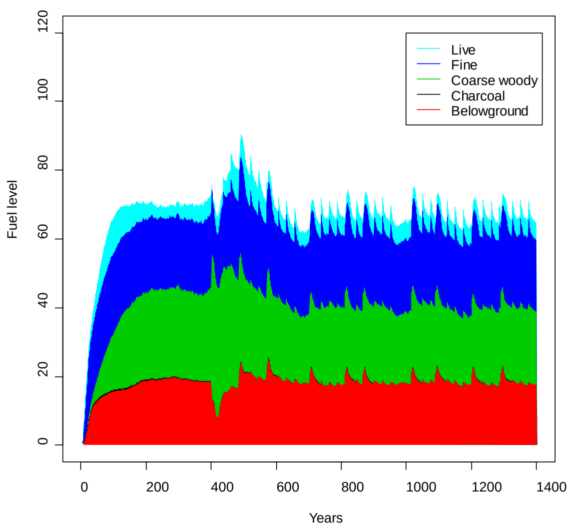
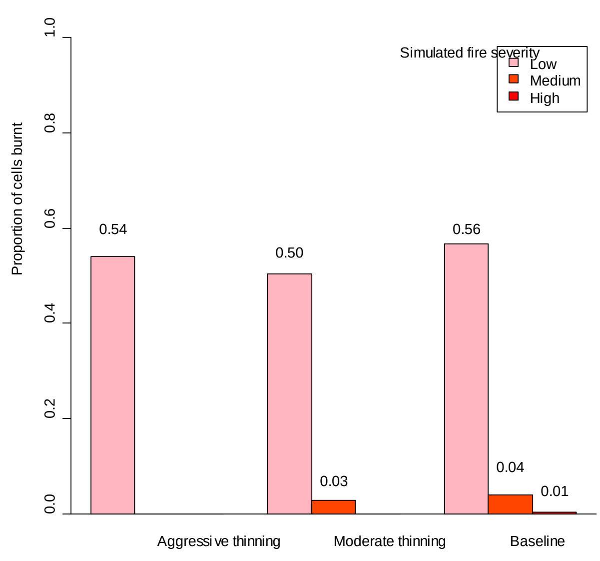


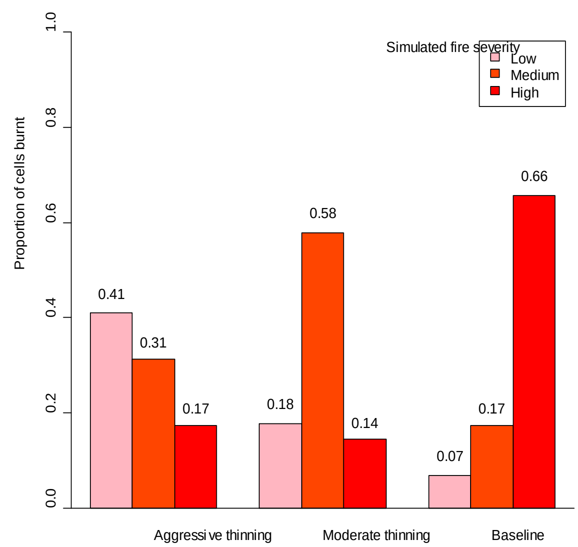
Figure 9. Combined effect of different wild fire scenarios on fuel levels and composition



Combined thinning and burning scenarios reduced the average level of fuels on site by 4-6 MgC/ha in Ponderosa Pine forest type primarily because of the reduction in coarse woody fuels level. In Lodge-pole pine virtually no reduction in fuel level was found.

The STANDCARB simulation experiment with wild fire severity determined by the model for the same set of combined thinning-fire scenarios and baseline (burn-no-thin scenario) indicated that the scenario assumptions are valid overall for

Ponderosa pine forest type, but different fire severity occurred in all scenarios and in the



control as well (Figure 10).

Figure 10. Proportion of wild fires at different severity levels projected by STANDCARB for combined thinning and wild fire scenarios in Ponderosa Pine (left) and Lodgepole Pine (right) forest types. Thinning intensity was 50% and 35% in aggressive thinning scenarios and 20% in moderate thinning scenario; thinning interval was 25 years for all scenarios. Baseline scenario did not have thinnings. Note that proportions do not add up to 1.0 because a small fraction of STANDCARB cells was projected not to burn.

In the baseline scenario for Ponderosa Pine, high-severity fire was projected in 66% of cases, 24% of fires were of moderate/low severity, and 10 % of cells did not burn at all. In the aggressive thinning scenario not all fires were projected to remain at the low severity level; moderate to high fire severity level was projected in 48% of the cases. While we acknowledge that the severity levels were set by us, the simulated proportion of wild fires at different severity levels seems realistic.

The levels of fuel projected for Lodgepole pine suggested low probability of medium to high severity fire in all scenarios and the distinct prevalence of low-severity fire. This however may not be a realistic projection because high-severity fires are common in Lodgepole Pine forests. The STANDCARB model settings for fuel levels corresponding to different levels of fire severity need to be adjusted to reflect the differences in fire behavior that is characteristic for individual forest types (this effort is beyond the scope of the current project).

Table 5. Long-term averages of carbon stores (MgC/ha) for thinning + fire scenarios with wild fire severity defined by STANDCARB. In all scenarios the interval between thinnings is 25 years and the average wild fire return interval is 100 years.

Ponderosa pine

	No thinning, (baseline)	Thinning 20%,	Thinning 35%,	Thinning 50%
Live	62.78	72.81	70.30	70.54397
Dead	73.47	67.69	66.19	64.35037
Stable	51.07	53.60	53.60	53.76243
Total	187.31	194.10	190.03	188.6568
Fuel levels	74.83	70.38	69.52	68.23997

Lodgepole pine

	No thinning, (baseline)	Thinning 20%,	Thinning 35%,	Thinning 50%
Live	37.44	35.03	33.55	32.82
Dead	29.86	28.51	27.58	27.21
Stable	12.11	12.01	11.99	11.99
Total	79.41	75.55	73.12	72.02
Fuel levels	30.56	29.43	28.75	28.55

Combined thinning+wild fire scenarios for Ponderosa Pine forest type with burning severity defined by the model show that aggressive thinning may result in smaller gains in on-site C stores than assumed initially (Table 5). Because the severity of burning in the baseline scenario was in some cases lower than the assumed high severity, the baseline stores of live biomass and total carbon were higher. Relative to this higher baseline, the long-term averages of live biomass stores increased by 8-10 MgC/ha, while dead stores are reduced by 6-9 MgC/ha, and the average total stores are increased by only 1-7 MgC/ha (< 4%) in the examined thinning scenarios. The largest increase in the long-term average total C stores on site was found in the moderate thinning scenario.

In the Lodgepole pine forest type, the same set of scenarios resulted in lower live, dead, total and fuel stores in thinning scenarios compared to baseline. The productivity in this forest type is too low to adequately rebuild carbon stores following thinning is the likely explanation for this result.

The projected effect of thinning on wild fire severity in combined thinning+wild fire scenarios for Ponderosa Pine forest type appears greater than simulations of fuel level following thinning would suggest (Figure 3). This is likely because effects of wild fires and thinnings on fuel loads are synergistic in that fires tend to reduce fine and belowground fuels, while thinning reduces the coarse woody fuels over long term.

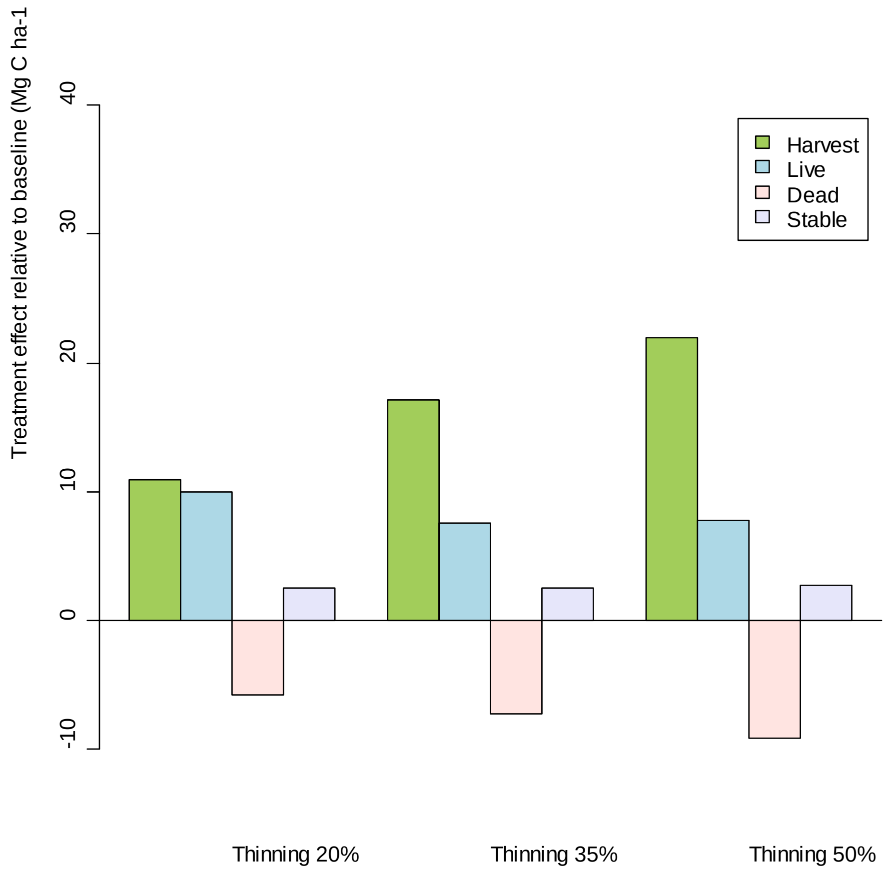


Figure 11. Summary of Combined Thinning + Wild Fire Effects in Ponderosa Pine forest type: comparison with baseline (fire-no-thinning). Average C stores on site over 965-year simulation and total harvest over the first 165 years (for comparison with Figure 4).

Removal of carbon with harvested wood plays a smaller role in combined thinning+fire simulation results because wild fires destroy some of potentially harvestable wood (Figure 11). Nevertheless including harvested material in the comparison of scenarios makes aggressive thinning scenario more attractive.

The difference between near-term and long-term effects is especially significant in combined thinning+wild fire scenarios (Figure 12). After hundreds of years in aggressive thinning, the fuel levels are gradually reduced and wild fire severity declines leading to higher average live biomass stores and significantly reduced dead stores in comparison with baseline scenario.

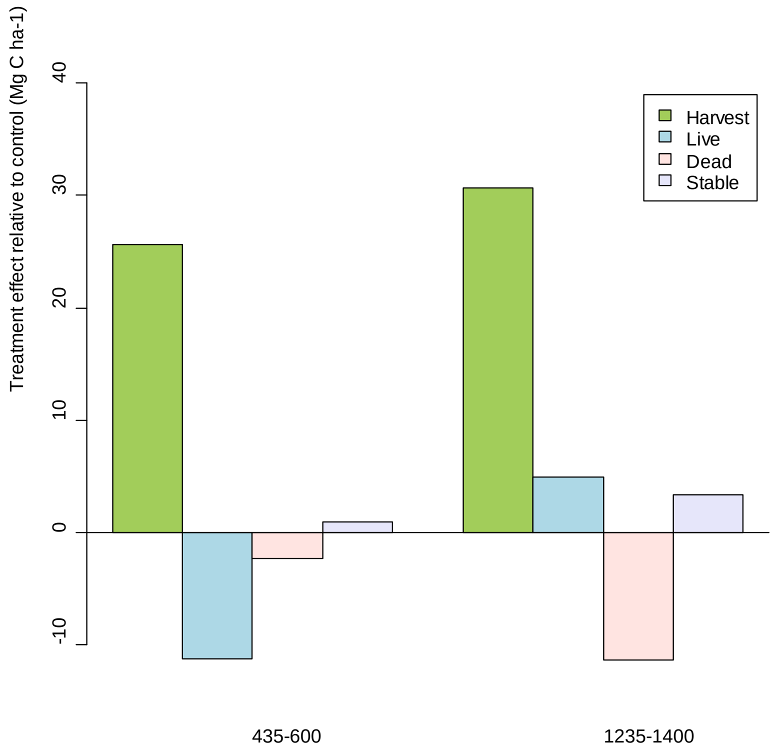


Figure 12. Near-term and long-term effects of aggressive thinning + wild fire scenarios (severity 50% every 25 years) for Ponderosa Pine forest type: comparison with baseline (fire-no-thinning). Average C stores on site and total harvest over the first 165 years and the last 165 years.

Discussion and Conclusions

1.

For thinning to be an effective measure to reduce the impact of wild fire, the impact of thinning on forest fuels has to be significant. The model simulations suggest that in the short term (for several decades after the start of the thinning treatments) the periodic addition of slash to the forest floor actually increases the level of forest fuel above the level found in the control (i.e., stands that are not thinned). This agrees with some recently published results of field studies that suggest that thinning may increase rather than reduce the fuel load, at least in the short term (e.g., B. Bormann presentation). Over time the examined thinning scenarios do reduce the level of fuels, but this reduction develops gradually over 100+ years. Moreover, for all thinning scenarios the reduction of on-site C stores was projected suggesting that thinning forest stands leads to additional C emission compared to control. Thus, based on consideration of on-site carbon stores “carbon credits” for thinning do not appear feasible in the short term.

2. The total amount of carbon moved off site with harvested biomass over 165-year simulation significantly exceeds on-site losses due to thinning. To what extent this removed C can be counted against the losses on site depends on the accounting method used. If the harvested wood replaces fossil fuels in energy generation then as much as 90% of the harvested carbon can be counted as “credit” and this would exceed significantly the losses of C on-site and create a potential for assessing C credit.

3. The short-term effects of thinning and wild fire depend on the initial condition of the stand being treated. In this report we used a 35-year-old stand initiated by a high-severity wild fire in an old forest as the initial condition. Without disturbance or thinning treatment this stand accumulates C stores and thinned stands are projected to follow a similar general pattern of C accumulation, but at a slightly lower level. Over time the difference between thinned and control stands increases, a result of the fact that the same percent thinning intensity removes greater absolute amount of C with harvested wood while older stands are less capable in recovering carbon after thinning. This general pattern was projected in both examined forest types.

4. If low severity burns repeat at a 20-year interval as simulated, the average fuels level remains higher than in the no-burn scenario. Live fuels are the only fuel type that is significantly reduced by frequent burns. Among all wild fire simulations the lowest level of fuels was predicted at the beginning of our high severity fire scenario (e.g. Figure 7). This low level of fuels occurred following 2 high-severity burns at 35-year interval (a high-severity fire 35 years prior to the starting point of simulations, then the first fire of high-severity scenario). Repeated high severity wild fire is not unusual (Thompson et al. 2007) and may create an impression that frequent burns result in low fuel loads, but our modeling results indicate that for low-severity fires at 20-year interval this is not the case. While general pattern was similar in both examined forest types, more productive Ponderosa Pine type had nearly twice as high a fuel level as a low-productivity Lodgepole pine type.

5. Reducing wild fire severity from high to low caused a significant increase in long-term averages of C stores on site (up to 45 MgC/ha or 25% for 100-year fire return in simulation for Ponderosa pine forest type). While thinning alone does not seem to reduce average fuel levels in the short term, other methods of fuel treatment (prescribed burning, removal of ladder fuels, removal or accelerated decomposition of slash) could reduce fuel levels to the point where burn severity is reduced. If the losses of C associated with these fuel reduction measures are smaller than gains associated with lower burning severity, then treating on site fuels appears a feasible way to increase the average on-site carbon store.

6. **Significance of baseline.** The simulation results for thinning scenarios alone and for combined thinning and fire scenarios are not directly comparable because they use

different baselines. Compared to the no-burn/no-thin baseline, all thinning scenarios reduce on-site carbon stores. When the baseline includes high-severity wild fire with average fire return of 100 years, then thinning scenarios do not reduce average C stores on site over long-term in Ponderosa pine forest type, but for Lodgepole pine type there is small reduction.

7. **Near-term vs. long-term effects.** Near-term effects of thinning include (1) fluctuations in live and dead biomass and fuel levels , (2) increase in average fuel levels and decline in average live and total biomass on site at the scale of several decades to a century. The some extent this decline can be offset by carbon credits if harvested biomass substitutes fossil fuels in energy production. Thus in the short term it does not seem feasible to generate carbon offsets by forest thinning aimed at wild fire control. The long-term effects at the scale of several centuries to a millennium include reduced fuel loads and burning severity, slightly higher live biomass stores and reduced dead stores.

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WINROCK SOP

Standard Operating Procedures for Fuels Measurements




WINROCK INTERNATIONAL

CONTENTS

SOP GLOBAL POSITIONING SYSTEMS

All permanent plots that are established must have GPS coordinates to ensure the plot can be relocated in future inventories.

- The default geodetic datum for most GPS units is WGS84 which is acceptable
- The coordinate system should be the same for all fieldwork
- An advanced user can pick a projected coordinate system appropriate for that location on the planet. A novice should use a geographic coordinate system based on WGS84 geodetic datum and record the coordinate pairs in decimal degrees.
- The coordinate system and datum used must be recorded on the field notes
- The data should be collected using metric units not English units

Uploading Plot Coordinates to GPS Unit

The plot coordinates will provided before the start of fieldwork. These coordinates can be uploaded to a GPS unit either manually, or using a fairly user-friendly software program called DNR Garmin Extension. The extension can be downloaded from http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html . Please follow instructions for software installation.

Once installed, follow these two steps to upload coordinates from your PC into the GPS unit:

1. Load data from a file or GIS graphic into the DNRGarmin Data Table

   Go to File => Load From and choose a source (File, Arcview, Landview, Arcmap). Select PLOT field as Identification field and select TODAY'S DATE as Comment field. Note: You can only load from Arcview/Landview/Arcmap if that software is running. Also, to upload from Excel rather than Arcview, you may need to export the Excel to a database format (.dbf) first.

2. Upload data to the GPS

   Depending on the radio dial you have selected (Waypoint), go to that shape type's menu and select Upload (**Waypoint => Upload**). The data will be uploaded into your GPS. Check whether the points are on your GPS unit.

Navigating to Plot Centers

Once you have all the plot coordinates in the GPS, travel to each unit where treatment has been completed. Once in a unit, navigate to each plot using the "navigate" or NAV function on the GPS. Set the unit to the nearest plot and let the GPS tell you where to go. Make sure GPS unit is set to WGS84 projection.

At each plot center, please re-record the GPS coordinates (take a point and note the point number).

SOP ESTABLISHMENT OF PLOTS

Required equipment:

All Plots

GPS

Flagging tape

Clinometer

Iron bar about 1-2 cm in diameter and approx. 20 cm long

Hammer

Fluorescent paint

Permanent marker

The plot should be navigated to using a GPS. On occasion the plot will fall in an area of mixed slopes. One portion of the plot might be on level ground but another portion might fall on a hillside. Since the plot dimensions are a function of slope, it is important to establish the plot center in an area that is either on a slope or on level ground. The potential for error is too high to have a portion on sloping land and the other portion on level ground. Therefore, prior to establishing a plot it should be determined if any portion of the plot will be on a slope > 10 %. If more than 50 % of the plot falls on a slope > 10 %, move the plot center so that the entire plot is located on the slope. If more than 50 % of the plot is located on level ground, but the rest of the area is on a hillside (slope > 10 %) move the plot center so that the entire plot will fall on level ground.

If the plot has been moved record GPS coordinates for the center of the plot.

If the slope is greater than 10 % record the exact slope for later correction of plot area.

To record the slope use a clinometer. Stand upslope and sight the head of someone of a similar height and record either the % slope of the angle of the slope in degrees (include units on the worksheet).

Establishing Plot Marker

Plots are given a unique number/name.

- The first number/letter should indicate the site – such as National Forest X or Land Belonging to Private Company Y.
- The second number/letter describes the specific unit
- The last number/letter should indicate the plot number within the unit

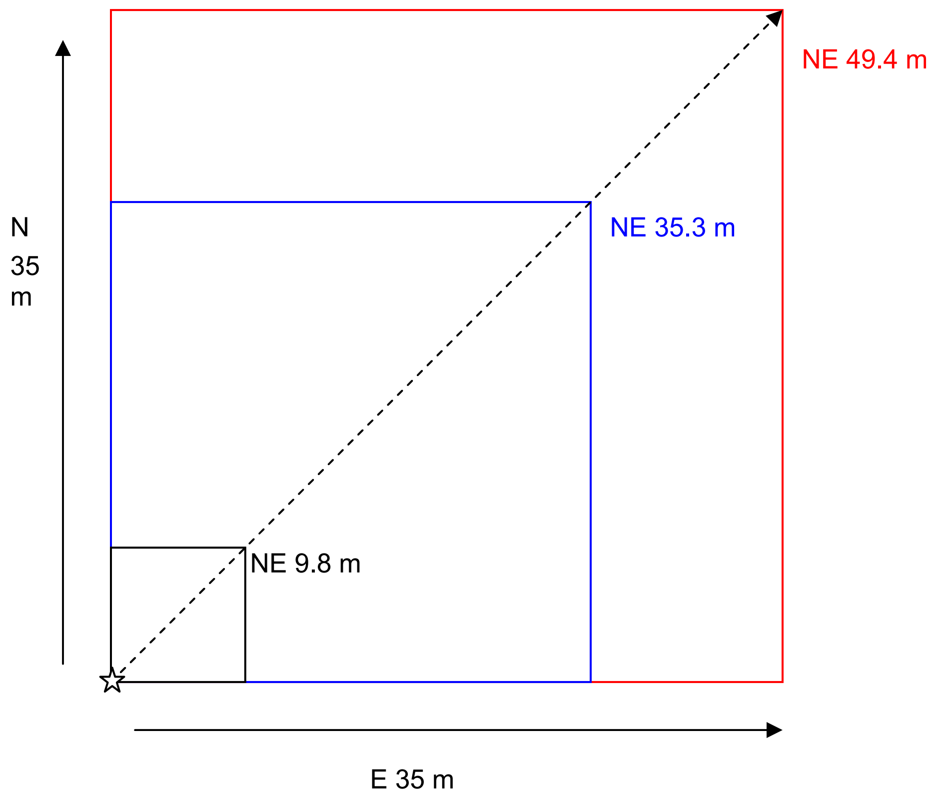
At the plot marker point, sink the iron bar into the ground using the hammer. Leave approximately half an inch above the ground. Spray the tip with fluorescent paint and then tie flagging tape to the tip. Mark on the flagging tape the unique number/name of the plot.

Tree Plot Structure

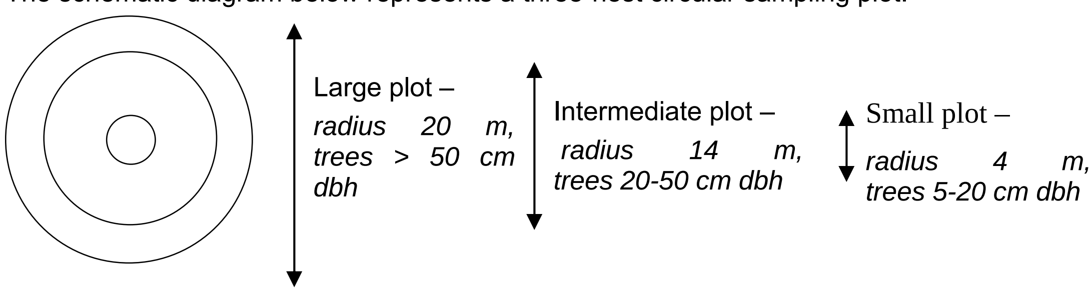
Typically we measure trees measuring between 5 cm and 20 cm at breast height within 4 m of the plot center, trees measuring between 20 and 50 cm within 14 m of the plot center and trees measuring greater than 50 cm at breast height within 20 m of the plot center.

If distance measuring equipment is not available it may be more time efficient to measure in square rather than circular plots and to lay out the plot boundaries using rope during measurement.

One protocol for doing this may be to measure out 35 meters of rope to the East and 35 meters of rope to the North from the marked plot center. Returning to the center measure out 49.4 m to the Northeast and mark the corner before laying down line to complete the four sides of the square. Then along the North and East lines mark off 7 meters and 25 meters. Walking northeast from the plot center again mark off corners at 9.8 m and 35.3 m and complete these squares with rope.



The schematic diagram below represents a three-nest circular sampling plot.



SOP MEASUREMENT OF TREES

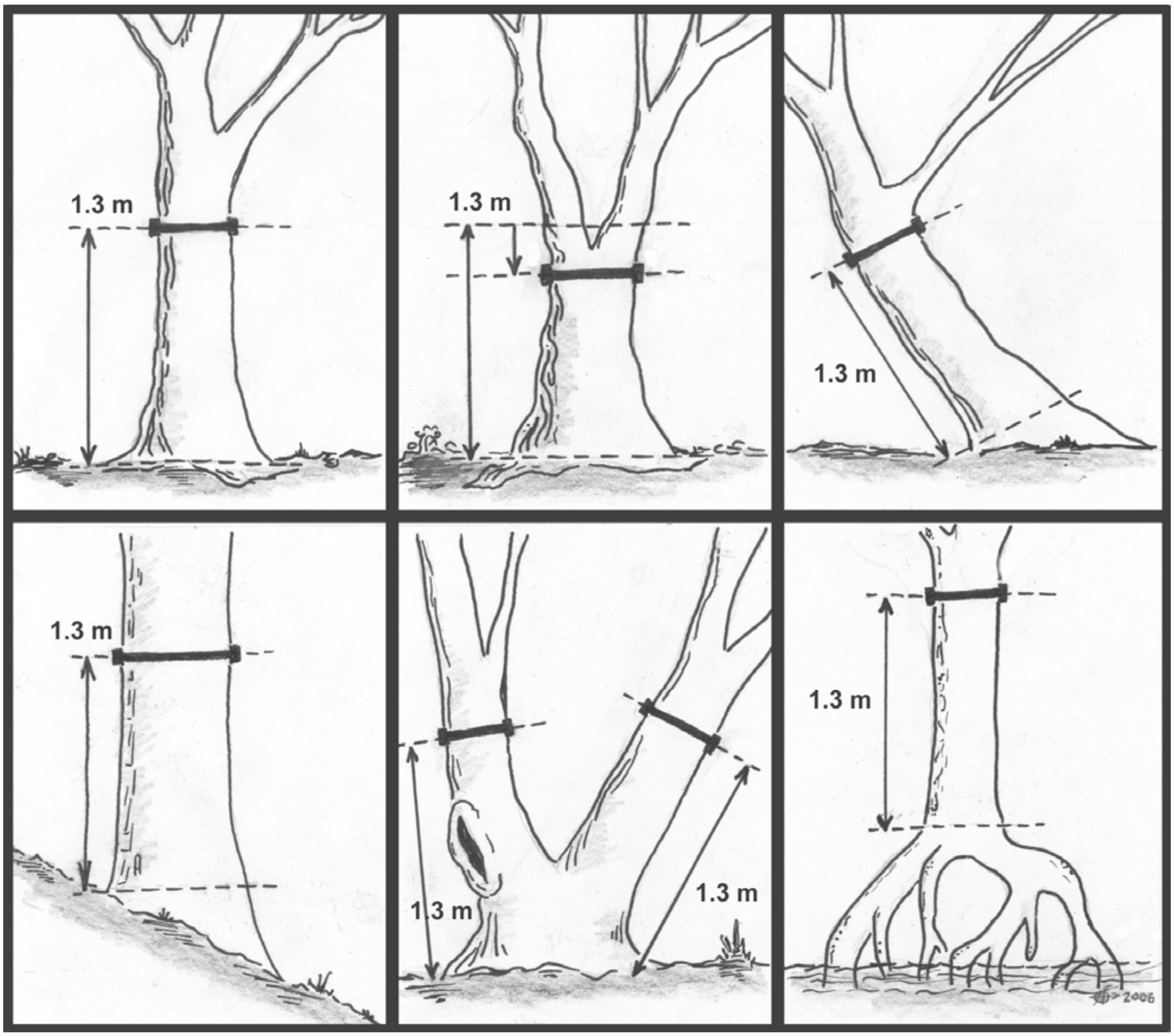
Field equipment:
DBH tape
Flagging tape
1.3 m pole
Spray paint

Initial Measurement

1. Assign one person to record the data and all others should be measuring and marking trees. The recorder should stand in the center of the nested plot being measured. He or she should track those measuring the trees and should endeavour to assure that no trees are missed
2. Count the number of trees with a dbh of less than 5 cm in a radius of 1m from the plot marker, only include if the tree has a measurable dbh.
3. Measurement in each of the other nested plots should be conducted in turn. So that all trees should be measured in the smallest plot, followed by all trees over 20 cm dbh in the additional area included by expanding to the middle plot followed by all trees over 50 cm dbh in the additional area included by expanding to the largest plot.
4. To avoid either missed trees or double recording, measurement should begin to the North and the first tree should be flagged
5. Marking trees
    a. All trees in long-term measurement plots should be marked with a unique number using spray paint
    b. It is important to use a paint designed for the marking of trees and it is important that the color is different to any color that is being used in the forest to indicate treatments or which trees to cut and which to leave
    c. Begin with number 1 in the smallest plot and continue sequentially upwards. If there are multiple people measuring trees then the person recording the data is responsible for assuring that each tree has a unique number
    d. Paint the number on the tree facing towards the plot center
6. All trees should be measured at 1.3 m
    a. It is important that a DBH tape is used properly to insure consistency of measurements.
    b. Place the 1.3 m pole stick against the tree to indicate the location of DBH. Placement of the measuring stick depends on the slope of the ground as well as the tree's shape.
        i. Always place pole and measure DBH on the *upslope* side of the tree
        ii. Always measure 1.3 m parallel with the tree, *not* perpendicular to the ground. Therefore, if the tree is leaning, measure 1.3 m from the upslope side of the lean, parallel with angle of tree.
        iii. Trees are considered alive if there are green leaves present. Even if there are only one or two green leaves present the tree is considered alive.
    c. Measure DBH
        i. Measure trees of appropriate sizes for each nested plot.
        ii. If tree is in dead class 1, mark as dead on data sheet

iii. If the tree is forked at DBH, measure the diameter just below the fork and tag the tree, Record as if it were one tree on the data sheet, but with a note that the diameter is below the fork.

iv. If using a standard DBH tape, the DBH tape has a hook on the end. Push the hook into the bark of the tree and pull the tape to the right. The DBH tape should always start left and be pulled right around the tree, even if the person taking the measurement is left-handed. As the DBH tape wraps around the tree and returns to the hook the tape should be above the hook, as shown below. The tape should not come around the tree below the hook. The tape should not be upside down; the numbers must be right side up



7. Record species or species group
   a. If you know the species record it
   b. If you do not know the species record the species group: fir, pine, aspen, hardwood or other
8. Boundary trees

Occasionally trees will be close to the border of the plots. The plots are relatively small and will be expanded to estimate biomass carbon on a per hectare basis. It is therefore important to carefully decide if a tree is in or out of a plot. Measure the distance from the plot center to the tree in question, if more than 50% of the trunk is within the boundary the tree is in. If more than 50% of the trunk is outside of the boundary it is out and should not be measured. If it is exactly on the border of the plot, flip a coin to determine if it is in or out.

9. When all of the trees in the plot have been measured, there should be a double-check to see that all of the trees have been measured and tagged.

Post Treatment Remeasurement

Before going in the field, data sheets should be prepared listing each of the trees initially measured.

Record the Plot ID number.

On the datasheet mark if each numbered tree is still present. Search carefully so that all trees are included. Trees are not necessarily numbered sequentially as you go around the plot, but all numbers should be present unless a tree has been harvested. Remember that any tree <20 cm DBH will only be in the smallest plot.

If there is a tree that doesn't have a number on it but in your opinion should (, then measure its diameter at breast height and record whether it is a fir, pine, aspen or other.

For any tagged trees which cannot be found a note of MISSING should be placed on the data sheet. If a tree has been harvested since the last inventory, a note of HARVESTED should be place on the data sheet. If a tagged tree has died since last inventory, a note of DEAD should be placed on the data sheet and 'SOP 13 Measuring Dead Wood' followed.

SOPS ADDITIONAL TREE PLOT MEASUREMENTS

Take a Photograph

Take a photograph standing to 2 m to the north of the plot marker facing the plot marker (i.e. facing south). Make a note of the photograph number in the space provided on the field data sheet.

Measure Tree Heights and Height to Live Canopy

For trees number 1, 6, 11, 16, 21 etc measure the height of the tree using a clinometer and tape measure or a laser rangefinder. Subsequently for the same trees measure the height to start of the live canopy.

Measuring heights

-Use clinometer to estimate % to top of tree

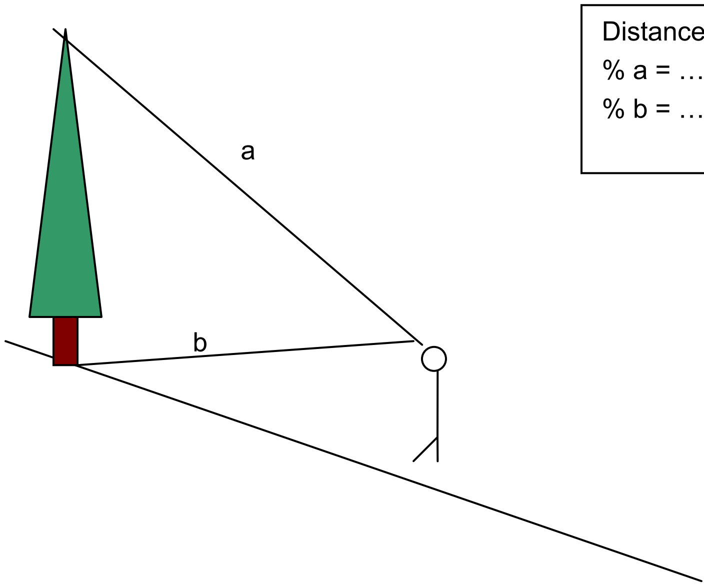
-Use laser range finder to measure distance to tree

-Know the height from the ground to your eye.

If not flat, note this and measure % to bottom of tree

Include a diagram showing which measurement applies where

-Distance to tree must be measured in a perfectly horizontal line, if slope is such that your head is below the bottom of the tree, measure distance to top of tree (using laser) and using the clinometer the angle in degrees to top of the tree[1].



Distance to tree = …….
% a = ………
% b = ………

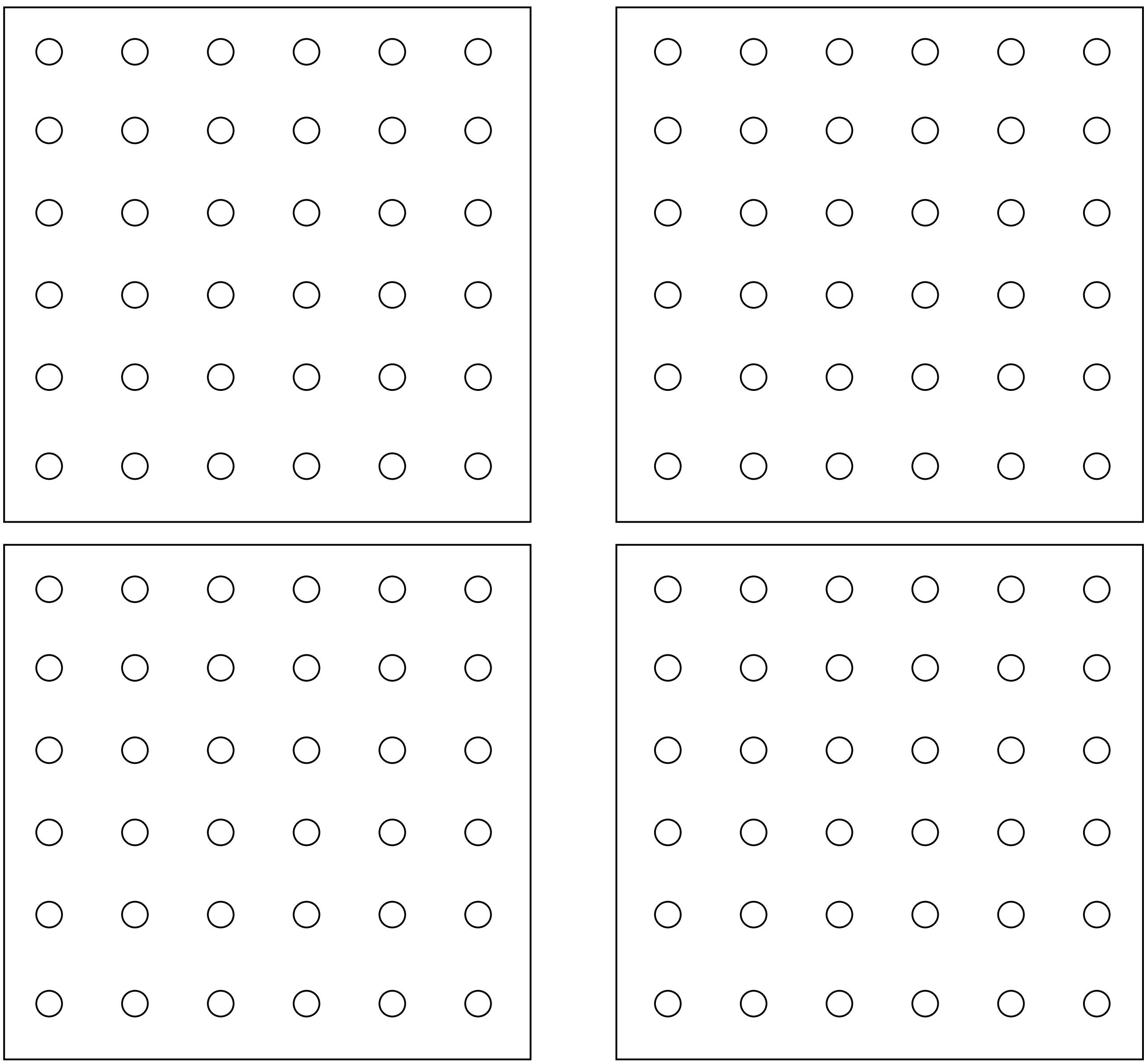
Using a clinometer

- Hold clinometer up to your dominant eye, the string on the clinometer should be below the eye piece
- Keep both eyes open and simultaneously look at the numbers through the clinometer and the object you want to measure in the distance
- The units on the right are %, on the left are degrees. Use percent wherever you can but note carefully if you do not. To look directly overhead use degree and tip your head back until you see 90.

[1] Horizontal Distance = Cosine of angle x distance to top of tree.

Canopy Cover

1. Lay down a tape measure along 15 m transect.
2. Start at 0 cm and use the densitometer. Looking through the densitometer you can see two spirit levels. When both are centered you are looking directly overhead. In the center of the field of vision there is a small circle. If you can see leaves within this circle then fill in the first circle on the grid (on next page), if not leave blank.
3. Move forward 3 m and repeat.
4. Move forward 3 m repeatedly until reach 15 m (6 recordings)
5. Move tape measure 3 m to your right and repeat measurements along line.
6. Move tape measure 4 more times until 6 lines have been completed and all 36 circles have either been filled in or left blank.



SOP MEASUREMENT OF STANDING DEAD WOOD

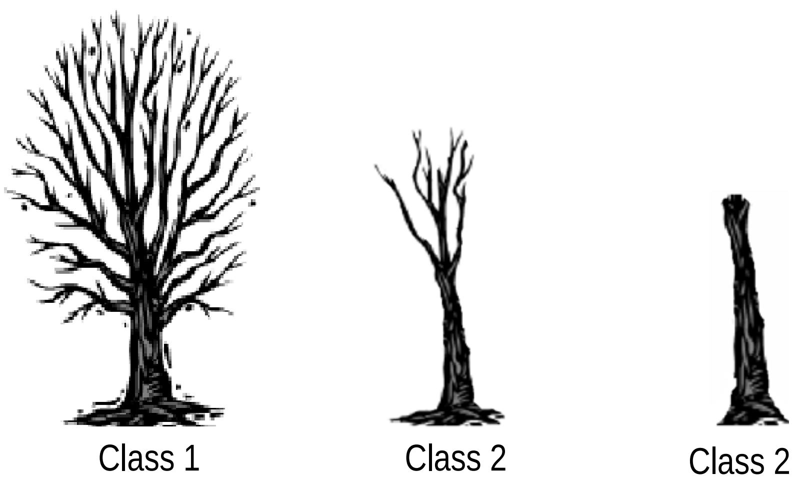
Field Equipment:
DBH tape
Clinometer
Laser range finder
Transparent ruler or relascope
Measuring tape

Within plots delineated for live trees, standing dead trees should also be measured. Standing dead trees should be classified into two classes:

Class 1: Tree with branches and twigs and resembles a live tree (except for leaves)

Class 2: Trees ranging from those containing small and large branches to those with bole only

By classifying trees into these two simplified classes, a conservative estimate of biomass will be taken.



Class 1 trees:

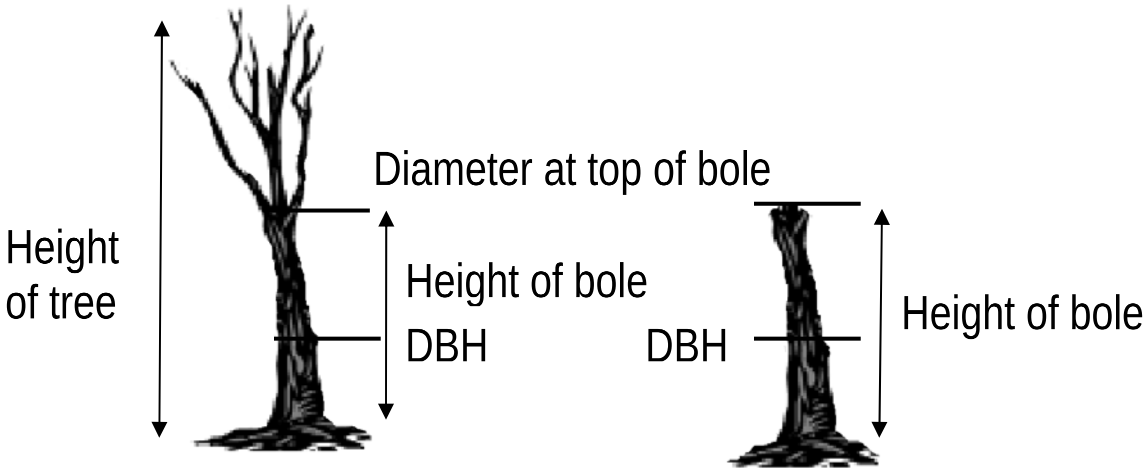
1. Measure DBH using methods for live trees. If nested plots are used, only dead trees of the appropriate DBH should be measured for each nest.

Class 2 trees:

1. Measure DBH using methods for live trees. If nested plots are used, only dead trees of the appropriate DBH should be measured for each nest.
2. Measure height of bole using a clinometer
3. Estimate diameter at top of bole using either:
    a. Relascope or
    b. Transparent ruler
        i. Hold the ruler approximately 10-20 cm from your eye
        ii. Record the distance from the ruler to your eye
        iii. Record the apparent diameter of the top of the tree
        iv. Measure the distance from your eye to the tree using a laser range finder
        v. The true diameter is then equal to:

$$\text{True Diameter (m)} = \frac{\text{Distance Eye to Tree (m)}}{\text{Distance Eye to Ruler (m)}} * \text{Ruler Measurement (m)}$$

4. Use the average density calculated for ‘sound wood’ in calculation of carbon stock.



SOP MEASURING NON-TREE VEGETATION AND LITTER

Field Equipment
Clip plot
Measuring tape
Clippers to remove vegetation
Hanging scale
Durable plastic sheeting
Durable plastic tarp
Paper bags
Compass

Non-tree vegetation includes grasses, non-woody vegetation, shrubs and trees that have not attained a diameter at breast height.

Measurement of Large Shrubs

Within the smallest square or circular measurement plot (e.g. the 4 m radius plot) record the basal diameter of each shrub. For each measure the maximum height of the shrub and the diameter of the crown of the shrub North to South and East to West. If known also record the species.

Measurement of Remaining Non-Tree Vegetation and Litter

Sampling for the remaining pools of non-tree vegetation and litter should occur at 2 locations within the tree plots. The non-tree vegetation will include tree seedlings that have not yet reached sufficient height to have a dbh, small shrubs and herbaceous vegetation. Clip plots should be used to sample this non-tree vegetation. These plots can be circular or rectangular and can be made out of various materials. A square clip plot made of pvc pipe 30 cm x 30 cm is usually sufficient for sampling.

The litter layer is defined as all dead organic surface material on top of the mineral soil. Some of this material will still be recognizable (dead leaves, twigs, dead grasses, and small branches) and some will be unidentifiable decomposed fragments of organic material. Note that dead wood with a diameter of less than ¼ inch is included in the litter layer.

1. Record the dimensions of the clip plot on the data sheet
2. From center of plot, walk 5 m to the South of the plot marker.
3. Place clip plot at this location
4. Clip all vegetation originating from inside the plot at ground level. Place on the plastic sheeting or tarp.
5. Weigh the total amount of clipped vegetation and record the weight on data sheet.
6. From the total amount of clipped vegetation, take a representative subsample.
7. Collect all litter inside the frame. A knife can be used to cut pieces that fall on the border of the sampling frame. Place the litter on the plastic sheeting or tarp.
8. Weigh entire sample using sheeting or bag and hanging scale.
9. Mix the litter thoroughly and collect a subsample (approximately 80-100 g) that is representative of the material found in the litter.
10. Weigh subsample and record weight.
11. Place subsample in paper bag, label and bring out of field
12. Repeat for location 5 m to West of plot marker.
13. Later oven-dry subsample of non-tree vegetation at 70ºC to a constant mass, and oven dry litter subsample (at 80^{o} C) to a constant mass and weigh both with laboratory scale

When returning for post-treatment remeasurement place clip plots 5 m to the North and to the East of the plot marker.

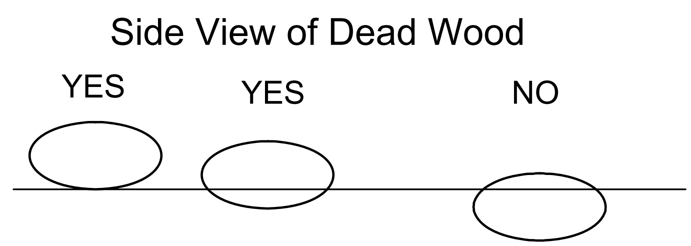
SOP MEASUREMENT OF LYING DEAD WOOD

Field Equipment:
Calipers (preferred) or DBH tape
Measuring tape
Machete or knife
50 m line with marks on the line indicating 2m and 4m

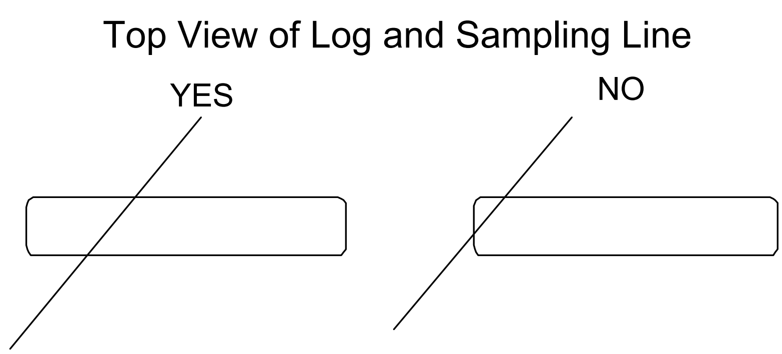
Lying dead wood will be measured using the line-intersect method outlined in Harmon and Sexton (1996). Lying coarse dead wood is defined as all woody material on the ground with a diameter ≥1/4".

1. From the plot marker, lay out the 50 m line to the South.
2. Along the length of the line measure the diameter of each intersecting piece of coarse dead wood (≥ 3" diameter). Calipers work best for measuring the diameter. It is time efficient to measure a twig or similar to 3 inches and to use this as the reference for determining whether or not to go ahead and measure a piece of wood. When measuring the diameter of dead wood it is not always possible to place a tape around the log. It can also be dangerous because logs are usually home to snakes, spiders, etc. If you are going to measure the diameter of the piece of dead wood with a diameter tape, make sure the route is clear before placing your hand underneath the log.

   A piece of dead wood should only be measured if: (a) more than 50% of the log is aboveground, and (b) the sampling line crosses through at least 50% of the diameter of the piece (Figure 14-2). If the log is hollow at the intersection point, measure the diameter of the hollow; the hollow portion in the volume estimates is excluded. Some examples are displayed below:



The first two logs should be measured because the log is more than 50% above ground, but the third log should not be measured.



The first log should be measured because the sampling line crosses more than 50% of the diameter of the log. Conversely, the second log should not be measured because the sampling line does not cross more than 50% of the log diameter.

3. Assign each piece to one of three density states: sound, intermediate, or rotten. To determine what density class a piece of dead wood fits into, each piece will be struck with a machete or knife. If the machete or knife does not easily sink into the piece (bounces off), classify it as sound. If the machete or knife sinks partly into the piece, and there has been some wood loss, classify it as intermediate. If the machete or knife sinks easily and entirely into the piece, if there is more extensive wood loss, and the piece is crumbly, classify as rotten. Record on data sheet.
4. The volume of lying dead wood and then carbon stocks will be estimated using the diameters of each piece of wood and the length of the line transect.
5. From zero to 2 m along the line, count the number of pieces of dead wood with a diameter of ¼" to 1" that the line crosses. Count these only; no need to record their dimensions or density class. Record on data sheet.
6. From zero to 4 m along the line, count the number of pieces of dead wood with a diameter of 1" to 3" that the line crosses. Count these only; no need to record their dimensions or density class. Record on data sheet.
7. Lay the line out to the West of the plot marker and repeat measurements.

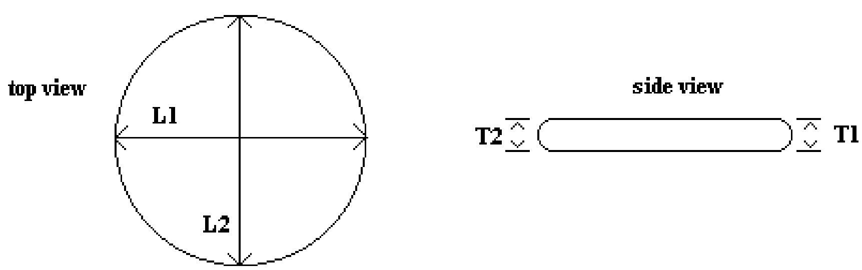
At the time of remeasurement lay lines out to the North and East instead of South and West.

SOP MEASUREMENT OF DEAD WOOD DENSITY

Field Equipment:
Measuring tape
Chainsaw or handsaw
Paper bags
Permanent marking pen

At the time of pretreatment field sampling, estimates of dead wood densities need to be taken if standing dead or lying dead wood will be sampled. If the decomposition of wood is predicted to be different within each strata, then this SOP needs to be repeated for each strata. If only the standing dead wood pool is being measured, then only the density of 'sound wood' needs to be estimated. After these densities are determined, this SOP does not need to be repeated unless a new strata is measured.

1. Randomly locate an area that is representative of strata/area.
2. All dead wood will be classified into three density classes: sound, intermediate, and rotten.
   a. Sound: Machete does not sink into the piece (bounces off)
   b. Intermediate: Machete sinks partly into the piece, and there has been some wood loss
   c. Rotten: Machete sticks into the piece, if there is more extensive wood loss, and the piece is crumbly
3. Collect wood samples for each density class for density (dry weight per green volume) determination. The number of wood samples will depend on the variability between tree species within the forest. A minimum of 10 samples should be collected for each density class of each species group. For example, for a forest containing mixed broadleaf and palm species , a minimum of 10 samples of dead wood from each tree group should be collected per density class—for a total number of 30 samples for broadleaf species and 30 for palms.
   a. Using a chainsaw or a handsaw, a complete disc from the selected piece of dead wood can be cut.
   b. Measure the diameter (L1 and L2) and thickness (T1 and T2) of the disc to estimate volume.
   c. The dimensions of the sample should be recorded on data sheet. The fresh weight of the disc does not have to be recorded.



   d. Alternatively volume can be derived through use of the Archimedes principle whereby the volume of water displaced by the sample is equal to the volume of the sample. For this method you will need to use a bucket and a measuring cylinder.

4. Place sample in paper bag and bring out of field
5. Oven dry disk (80^{o} C) to a constant weight
6. Weigh disk with laboratory scale
7. Calculate density using the following formula:

density = mass (g) / volume (cm^3)

Where:

mass = the weight of the oven dried sample

volume = π * (average diameter/2)^2 * average width of sample

8. Mean the densities for each density class to create an average density for sound, intermediate and rotten samples.

MAY 2010

Long-range strategy for the Lakeview Federal Stewardship Unit

Forest and Rangeland Health, Soils and Water
Fish and Wildlife, Wilderness and Roadless Areas
Recreation, Community Benefits Forest Restoration Economics

prepared by:

LAKEVIEW Stewardship Group

2010 LONG-RANGE STRATEGY FOR THE LAKEVIEW FEDERAL STEWARDSHIP UNIT

PREPARED BY THE LAKEVIEW STEWARDSHIP GROUP

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LAKEVIEW
Stewardship Group

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(Maps prepared by Chris Weller and Bo Wilmer with The Wilderness Society's Center for Landscape Analysis and by Chris Zanger with The Nature Conservancy's Fire Learning Network)

EXECUTIVE SUMMARY

LONG-RANGE STRATEGY FOR THE LAKEVIEW FEDERAL STEWARDSHIP UNIT

The Lakeview Stewardship Group envisions a sustainable forest ecosystem that, through a new understanding of the interrelationships between the people and the land, will ensure quality of life for present and future generations.

This updated long-range strategy is part of a unique, collaborative effort to help restore the ecological health of the 500,000-acre Lakeview Federal Stewardship Unit in the Fremont-Winema National Forest and provide economic and social benefits for the local community. The strategy is based on a common vision and set of goals and objectives developed by the Lakeview Stewardship Group and adopted by the U.S. Forest Service. The Lakeview Stewardship Group includes conservationists, timber workers, local government officials, the Bureau of Land Management, and other civic leaders working in cooperation with the Forest Service. Originally released in November 2005, the strategy has been updated in 2010.

The Lakeview Federal Stewardship Unit was originally established in 1950 as the Lakeview Federal Sustained Yield Unit for the purpose of supplying timber to local mills in the communities of Lakeview and Paisley in Lake County. In 2001, the Chief of the Forest Service re-authorized the Unit with a revised policy statement that established new goals and updated its name to the Lakeview Federal Stewardship Unit.
The goals of the Stewardship Unit are as follows:

- 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.
- Provide opportunities for people to realize their material, spiritual, and recreational values and relationships with the forest.

To achieve the collaborative vision and goals of the Unit, the long-range strategy takes a holistic and scientific approach toward restoration. The strategy builds on regional ecosystem assessments and local watershed analyses by the Forest Service and BLM, as well as independent scientific and university studies. It is also informed by the results of an intensive seven-year monitoring program conducted by Lakeview-area high school graduates under the supervision of experienced scientists.

The strategy recognizes that restoration of the Unit will require comprehensive solutions to a variety of often inter-related problems. For example, decades of aggressive fire suppression and intensive logging of old-growth ponderosa pine trees have created unnaturally dense young forests, excessive fuel loads, and much greater risk of severe fires. Absence of fire has altered the forest species composition with increases in white fir, lodgepole pine, and western juniper above historic levels. Lodgepole pine has spread into wetlands and riparian systems. Changes in forest species composition and density have increased the incidence and risk of insects and disease, reduced biodiversity and resiliency of trees, and affected the hydrologic regime. Also, past road building and grazing have altered the hydrologic regime through the timing and magnitude of stream flows, removed and altered riparian area vegetation, changed channel morphology, altered sediment transport, and reduced in-stream habitat. In addition, invasive plants such as cheatgrass are spreading rapidly to the detriment of native grasses, aspen groves, sagebrush, meadows, and other important habitats. Climate change may be exacerbating these problems now and in the future.

To address the risks associated with climate change, altered forest structure, and altered fire regimes, we have developed a strategic approach that prioritizes treatments based on restoration of key values and fuels reduction. The strategy recommends an accelerated thinning and prescribed burning program, focused on the relatively dry, low-elevation ponderosa pine and mixed conifer forests. Where appropriate, proposed treatment areas may extend onto adjacent BLM administered lands. The remaining large, fire-resistant, old-growth trees should be retained wherever possible. Additionally, considerable care must be taken to monitor watershed processes, and to protect the soil from excessive disturbance, compaction, erosion, loss of nutrients, and invasive plants. Restoration treatments will require no new permanent roads, and any temporary roads will be promptly decommissioned as part of the stewardship contract.

The strategy calls for continuing and expanding the Lakeview monitoring program to ensure that management actions are having the intended effect and can be quickly modified based on locally relevant new information. It also points out the need to upgrade logging equipment and develop new equipment that is affordable in order to minimize roads, soil compaction, and other potential impacts of an expanded thinning program.

Additional actions are needed to restore high-quality habitat and healthy populations of fish and wildlife. Closing unnecessary roads will benefit big game populations as well as improve water quality and stream habitats. Native riparian vegetation such as willows and aspen should be restored, and barriers to fish passage removed.

The strategy recognizes that not all the Lakeview Unit is equally in need of restoration work. About one-eighth of the Unit is in either the Gearheart Mountain Wilderness or the Unit's seven inventoried roadless areas. The strategy recommends keeping the roadless areas free of road building and logging.

The Lakeview Unit provides important social and economic benefits to the nearby communities. It supplies about 10-15 percent of the timber processed by the Fremont Sawmill and its 100 employees. Many local residents obtain their firewood, Christmas trees, and other forest products from the Unit. About 34 businesses and families graze livestock within the Unit for part of the year.

The Unit also offers many recreational facilities, attractions, and opportunities that contribute to the enjoyment and quality of life for local residents and visitors alike. However, widespread mortality of mature lodgepole forests and reduced federal funding for recreation have put some campgrounds and other recreation sites in jeopardy.

The communities of Lake County have struggled to maintain or diversify their economies. While fairly typical of rural Northwest communities in regard to socio-economic distress, Lake County's remote location and lack of transportation options pose special difficulties for economic development. Local contractors need to have easier access to job opportunities created within the Unit.

The Collins Companies' addition of a $6.8 million small-log mill to the Fremont Sawmill in 2007 was an important investment in the future of the Lakeview community, as well as a turning point for restoration forestry in the Lakeview Stewardship Unit. In order to promote steady supply and utilization of small-diameter trees in the Unit, Collins and the Forest Service that same year created the first and only ten-year stewardship contract in the Pacific Northwest. The stewardship contract was also intended to increase implementation of other restoration activities in the Unit through trading of goods-for-services. However, the severe economic recession that hit the wood products industry beginning in 2008 has limited the amount of restoration work that can be accomplished through stewardship contracting.

Building a biomass plant is a key objective to improving the local economy and helping accomplish ecologically beneficial thinning projects within the Unit. In 2007, under the auspices of the Oregon Futures program, numerous public and private entities signed a 20-year memorandum of understanding to develop a woody biomass industry in the Lakeview community. Despite unforeseen obstacles and setbacks, efforts continue to begin construction of an economically viable and appropriately sized biomass plant.

Since the Long-Range Strategy was adopted in 2005, the Forest Service has collaboratively planned and implemented several restoration projects in the Unit that are consistent with the goals of the Unit and the recommended guidelines of the Strategy. The West Drews project, for example, authorized 15,000 acres of thinning, 26,000 acres of prescribed burning, and 90 miles of road decommissioning – all with a single environmental assessment and without an administrative appeal.

In the coming ten years, given adequate funding, the Forest Service should be able to plan and conduct various forms of restorative treatments on about 200,000 acres in and around the Lakeview Stewardship Unit. Major landscape-scale projects on the drawing board include Deuce in the Paisley District and East Drews in the Lakeview District. A ten-year schedule of planned and potential vegetation management projects is included in this Strategy.

Additional funding from Congress or other sources will likely be necessary to accomplish the forest health restoration treatments, monitoring, and logging equipment upgrades recommended by this long-range strategy. The Collaborative Forest Landscape Restoration Program established by Congress in 2009 could provide a much-needed new source of funding to eliminate at least some of the budget shortfall. Working with the BLM when administrative lines bisect watershed boundaries will add opportunities to manage larger landscapes in a more holistic manner and may help leverage funding.

The Lakeview Stewardship Group welcomes all feedback on this collaborative strategy and intends to update, expand, and improve the strategy as more and better information becomes available. We consider the strategy to be an important step towards achieving the collaborative vision and goals of the Lakeview Federal Stewardship Unit.

introduction

I. INTRODUCTION

The Lakeview Federal Stewardship Unit within the Fremont National Forest (now Fremont-Winema National Forests) was originally established in 1950 as the Lakeview Federal Sustained Yield Unit for the purpose of enhancing the economic stability of the communities of Lakeview and Paisley in Lake County, Oregon. In 2001, the Chief of the Forest Service re-authorized the Unit with a revised policy statement that established a new name for the Unit, a common vision and a set of new goals and objectives that were developed by the Lakeview Stewardship Group and adopted by the US Forest Service.

> ***Lakeview Federal Stewardship Unit Vision: We envision a sustainable forest ecosystem that, through a new understanding of the interrelationships between the people and the land, will ensure quality of life for present and future generations.***

The Goals of the Stewardship Unit are as follows:

- 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.
- Provide opportunities for people to realize their material, spiritual, and recreational values and relationships with the forest.

The goals and objectives of the Unit are addressed in the Key Issues section of this strategy and are set out in Appendix A.

In order to help achieve these goals, the Lakeview Stewardship Group has developed this long-range strategy as guidance to the Forest Service and others involved in managing the Unit. We view this long-range strategy as part of a unique, collaborative effort to help restore the ecological health of the 500,000-acre Stewardship Unit and to provide economic and social benefits for the local community. The Lakeview Stewardship Group includes conservationists, timber workers, forest managers, local government officials, and other civic leaders. Forest Service and BLM managers are regularly invited to participate with the Group.

The strategy is intended to provide an overall management framework for the Unit as well as help identify funding needs and prioritize areas for active restoration. The strategy should also make it easier for the Forest Service to revise its land and resource management plan for the Fremont-Winema National Forests in the next few years.

In 2009, the Group decided to update the strategy in order to take advantage of the funding opportunities provided by the Forest Service's new Collaborative Forest Landscape Restoration Program. A proposal for CFLRP funding must be based on a "landscape restoration strategy" that:

- identifies and prioritizes ecological restoration treatments for at least a 10-year period;
- encompasses a landscape that is at least 50,000 acres in size and is comprised primarily of National Forest System (NFS) forest lands;
- involves active ecosystem restoration in support of the purposes of the Forest Landscape Restoration Act of 2009;
- includes ecological restoration treatments that will contribute by-products to existing or proposed wood-processing and/or biomass processing infrastructure;
- incorporates the best available science and application tools;

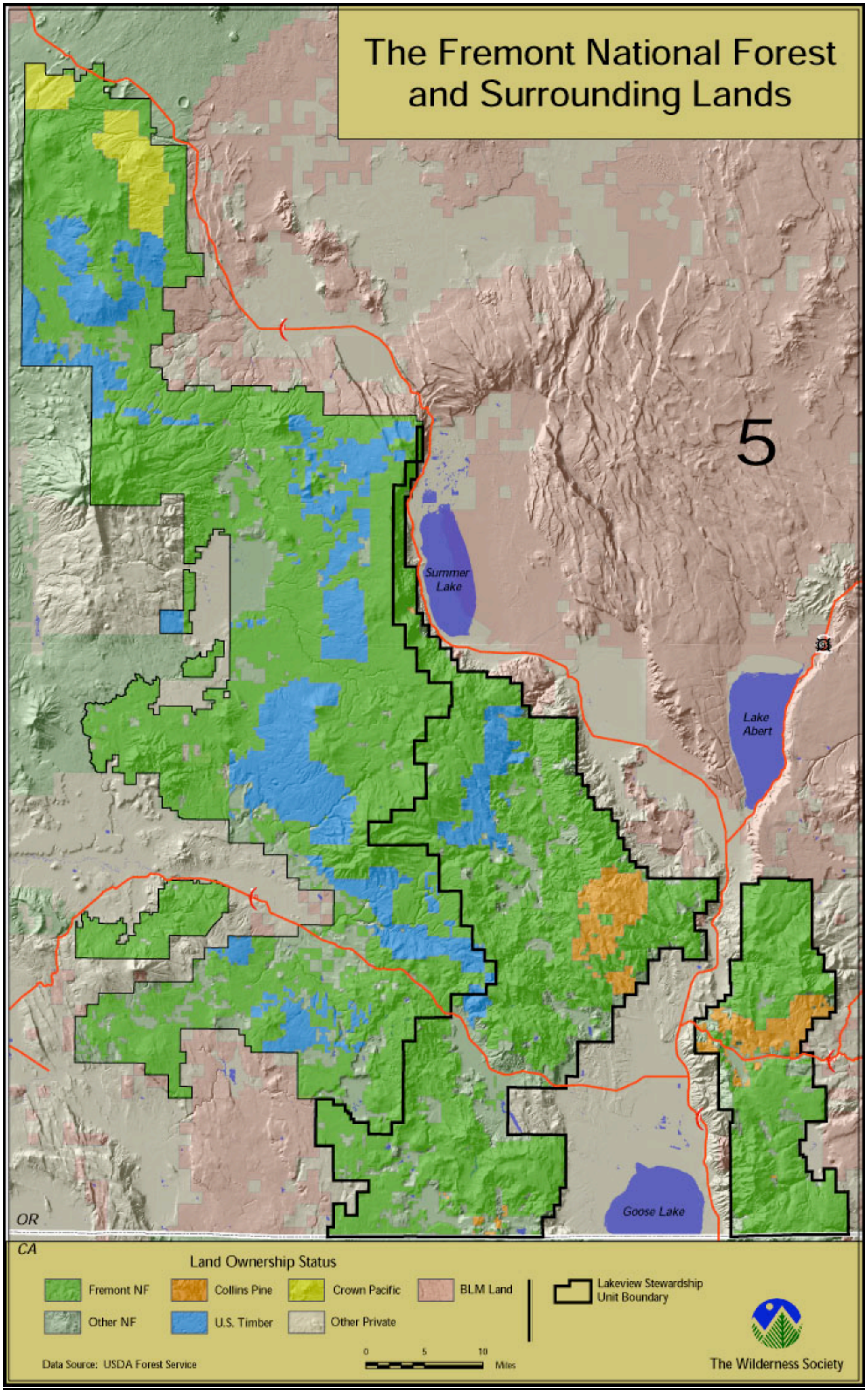
- maximizes retention of large trees and fully maintains, or contributes to the restoration of pre-suppression old growth conditions;
- modifies fire behavior by focusing on the removal of smaller diameter trees in thinnings, strategic fuel break construction and maintenance, and fire use;
- does not involve the establishment of permanent roads to carry out the strategy; and,
- includes funding provisions to decommission all temporary roads constructed to carry out the strategy.

This updated strategy for the Lakeview Federal Stewardship Unit builds on numerous scientific assessments and planning efforts by the Forest Service and independent experts. These past assessments and plans range in scale from the regional Interior Columbia Basin Ecosystem Management Project to several watershed analyses and transportation plans within the Unit completed by the Fremont-Winema National Forests in recent years. The long-range strategy also incorporates elements of the Klamath Tribes' forest management plan developed by the Klamath Tribes for their former reservation land that is managed by the Fremont-Winema National Forests.

We will continue to update, expand, and improve this strategy as more and better information becomes available and can be incorporated. An "adaptive management" planning approach is especially appropriate and feasible here because of the Chewaucan Biophysical Monitoring Project. Beginning in 2002, this monitoring effort has been gathering a great deal of data about the trees, plants, wildlife, insects, soils, streams, and other ecosystem elements within a large part of the Stewardship Unit. The detailed monitoring information about site-specific ecological conditions and trends supplement the data that were used in the initial strategy.

This long-range strategy begins with an overview of how to approach restoration in the context of eastern Oregon and the Lakeview Federal Stewardship Unit. Next, it reviews past studies and existing data relevant to planning for the Unit. The strategy then focuses on eight main issues: (1) forest and rangeland health, (2) soils and water, (3) fish and wildlife, (4) roads, (5) roadless areas and wilderness, (6) recreation, (7) community benefits, and (8) implementation and economics. Finally, the strategy presents a ten-year schedule of management activities, along with a proposed budget.

The Lakeview Stewardship Group appreciates the assistance of the Forest Service in developing and updating this long-range strategy. Several staff members of the Fremont-Winema National Forests generously provided information that we requested, reviewed drafts, and participated in the Group's discussions about the strategy. The purpose of the long-range strategy is to provide collaborative input to help the Forest Service achieve the goals of the Lakeview Unit. The update is also intended to provide a strong scientific, social, and economic foundation for a proposal to the agency's Collaborative Forest Landscape Restoration Program. The long-range strategy does not affect the standards and guidelines, management area prescriptions, or other components of the Fremont land and resource management plan, but strives to contribute information and knowledge of current science.


The Fremont National Forest and Surrounding Lands
5
Summer Lake
Lake Abert
Goose Lake
OR
CA
Land Ownership Status
Fremont NF
Collins Pine
Crown Pacific
BLM Land
Other NF
U.S. Timber
Other Private
Lakeview Stewardship Unit Boundary
Data Source: USDA Forest Service
0 5 10 Miles
The Wilderness Society

Restoration Planning Overview

Restoration Planning Overview

II. RESTORATION PLANNING OVERVIEW

In developing this long-range strategy, the Lakeview Stewardship Group attempted to take a scientifically sound approach. During the past 15 years, scientists from numerous government agencies, universities, and non-governmental organizations have examined environmental and social conditions within and around the Lakeview Federal Stewardship Unit. Many studies have focused on the need to restore the ecological health of forests, rangelands, watersheds, and fish and wildlife habitats. As discussed in Section III, much of the information produced by these studies is relevant to the Unit and useful for this long-range strategy.

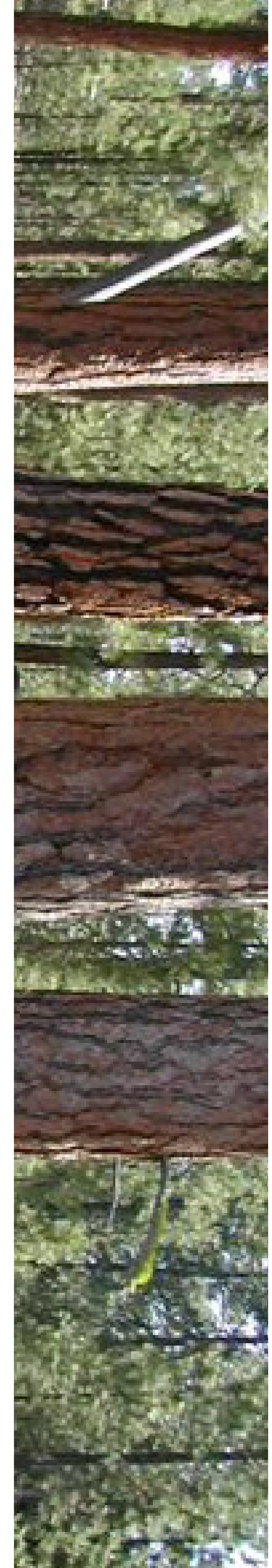
Our overall planning effort generally follows the strategic approach presented by Rick Brown in a report, *Thinning, Fire and Forest Restoration: A Science-Based Approach for National Forests in the Interior Northwest* (Defenders of Wildlife 2000). Rick Brown is a long-time member of the Lakeview Stewardship Group and a senior resource specialist for Defenders of Wildlife. In his report, Brown suggests that active forest restoration efforts that reflect the following guidelines will be most likely to succeed:

- Be part of comprehensive ecosystem and watershed restoration that addresses roads, livestock grazing, invasive exotic species, off-road vehicles, etc.;
- Consider landscape context, including watershed condition and both populations and habitats of fish and wildlife;
- Address causes of degradation, not just symptoms;
- Provide timber only as a by-product of primary restoration objectives;
- Avoid construction of new roads;
- Be based on local assessment of pre-settlement conditions;
- Take place in dry forest types;
- Use fire as a restoration treatment, either alone or following thinning;
- Treat thinning slash and other surface fuels (preferably with fire);
- Retain all large, old (presettlement) trees and large snags, and provide for their replacement over time;
- Have negligible adverse effects on soils;
- Address other vegetation in addition to trees, including noxious weeds;
- Incorporate monitoring as an essential element and cost of the project;
- Learn from monitoring and adapt management accordingly.

These guidelines continue to provide a scientifically sound basis for restoration management in the Lakeview Unit and many other areas of the Interior Northwest.

In 2009, Dr. Norm Johnson from Oregon State University and Dr. Jerry Franklin from University of Washington issued a paper on forest management in the Pacific Northwest that is directly relevant to the Lakeview Unit. The information and recommendations in this paper have been carefully considered in updating the long-range strategy.

Relevant Studies and Existing Data



III. RELEVANT STUDIES AND EXISTING DATA

A. Regional Context: Interior Columbia Basin Assessment (ICBEMP)

The Interior Columbia Basin Ecosystem Management Project (ICBEMP) was a massive interagency scientific study that included all of eastern Oregon and the interior Columbia River Basin. The ICBEMP examined changes in the terrestrial and aquatic ecosystems that have occurred throughout the Basin since European settlement. Areas that had changed markedly were considered to have lower ecological integrity than areas that had not changed much. The Fremont National Forest, BLM Lakeview District, and LFSU were considered as part of a cluster of forests that have low forest integrity and low or moderate aquatic integrity. The area is dominated by dry forests that are extensively roaded and have little, if any, Wilderness. Forest structure and composition have been substantially altered from historical conditions. These forests show large changes in fire frequency but less change in fire severity. (Status of the Interior Columbia Basin: Summary of Scientific Findings, PNW-GTR-385, p. 122)

The ICBEMP study also found that the amount of forest in the Basin with "lethal" fire regimes has more than doubled, posing a significant risk to ecological integrity, water quality, species recovery, and homes in rural areas. Drought, fire suppression, overgrazing, and logging have contributed to significant changes in forest and range landscapes. Native grasslands and shrublands have declined and noxious weeds are spreading rapidly. Uniform stands of middle-aged trees have replaced old and mixed age stands, and much more of the timber volume consists of small-diameter trees. (Highlighted Scientific Findings of the Interior Columbia Basin Ecosystem Management Project, PNW-GTR-404, p. 13-14)

Based on the ICBEMP study, the Forest Service and BLM recommended a management alternative that aggressively restores ecosystem health through active management using an integrated ecosystem management approach. However, the agencies did not make a final decision on the ICBEMP plan and instead adopted a strategy in 2003 to incorporate the science data into local forest plans and projects. (The Interior Columbia Basin Strategy, www.icbemp.org).

Johnson and Franklin

Dr. Norm Johnson and Dr. Jerry Franklin have extensively studied forest conditions in the Fremont-Winema National Forest and elsewhere in the region and have proposed authoritative restoration strategies. In 2008 they completed a detailed forest restoration plan for the Klamath Tribe's former reservation land in the Fremont-Winema. (Norman K. Johnson, Jerry F. Franklin, Deborah Johnson, "A Plan for the Klamath Tribes' Management of the Klamath Forest," May 2008,
http://www.klamathtribes.org/information/background/documents/Klamath_Plan_Final_May_2008.pdf).
The following year they produced an influential forest management proposal for both dry and moist Pacific Northwest forests. (Johnson and Franklin, "Restoration of federal forests in the Pacific Northwest: Strategies and management implications," 2009). Johnson and Franklin recommend active restoration management of the dry forest types, including both ponderosa pine and mixed conifer stands. They suggest treating approximately two-thirds of the forests within a landscape to restore ecological integrity.

B. Local Studies

Third Party Review

In 1999, at the request of Sustainable Northwest and Lake County, a consulting team of four scientists and management specialists conducted a study of the LFSU. (Wayne Elmore, Robert Hrubes, Chris Maser, Walter Smith, "A Third Party Review of the Lakeview Federal Sustained Yield Unit," March 1999). While admittedly not an in-depth analysis of ecological conditions within the Unit, the review was informed by the results of several site-specific watershed analyses that the Fremont National Forest completed between 1995 and 1998. The consultants found considerable ecological alteration and degradation due to past management emphasis and practices, along with significant restoration and stand-improvement needs. More specifically, the team concluded that past practices had resulted in:

- loss of habitat diversity leading toward management-created homogeneity across the landscape as a whole;
- soil compaction;
- high road densities;
- loss of mature forest structure;
- increased density and risk of fire;
- species conversion from Pine-associated to Fir-associated forest types;
- loss of habitat for threatened and endangered species; and
- lack of a comprehensive monitoring system.

Watershed Analyses

As noted above, the Forest Service and BLM completed several site-specific watershed analyses covering large portions of the LFSU – including the Upper and Lower Chewaucan River, Deep Creek, and Thomas Creek during the late 1990s. The watershed analyses identify issues, describe current and historical (reference) conditions, synthesize and interpret data, and make recommendations for management. This long-range strategy relies significantly on the resource information and recommendations contained in the watershed analyses.

University of Washington Fire Study

In 2003, the University of Washington's Rural Technology Center completed a study of fire conditions and potential fuel treatments in the Fremont National Forest. (Mason et al. 2003, Investigation of Alternative Strategies for Design, Layout and Administration of Fuel Removal Projects). Using Continuous Vegetation Survey data collected on 502 plots, the UW study calculated proportions of the Fremont with high, moderate, and low levels of fire risk. The UW study also used computer models to evaluate the effectiveness of various types of fuel treatments in reducing fire risk. Results of this study are presented in the Fuels and Fire section below.

Nature Conservancy Fire Learning Network

Conducted in 2007-2009, the goal of this project was to develop scientifically sound and socially acceptable solutions to the problem of altered fire regimes and degraded forest health. These were key issues identified in the *Oregon Conservation Strategy.* The project has produced a collaboratively developed treatment prioritization map for the 500,000-acre Lakeview Stewardship Unit in Southern Oregon.

Because it is important to understand the ecological trade-offs that occur when management is required to balance many stakeholder preferences, it was of interest to compare and assess the stakeholder-designed priority map with a Treatment Optimization scenario to determine which approach maximizes landscape restoration while simultaneously reducing the threat of uncharacteristic fire. In addition, the assessment provided an up-to-date vegetation assessment for the Lakeview Stewardship Unit. This information can be used to assess the effects of management actions to reduce the threats of wildfire, and to analyze how climate change will influence fire behavior and the effectiveness of the restoration approaches.

The work and products provide a foundation for strategic federal land management decision-making and project selection in the Lakeview Stewardship Unit for the next ten years. Working in cooperation with stakeholders and federal partners, it was possible to prioritize approximately 110,000 acres for active restoration. Treatment of the priority sites will support restoration and conservation of multiple ecosystem services including wildlife habitat. By identifying high-priority places for treatment in a collaborative framework, the Forest Service will have the benefit of knowing locations where there is likely to be public support for management (and therefore potentially less conflict) and where each management dollar spent will yield multiple resource benefits.

An analysis of focal wildlife species habitat was also completed. The analyses identified species representative of each plant community and evaluated the historic and current habitat conditions. Habitat assessments identified species and areas where management would best meet ecological requirements. The focal species assessment was met with enthusiasm by state and federal wildlife biologists, who will use the analysis to help inform forest plan revisions.

The actions and products facilitated by this analysis create a compelling case for why restoration is needed in ecologically degraded fire-dependent forests. It builds the case for restoration through a habitat analysis conducted for focal species in the Lakeview Stewardship Unit. Through modeling, it was possible to demonstrate that current habitat conditions will favor those species that prefer dense conditions at the cost of those species that require open canopy. Open canopy-dependent species are declining, much to the alarm of wildlife managers, academic scientists, and stakeholders. In addition, their habitat is vulnerable to significant loss due to uncharacteristic fire, insect and disease outbreaks, and the stress induced by climate change.

Biomass Supply Study

In 2005 Catherine Mater of Mater Engineering completed a Coordinated Offering Protocol (CROP) for a 100-mile radius around Lakeview. This analysis covered portions of 3 states, 4 National Forests, 14 Ranger Districts, 8 BLM Districts, 9 counties, State lands and tribal lands. The analysis demonstrated that there was enough volume to support a small diameter sawmill and a biomass energy plant.

In 2007 TSS Consultants analyzed Lakeview's biomass potential for Marubeni Sustainable Energy. The information, while proprietary, was used by Marubeni to develop plans for building a 15 MW plant. In 2009 Iberdrola Renewables purchased the development rights for the Lakeview Biomass project.

In the past two years, monitoring of completed operations under Forest Service Stewardship authorities has improved the understanding of volume per acre that could be expected under the new 10-year Stewardship Contract. Greater knowledge of actual volumes, more efficient biomass technology, and additional acres from Jen-Weld Timber Resource lands and lands south into California showed that a 25 MW biomass plant would be sustainable for the 20-25 year life of a biomass plant.

Key Issues

IV. KEY ISSUES

A. Forest and Rangeland Health

Goal: Sustain and restore a healthy, diverse, and resilient forest ecosystem that can accommodate human and natural disturbances.

1. Fuels and Fire

Objectives:
- *Restore stand-maintenance fire regimes.*
- *Restore forest conditions that approximate historical species composition and stand ages.*

The major tree species in the Fremont National Forest are ponderosa pine, juniper, lodgepole pine, and at higher elevations white fir. Most of these trees are adapted to summer drought and extreme temperature fluctuations due to the nature of the arid region. Annual precipitation is 10-20 inches from autumn through spring, and summers are hot and dry. (Mason et al., p. 17.)

Historically, the ponderosa pine forests were maintained by relatively frequent, low-severity surface fires. Lodgepole pine forests were maintained by infrequent, intense insect attack followed by high-severity stand-replacing fire. In mixed conifer and white fir stands, fire and insect disturbances were variable in frequency and intensity, resulting in a wide range of conditions. (Upper Chewaucan Watershed Analysis (WA), p. RC-4 & 5)

Ponderosa pine stands were typically park-like with large, well-spaced trees and sparse shrubs and down wood, maintained by frequent light surface fires at 1-25 year intervals. Ponderosa pine dominated below 6,000 feet and on south-west slopes above 6,000 feet. Mixed conifer stands were “jumbled up” with complex structure and severe fire return intervals of 25-300 years. (Lower Chewaucan WA, p. RC-4 & 5)

Lake County Resources Initiative has collected data on the number and acreage of wild fires that burned within and adjacent to the Unit for the past 25 years. Notably, in the first decade the fires averaged about 430 acres, but between 1995 and 2005 the average exceeded 6,000 acres. Over the 25-year period, most of the acreage burned in 2002 due to the large Grizzly, Toolbox, and Winter Rim fires. Even omitting the 2002 fires, average acreage in the past decade exceeds 1500 acres, triple the previous decade.

The Klamath Tribes’ Forest Plan contains some useful historical data about forest conditions in Lake County prior to widespread logging and fire suppression. These data suggest that ponderosa pine stands generally contained about 15 trees/acre larger than 20 inches in diameter and about 40 trees/acre between 20 and 4 inches in diameter. The Chewaucan Biophysical Monitoring Project is also providing useful data on local reference conditions.

As in many other eastside forests, years of fire suppression, extensive high-grading of the dominant ponderosa pine overstory, and extensive livestock grazing have resulted in many acres of the Fremont being increasingly converted to a forest that is dominated by white fir. Forest stands dominated by white fir are more susceptible to drought stress and associated outbreaks of insects and disease, increasing the risk of large-scale wildfires. (Elmore et al., p. 16 & 17).

With fire exclusion, formerly single-storied, park-like ponderosa pine stands are becoming increasingly multi-storied. The practice of high grading has left many stands with a large stagnant component of white fir that normally would have been absent historically. Current stand density is higher than the historical level in many areas of the forest. White fir and mixed conifer stands have high densities that place them at risk of disease, insect attack, and density-related mortality. (Deep Creek WA, p. CC-11; Lower Chewaucan WA, p. CC-8)

The University of Washington study of high severity fire risk on the Fremont National Forest found that 31% of the forest was at high risk, 47% moderate risk, and 22% low risk. The dominant tree species in high risk stands are 53% white fir, 25% ponderosa pine, and 21% lodgepole pine. Low risk stands are 73% ponderosa pine and 21% lodgepole. The study found that thinning to remove one-half of the basal area would result in shifting the high-risk stands to 66% moderate risk and 27% low risk, while thinning to leave 45 sq. ft. of basal area per acre would change the high-risk stands to 27% moderate risk and 71% low risk. However, under any treatment scenario, nearly all stands would return to high risk within 15-20 years unless there was follow-up treatment. (Mason et al.)

The Forest Service has been underburning ponderosa pine stands since the 1970s. Very little underburning has occurred in mixed conifer forests. (Lower Chewaucan WA, p. CC-11). During the past decade, the Forest Service has been thinning ponderosa pine stands to remove the white fir understory and reduce overall stand density.

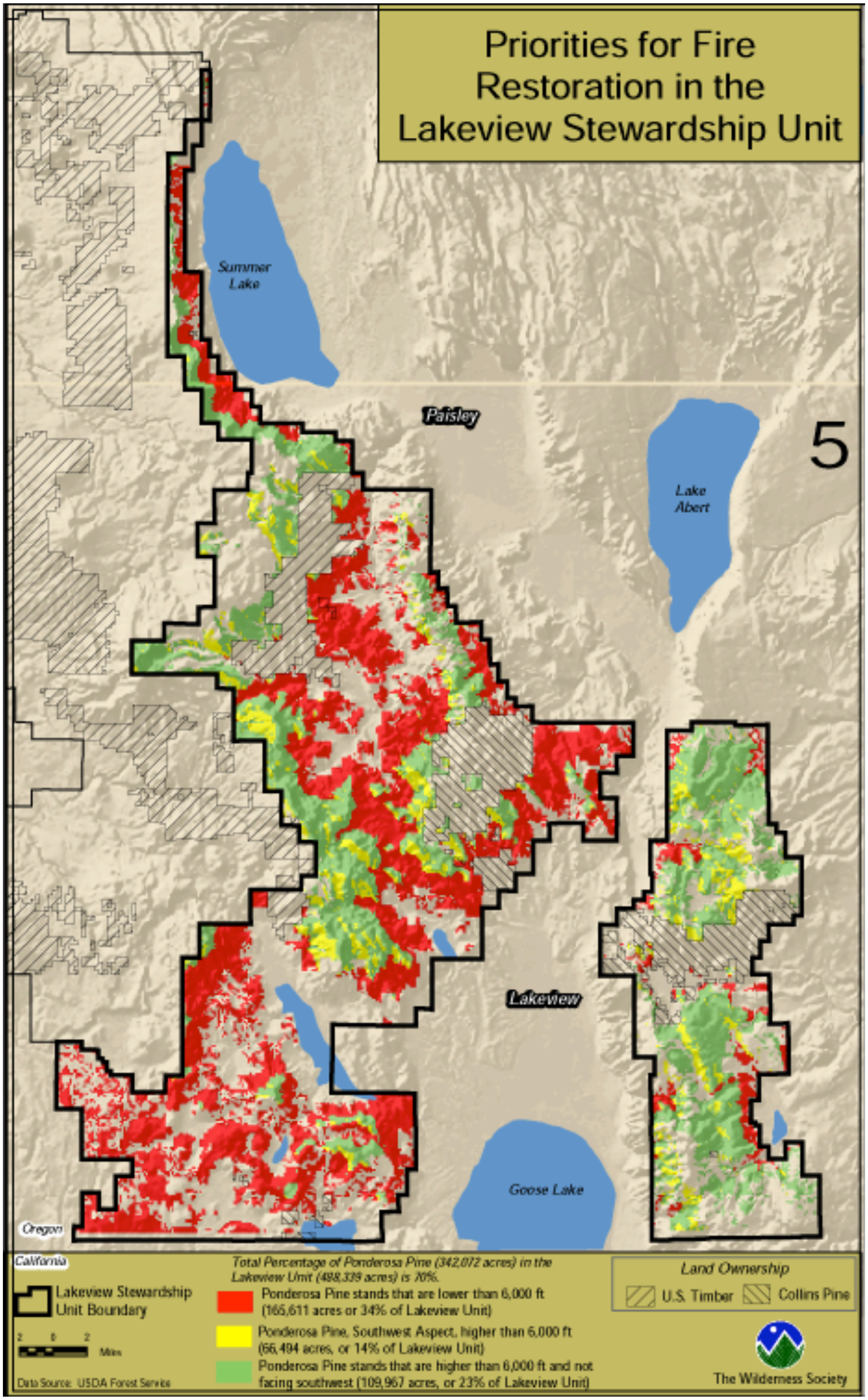
KEY VEGETATIVE TREATMENT ACTIVITIES IN LAKEVIEW FEDERAL STEWARDSHIP UNITY, 2001-2009

Year	Commercial Treatment Acres	Non-Commercial Fuel Reduction Acres	Prescribed Burning Acres
2001	3,647	2,872	3,750
2002	1,048	2,708	4,000
2003	2,833	1,343	9,187
2004	5,626	4,453	10,487
2005	507	5,357	0
2006	1,783	5,302	9,864
2007	3,562	4,614	12,178
2008	5,712	3,209	167
2009	2,203	5,927	0
Totals	**26,921**	**35,785**	**49,633**

These data need some interpretation and explanation. First, the commercial treatment numbers include both commercially-driven post-fire salvage logging of large dead trees and ecologically-driven “green” commercial thinning of generally small diameter trees. For the years 2001-2005, the acres of commercial treatment primarily consisted of fire salvage treatments, whereas since 2006 commercial treatments have focused on green tree thinning. Second, the annual prescribed burn numbers fluctuate widely because the Forest Service’s burn program focused on areas within the Unit in some years and moved to other parts of the Forest in other years. The large burns have generally occurred in relatively open forest lands, where per-acre costs are low compared to the more heavily forested lands that require substantial thinning and other treatment before they can be burned.

2005 Analysis of Potential Restoration Treatment Areas

For the 2005 Long-Range Strategy, The Wilderness Society conducted a GIS analysis of forest vegetation within the Unit to determine the approximate amount and location of areas that have relatively frequent fire return intervals and potentially would benefit from restoration treatment. Specifically, the analysis identified stands that are in the ponderosa pine ecotype, are located below 6,000 feet in elevation, and are located above 6,000 feet on southwest-facing slopes. As indicated in the table below, the analysis found that about 342,000 acres, or 70 percent of the Unit, are ponderosa pine stands. Of these, about 232,000 acres, or 48 percent of the Unit, are below 6,000 feet elevation or at higher elevations on southwest-facing aspect.


Priorities for Fire Restoration in the Lakeview Stewardship Unit
5
Summer Lake
Paisley
Lake Abert
Lakeview
Goose Lake
Oregon
California
Lakeview Stewardship Unit Boundary
2 0 2
Miles
Data Source: USDA Forest Service
Total Percentage of Ponderosa Pine (342,072 acres) in the Lakeview Unit (488,339 acres) is 70%.
Ponderosa Pine stands that are lower than 6,000 ft (165,611 acres or 34% of Lakeview Unit)
Ponderosa Pine, Southwest Aspect, higher than 6,000 ft (66,494 acres, or 14% of Lakeview Unit)
Ponderosa Pine stands that are higher than 6,000 ft and not facing southwest (109,967 acres, or 23% of Lakeview Unit)
Land Ownership
U.S. Timber
Collins Pine
The Wilderness Society

ACREAGE OF PONDEROSA PINE ECOCLASS ABOVE AND BELOW 6,000 FEET ELEVATION AND ON SOUTHWEST ASPECT

Total LFSU Acreage	488,339 acres
Total Ponderosa pine Ecotype	342,072 acres
Low Elevation Ponderosa pine (<6,000 ft)	165,611 acres
High Elevation Ponderosa pine (>6,000 ft)	176,461 acres
High Elevation Ponderosa pine on SW Facing Aspects	66,494 acres
Low Elevation PPine and SW Aspect High Elevation PPine	232,105 acres

TNC Assessment of Values Mapping

This 2010 Long-Range Strategy has utilized The Nature Conservancy's (TNC) state-of-the-art Fire Learning Network to help identify the highest priority areas for restoration treatments. The goal was to develop a practical adaption planning process to guide selection and integration of forest management recommendations into existing policies and programs. This process aimed to facilitate restoration treatments across a broad geography and engage the Forest Service and Lakeview Stewardship Group (LSG) in conservation action at scale. Benefits of this approach are in evaluation of the effectiveness of alternative restoration treatments using an active adaptive management approach.

Collaboratively derived forest restoration prescriptions are the result of negotiations that attempt to balance values, ideology, and ecology. Although policy makers, land managers and stakeholders all agree that management action should be based on the best available science, this good intent rapidly erodes without site specific information on the historic conditions from which to ground truth and compare proposed treatments.

The process of building trust in management decisions is with scientifically defensible methods and transparency. Federal land managers and stakeholders need site-specific data on historic stand structure, fire-return intervals, and species composition as a starting point for prescription design. These data create a picture of the last time forests were resilient, where the full complement of biodiversity was present and the entire ecosystem was in dynamic balance with landscape processes and function. Without this information there is no ability to evaluate the effectiveness of management actions for meeting ecological goals. In addition, stakeholders and managers need this data to evaluate how proposed variation from historic site conditions (based on ideology or values) will affect long-term ecological sustainability at the site.

Providing baseline data on historical stand structure, fire return intervals, site potential, and current forest conditions is essential to monitor the effectiveness of forest treatments. It may be the best strategy in our adaption management arsenal to assess forest health with climate change. Current predictions are that the climate will be warmer in areas of the Pacific Northwest. Recent research shows that fire seasons are already lengthening and fire duration is increasing (Westerling[1], et.al. 2006). Reducing fuel loads and focusing on building resiliency in old trees that have the genetic code for surviving long periods of drought in the past is urgently needed in the face of rapidly changing conditions.

[1] Westerling, A.L., H. G. Hidalgo, D. R. Cayan, and T. W. Swetnam. 2006. "Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity. Science. V 313: pp.940-943. www.sciencemag.org

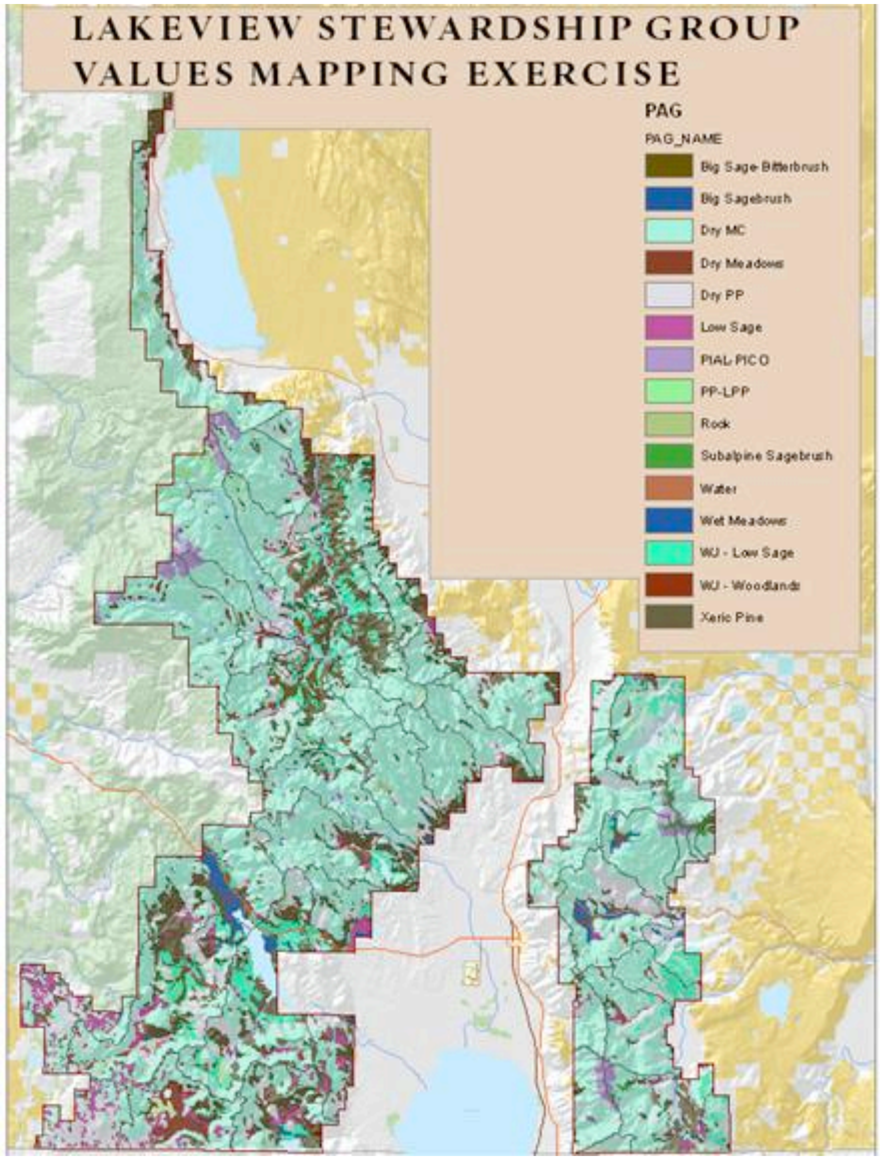
Consistent with the Forest Service's new approach to forest management through collaboration and managing for a full suite of ecosystem benefits (Vilsack[2], 2009), this analysis demonstrates how collaborative efforts can accelerate restoration of fire-adapted forests on federal lands at meaningful scales. Results of this effort have: 1) increased capacity with landscape assessments to prioritize restoration; 2) provided ecological data to ground truth and monitor management effectiveness; 3) added implementation capacity to restoration areas; and 4) developed an active adaptive management approach to evaluate the success of restoration treatments.

Objectives. Using a "nominal group technique," the LSG engaged in identifying, prioritizing, and weighting the places they felt need restoration action. The process was bounded by the realities of the land management agencies, data types, and the timeframe under which the data can maintain relevance to the federal agencies. The LSG identified eleven values which included: Mule deer winter range, Invasive species, Forested Ecosystems within Natural Range of Variability, Old Growth, Critical Infrastructure, Private lands buffer, Rare and sensitive plants, Recreation areas, Riparian Areas, Water Quality, and Wildland Urban Interface areas. The values assessment narrowed the final list to Forested Ecosystems within the Natural Range of Variability and Old Growth.

Forest Ecosystems within the Natural Range of Variability (NRV) were assessed as forests that are in mid- to late-succession with frequent fire regimes. The assessment was based on USFS Regional 6 Plant Association Guide (PAG) (Table 2) and LANDFIRE (Structural and FRCC) data. TNC used the FRCC data for Fire regime 1 and Condition Class 3 with mid-successional closed canopy stands. Through the assessment 200,000 acres were identified where treatments would restore NRV.

Treatable Stands. Treatable Stands are identified as Frequent Fire Stands that are highly departed and are over-abundant in a Closed Canopy state. In the initial analysis TNC used the PAG in our classification of Frequent Fire Systems. The analysis required using an updated PAG layer that was also correlated to current conditions. This data was then used to develop the Restoration Priority Scenario. Treatable Stands/Restoration Priority Areas data is the result of the LSG values assessment. We provide this information here to disclose the criteria and process used in the treatment prioritization classification knowing that there will be updates in data and methods, which will ultimately change the acres where treatment will occur.

[2] Vilsack, T.2009. AGRICULTURE SECRETARY VILSACK ANNOUNCES NEW DIRECTION AND VISION FOR AMERICA'S FORESTS. August 14, 2009. Seattle, Washington.
http://www.usda.gov/wps/portal/!ut/p/_s.7_0_A/7_0_1OB?contentidonly=true&contentid=2009/08/0383.xml


LAKEVIEW STEWARDSHIP GROUP
VALUES MAPPING EXERCISE
PAG
PAG_NAME
Big Sage-Bitterbrush
Big Sagebrush
Dry MC
Dry Meadows
Dry PP
Low Sage
PIAL-PICO
PP-LPP
Rock
Subalpine Sagebrush
Water
Wet Meadows
WJ - Low Sage
WJ - Woodlands
Xeric Pine

REGION 6 PLANT ASSOCIATION GUIDE DATA FOR THE LAKEVIEW STEWARDSHIP UNIT

Plant Associations	Total		Federal	Non-Federal
Total acres in LSU	662,289	Frequent	487,923	174,366
Non-Forested		Fire		
Big Sage/bitterbrush	6,727		2,248	4,479
Big sage	2,000		12	1,988
Dry meadows	15,472		6,279	9,193
Low sage	19,223		15,733	3,490
Wet meadow	8,242		1,180	7,062
Juniper / Low sage	37,187		21,705	15,482
Woodlands/juniper	1,670		826	844
Sub-alpine sage	2,336		2,148	188
TOTAL	**90,521**		**47,983**	**42,538**
Percentage	0.14		0.10	0.24
Rock	2,146		1,875	271
Water	3,547		840	2,707
Forested				
Dry mixed Con	381,395	381,395	294,691	86,704
Dry Ponderosa Pine	75,667	75,667	55,381	20,286
PIAL/PICO	10,563		9,855	708
PP/LPP	3,023	3,023	2,935	88
Xeric pine	93,091	93,091	72,215	20,876
TOTAL	**563,739**	**553,176**	**435,077**	**128,662**
Percentage	0.85	0.84	0.89	0.74

Climate Change is expected to change the intensity and magnitude of fire behavior. Most climate models for south central Oregon identify hotter and dryer conditions. TNC conducted a sensitivity analysis by increasing temperature 5 degrees and dropping humidity 5%. The results suggest that there may be slight difference in fire behavior (flame length changed in the highest category 7% and Crown Fire Activity Changed 18%). Additionally, we may need to change the previous two fire behavior metrics to include the factor of *contagion*. Fire is a contagious process. As we model fire behavior we can see that everywhere we treated the hazard dropped significantly. But, the cumulative benefit of treatments may not be accurately reflected through the fire modeling.

Modeling Forest Management to Reduce Fuel Loads and Restore Natural Stand Conditions

The 2005 Long-Range Strategy used Landscape Management System (LMS) to predict changes in stand conditions under one set of possible management options, modeling an approach similar in some respects to that proposed in the Klamath Tribes' draft forest plan. The model demonstrated that, on average, open stands dominated by trees generally 21 inches in diameter or larger can be created in 30 to 50 years for the ponderosa pine and mixed conifer habitat types, significantly reducing the risk of crown fire and allowing the forests to sequester and store carbon. The modeling also suggested that restrictions on cutting trees larger than 21 inches in diameter should be relaxed in 30 to 40 years to allow maintenance of desired stocking levels and stand characteristics. Surveys by the Chewaucan Biophysical Monitoring Team from 2006-2009 indicate that many stands are currently stocked with trees larger than 21 inches.

Some of the simplifications necessary to conduct this modeling include thinning to basal areas at or below the lower range suggested in the Klamath Tribes' plan and reaching the target basal area in the first thinning, rather than through successive entries. The model was also used to achieve open stands in moist mixed-conifer habitat types where complex, multi-species, multi-layered stands were probably common historically. Refining these models to more closely reflect anticipated on-the-ground management is an ongoing process.

Mountain Pine Beetle

Mountain pine beetles are currently ravaging the Upper Chewaucan watershed, infecting more than 300,000 acres in and around the Unit. Data gathered by the Chewaucan Biophysical Monitoring Team from 2007-2009 indicates that there is almost 100 percent mortality in all lodgepole pine larger than 12 inches in diameter and almost no mortality in trees smaller than 4 inches in diameter. Even though the big trees are dead, about 60 percent of the original stand is unaffected, leaving stands stocked with trees from 30 to 50 feet tall that become visible as the red needles fall off the large dead trees. There are several stands with unaffected big lodgepole pine in which the stocking levels of the large trees were at 35 basal area, though the stand had a basal area greater than 200. This hints at a management plan that limits the basal area of large lodgepole pine. More surveys need to be conducted to determine the significance of this finding. For more details, see www.lcri.org/monitoring/reports/Beetle Kill in the Upper Chewaucan.

These areas appear to be at high risk for catastrophic stand-replacing fires. As the large trees fall in the next few years (many large trees fell during 2009), the soils may be at risk of undesirable adverse effects of fire. This issue is discussed further in www.lcri.org/monitoring/reports/Potential Effect of Catastrophic Fires on Mazama Ash Soils in the Upper Chewaucan Red Zone.

The current outbreak of mountain pine beetle in south-central Oregon has led forest managers to consider thinning as a means of decreasing residual tree susceptibility to attack and subsequent mortality. Previous research indicates that susceptibility of lodgepole pine, to mountain pine beetle is a function of a tree's physiological vigor and the intensity of attack. Trees able to produce ≥80 g (g) of wood per m^2 of projected leaf area annually are highly resistant, because they are able to shift resource allocation locally from wood to resin production to isolate blue-stain fungi introduced by attacking beetles. Typically, the leaf area of susceptible stands must be reduced by two-thirds to permit most residual trees to increase their vigor to a safe level.

Generally, outbreaks of mountain pine beetle are more likely to occur in lodgepole pine stands with trees older than 60 years and larger than 25 cm in diameter (Cole & Amman, 1969; Amman, 1978; Wellner, 1978). Larger diameter trees have thicker bark, which facilitates the construction of egg galleries, provides better protection from natural predators, and insulates against external temperature extremes and desiccation (Safranyik& Carroll, 2006). In addition, there is a positive relationship between tree diameter and phloem thickness (Amman, 1969; Shrimpton & Thomson, 1985), with the phloem being the primary nutrient source for the beetles and their larvae (Amman, 1972; Amman & Pace, 1976; Berryman,1976; Klein et al.,1978). Thicker phloem results in larger broods, larger beetles, and enhanced survival rates (Safranyik & Carroll, 2006); however, phloem thickness is not directly related to a tree's ability to resist beetle attack (Shepherd, 1966). Large diameter trees appear more susceptible when their growth becomes reduced — either temporarily, through an event such as severe drought, or permanently, as a result of disease or mechanical damage.

There is debate over whether thinning is an effective treatment for managing mountain pine beetle infestations because it increases tree vigor (Mitchell et al., 1983; Waring & Pitman, 1985) or because thinning alters the microclimate (e.g., temperature and wind patterns), producing unfavorable conditions for beetles (Bartos & Amman, 1989; Amman & Logan, 1998). Regardless, increases to tree vigor and alterations to stand microclimate are both known outcomes of thinning treatments (Waring & O'Hara, 2005), and likely play some role in reducing stand susceptibility and subsequent mortality due to mountain pine beetle attack, although perhaps over different time horizons (Amman et al., 1977). In this context, we use vigor as an indicator of stand susceptibility, although we acknowledge the role of microclimate and stand dynamics in determining susceptibility.

In 2009, the Forest Service, in consultation with the Lakeview Stewardship Group, approved a Red Zone Safety Project to improve public and employee safety by removing beetle-killed lodgepole along 200 miles of roads and within 25 recreation sites in and around the Lakeview Unit. Implementation of this project will produce logs and biomass for commercial use as well as create strategic fuel breaks to help control fires.

<u>Fuels and Fire Guidelines:</u>

- Use Fire Learning Network, Landscape Management System, or similar GIS analyses and computer tools to model and inform forest restoration activity in the Unit.
- Undertake an accelerated thinning and prescribed burning program, using the Klamath Tribes' plan as a model, supplemented, as appropriate, by local or more recent information.
- Identify priority areas for treatment, including:
    1. near residences;
    2. adjacent to private forest lands that have approved management plans;
    3. in stands with remnant old-growth ponderosa pine (in ponderosa pine or mixed-conifer plant association groups) where dense younger trees put the stands at risk of uncharacteristically severe fire or drought stress;
    4. in other ponderosa pine and dry mixed-conifer stands with existing road access.
- Base restoration treatment prescriptions on Chewaucan Biophysical Monitoring and other local data about reference conditions, as well as other appropriate data and models.
- Restore more natural fire conditions in appropriate areas and circumstances through prescribed fire, modified suppression tactics, and updated fire management plans.

2. Old Growth

Objective: Restore forest conditions that approximate historical species composition and stand ages.

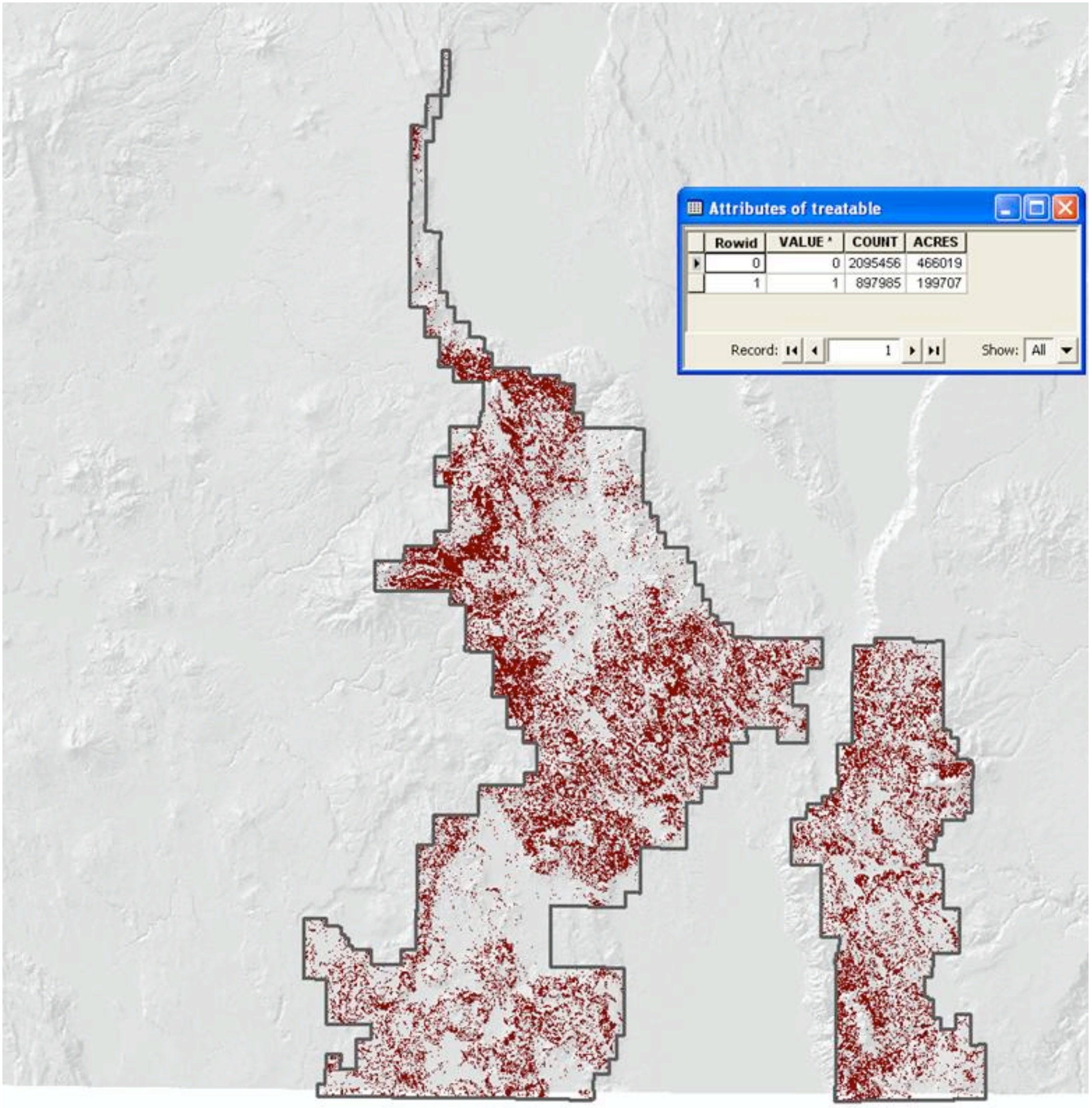
Historic and Current Conditions

Historically, ponderosa pine forests were mostly in large park-like pine stands with occasional small openings; 60-80 percent were in old structural condition. Mixed conifer forests had variable conditions due to infrequent, stand-replacing fires following insect mortality and high fuel loads; 40-70 percent were in old and late structural condition. Lodgepole pine forests had large, even-aged patches due to frequent stand-replacing disturbances; 30-90 percent were in early structural condition. (Upper Chewaucan WA, p. RC-4; Lower Chewaucan WA, p. RC-4). Continuing Forest Service analysis suggests that the old structural condition in ponderosa pine may have been somewhat lower (40-50%) than the estimate in the Chewaucan WA; preliminary national-level documentation can be found at
http://www.frcc.gov/docs/reference/WEST_Forest_BpS_01.11.05.pdf.

There are many different definitions for late successional, old, or old growth forest, and most of them center on age, size, and structure. The following table summarizes the attributes from the 1992 Region 6 Green Book definitions for old growth. The vegetation assessment used these definitions. The method to assess existing old growth incorporated Gradient Nearest Neighbor (GNN) data, which was calibrated using Forest Vegetation Simulation (FVS), and Viable. The methods used to assess the number of acres of old growth are in Appendix B.

Factor	Cold Forest	Moist Forest	Dry Forest	Lodgepole Pine cover type
DBH	21	21	21	12
Trees per acre	10	10-20	10	60
Age	150	150	150	120
Variation in Tree Diameter	yes	yes	yes	yes
Tree Decadence	yes	yes	N.A.	N.A.
Tree Canopy Layers		1	1	1
Dead DBH	12	14	14	12
Dead TPA	2	1	3	5
Down Diameter	12	12	-	-
Down Pieces per acre	4	5	0	0

According to this analysis, there are 199,707 acres of old growth on Federal lands in the Lakeview Stewardship Unit. This is equivalent to 46% of the forested acres. The general distribution of old growth is displayed on the following map where 30 meter pixels are highlighted in red where old growth currently exists.


Attributes of treatable
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1 1 897985 199707
Record: 1
Show: All

During the past three years, the Chewaucan Biophysical Monitoring Team has collected data and analyzed old-growth conditions on 21 forest sites within the Upper Chewaucan watershed. According to the Monitoring Team's analysis, the population of ponderosa pine within old-growth sites seems to be declining overall. Much of the ponderosa pine old growth is in very late seral condition and will need thinning from below in order to maintain a strong presence of old ponderosa pine trees and restore appropriate site capacity. There are a few sites with heavy ponderosa pine reproduction, but these sites too will need management to maintain the health of the old ponderosa pine.

The lodgepole pine in the old-growth ponderosa pine sites is almost entirely in mid to late seral condition, with one site showing only recent appearance of lodgepole. The lodgepole pine is reproducing very heavily where present and will surpass, and perhaps replace, ponderosa pine if left alone.

The white fir is very similar to the lodgepole pine, showing signs of recent entry in places and mid to late seral condition for most of the old growth. However, on some sites white fir is in very late condition. Like the lodgepole pine, the white fir is reproducing very well where present and could come to dominate or co-dominate the watershed.

Forest Service watershed analyses report similar findings. They indicate that overstocked understories in many stands are causing overstory mortality of large trees and an unraveling of late/old seral forest characteristics. (Upper Chewaucan, p. CC-20; Deep Creek, p. CC-37 and Lower Chewaucan, p. CC-37).

Current Management Direction

Current Forest Service management direction for old growth is based on the "Eastside Screens," which were adopted in 1994 and amended in 1995. Timber sale harvest activities are not allowed in late and old structural stage forests that are below historical range of variability, except where it will enhance the LOS character. All remnant late and old seral and/or structural live trees greater than 21 inches in diameter must be maintained. In stands that are not in late and old structural condition, treatments must move stands toward appropriate late and old structural conditions to meet historical range of variability. Open, park-like stand conditions must be maintained where this condition occurred historically. Treatments must encourage the development and maintenance of large diameter, open canopy structure. (ICBEMP Eastside Draft EIS, p. 3-71)

Fire and Salvage Impacts

In recent years, wildfires have caused significant losses of mature and old-growth forests. In 2002, the Winter Fire burned 34,000 acres, killing 50-80% of the trees across 70% of the burn area. The Grizzly Fire burned 3,760 acres of national forest land and 2,065 acres of adjacent private land. The Eastside Screens require salvage sales to provide 100% of potential population levels of woodpeckers and other primary cavity excavators. The Fremont forest plan standard calls for leaving a minimum of three snags per acre greater than 15 inches in diameter, plus one 10-inch snag. However, in portions of the Cub salvage sale the Fremont Sawmill agreed to retain all ponderosa pine trees larger than 28 inches in diameter as large tree snag habitat, and in the Winter Salvage Sale the Forest Service left additional snags in wildlife patches. The Klamath Tribes' forest management plan and Johnson and Franklin (2009) support leaving large dead trees following burns.

Recent surveys by the Chewaucan Biophysical Monitoring Team raise concerns about natural recruitment of trees in severely burned areas, some of which have virtually no trees growing on hundreds of contiguous acres. More than 50 percent of the areas surveyed 4 to 7 years after catastrophic wildfire had fewere than 25 trees per acre replacing mature trees that were destroyed. The tool used to fund tree regeneration may need revision allowing for planting in non-harvested areas. These areas of no regeneration would make excellent candidates for planting trees as part of a carbon sequestration project that might pay some or all of the planting costs. However, as Johnson and Franklin (2009) point out, it will be desirable to avoid overly dense, uniform stands that would result from applying conventional standards of "full stocking."

Old-Growth Guidelines:

- Retain all large (>21"), old (presettlement, > 120 years) trees and large snags, and provide for their replacement over time. In the long run, as more trees grow and age to old-growth condition, proportional removal of those trees may be appropriate.
- Propose adjustments to Eastside Screens to allow cutting of large (>21", but less than 120 years old) white fir in stands currently or historically dominated by ponderosa pine (like Klamath Tribe plan)
- Identify old-growth stands that should be high priority for restoration treatment.
- Propose guidelines for salvage logging to retain large dead trees (like Klamath Tribe plan, but bias retention of >21" snags toward largest available).

3. Invasive Species and Noxious Weeds

Objective: Eliminate and control spread of noxious weeds.

Habitat for noxious weeds is prevalent throughout much of the LFSU due to past management activities, overgrazing, and road construction. Weeds seem to be expanding each year. (Upper Chewaucan WA, p. CC-10; Deep Creek WA, p. CC-21).

The spread of non-native cheatgrass (*Bromus tectorum*, not formally designated as a noxious weed) is an especially serious problem in much of the Unit. Cheatgrass crowds out the native vegetations, hoards critical resources like water and potassium, and destroys the forage and habitat for wildlife. Also, when cheatgrass takes hold, it can change the site's fire regime, increasing fire frequency and intensity.

Another non-native grass, Medusahead (Taeniatherum caput-madusa) may also be making its way into the Unit. It is very competitive against native grasses, helps introduce fire into non-fire prone areas, and may combine with cheatgrass to cause havoc. A few species of Thistle (Musk, Scotch, Bull) also are increasing on disturbed, bare soils throughout the Unit, primarily on landings and along roadways. Knapweeds are being effectively controlled.

Noxious grasses are a telltale sign that the Unit is being degraded. Much of the area is not carpeted by an effective ground cover, creating openings for the invasive grasses and weeds. Sub-soiling has contributed to this condition at all elevations, according to recent monitoring. The non-native grasses pull vital and limited elements and minerals such as potassium out of circulation, which harms the conifers.

One problem with efforts to restore native grasses has been the absence of adequate seed and nursery stock. One possible solution is to use another non-native grass like crested wheatgrass as a way to prevent the spread of cheatgrass and as a transition to native grasses.

The Forest Service has accomplished noxious weed treatments on an average of 653 acres in the past seven years, of which 35 percent have been treated manually and 65 percent have been sprayed with herbicides.

NOXIOUS WEED TREATMENTS IN THE LAKEVIEW FEDERAL STEWARDSHIP UNIT, 2003-2009

	2003	2004	2005	2006	2007	2008	2009
Manual	182.9	130.3	214	363.3	293.1	173.8	231.8
Herbicide	277.5	601.6	359.1	623.6	566.7	300.7	254.8
Total	**460.4**	**731.9**	**573.1**	**986.9**	**859.8**	**474.5**	**486.6**

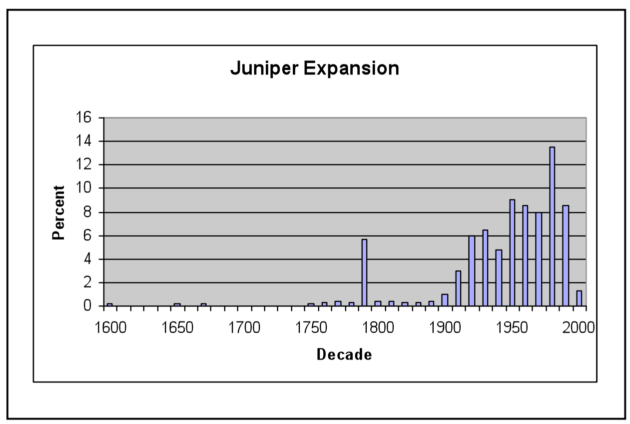
Invasive Species and Noxious Weeds Guidelines:

- Take precautions to ensure that weeds do not spread into areas where they do not currently exist – e.g. by avoiding sub-soiling and maintaining effective ground cover.
- Increase weed monitoring and eradication efforts, especially in juniper treatment areas. Secure access to a soil lab to analyze monitoring samples on a regular basis.

4. Juniper Encroachment

Objective: Restore forest conditions that approximate historical species composition and stand ages.

Prior to Euro-American settlement, many dry areas supported native bunchgrasses and sagebrush-steppe. Juniper was confined to rocky hillsides, ridges, and outcrops. Fire exclusion and overgrazing have allowed juniper to expand into communities historically dominated by sagebrush. (Lower Chewaucan WA, p. RC-8). With fire suppression, livestock grazing and, possibly, climate variation and change, juniper has come to dominate many areas. The juniper pockets have expanded and become more densely stocked, encroaching in aspen stands, riparian areas, and meadows.



The spread of juniper woodlands into rangelands poses a serious threat to watershed and ecosystem health on many sites. (Deep Creek WA, p. S&I-10). Juniper expansion has increased the amount of overland flow and erosion. Twelve years of studies done by the Eastern Oregon Agricultural Research Center has shown both erosion and runoff increase dramatically in a juniper woodland landscape versus area returned to a more natural open condition. With treatment the area goes from a little over 2 plants per square yard when dominated by juniper to 11-12 plants per square yard, increasing water absorption and reducing erosion. If these juniper areas and further encroachment are not managed, juniper will eventually dominate a much larger portion of the Unit. The expected result will be increased watershed degradation affecting site productivity, water quality and quantity, with ecological consequences. (Lower Chewaucan WA, p. S&I-1). Juniper expansion results in the displacement of some wildlife species, as trees dominate areas that previously provided habitat for ground and shrub nesters.

The Forest Service and BLM have undertaken juniper removal within the lower Chewaucan Watershed since 2002. This work is continued with the Jakabe Juniper/Aspen/Meadow Recovery Projects which are designed to restore historical conditions through removal of junipers followed by prescribed fire. No old-growth juniper will be cut. Research studies are showing differences in impacts from spring and fall burns of juniper. Data collected in the juniper treated areas along the Chewaucan River indicate that fall burning exposes and destroys soil structure so that for the next 3 or more years invasive pioneering plants alternately dominate the site along with cheatgrass. Juniper burned on snow has a much lower impact on soil structure and follows a succession similar to the juniper that is left unburned. Plant communities under the juniper are slowly being succeeded by plant associations common to the surrounding area. The process is very slow and may take longer than the 12 years suggested.

Initial monitoring of the juniper removal program has raised concerns about accelerating the spread of cheatgrass through soil disturbance and prescribed fire. A review of the studies done by Eastern Oregon Argricultural Reseach Center shows that while cheatgrass enters following disturbance, within twelve years native vegetation out-competes the cheatgrass and only small amounts remain. In one area with 7 sites, we have seen cheatgrass being replaced by Japanese brome. Cheatgrass trends need to be monitored, as twelve years is a very short time in ecosystem terms, and the sites in the study are different from those in the Unit.

Juniper Guidelines:

- Use prescribed fire and control grazing to avoid spread of juniper.
- Take an adaptive management approach toward juniper removal, including careful monitoring of impacts on effective ground cover, cheatgrass spread and burning times. Assess and attempt to improve vigor of existing herbaceous vegetation before removing juniper.

B. Soils and Water

Goal: Sustain and restore the land's capacity to absorb, store, and distribute quality water.
Objectives:

- *Manage upland vegetation to maintain and restore water and moisture absorption, retention, and release capacity over time.*
- *Maintain and improve aquatic and riparian habitat for native species.*
- *Lower stream temperature and sediment loads.*
- *Improve biophysical structure of soils.*
- *Restore forest health through treatments without undue disturbance.*

Soil and water are two interdependent critical resources at the landscape level. Water and soil quality are intimately linked to nature's activity at the topsoil and subsurface levels. Soil quality is intimately linked to the infiltrating moisture to dissolve minerals and move nutrients within the root zone where plants can access them.

Soil Functions and Repair

Topsoil is an atmospheric sink that collects solar inputs, gases, fuels, particulate matter, nutrients, litter and precipitation. It has to both utilize and buffer these inputs. Forest topsoil is created and supported by a specific architecture and mix of bacterial, fungal and soil animal populations to process not only what lands on top but what is underneath. The architecture or aggregate has to support the passage of air and water and feeder roots or the life above it is compromised. Compaction, displacement, erosion, and desiccation are the chief modifiers and destroyers of this habitat, its inhabitants and its functioning. Unacceptable levels of soil compaction and displacement have been observed across many areas of the Unit. (Lower Chewaucan WA, p. S&I-7).

During the last 3 years the Chewaucan Biophysical Monitoring Team has studied the impact of ground-based logging following revised Forest Service protocols on 56 sites. Sites show less compaction on cutting lanes, higher recruitment of down woody debris throughout the projects, and wide swaths of untouched soils in the corridors between the cutting lanes. Future studies will analyze vegetation recovery and compaction trends. Sites harvested over snow show little to no compaction or soil displacement. Plant responses following harvest over snow are immediate and demonstrate a wider range of species diversity. Soils conservation must remain a priority. A forest lives or dies from the ground up.

Soil development is a top-down process that takes millennia to create an adequate and functional topsoil. The Chewaucan monitoring team has found that the average organic soil layer is 2.2 inches thick, the product of 6,900 years of formation. Much of it lies on top of the soft unconsolidated ash and pumice from the eruption of Mt. Mazama. In the Upper Chewaucan Mazama ash soils tend to lie on top of older, thicker Western Cascade soils. Though it may have experienced many cycles of vegetative life, it is still young and developing in most areas throughout the watershed. Some exposed areas may never have been able to build an organic layer, while others have become exposed and contain remnant organics.

An effective ground cover is critical in order to establish and maintain soil repair. There are three general classes of effective ground cover:

- cryptobiotic crusts of mosses and lichen (rare within the Chewaucan);
- grasses and forbs (quite common, yet in various levels of health); and
- thatched duff (primarily found in the mixed coniferous stands and old growth).

Exposed organic and bare mineral soils are subject to frost heaving and accelerated erosion from heavy seasonal rains. The exposed remnant organic soils can be protected from further erosion through planting of native grasses and forbs. We need to identify ways to restore the nutrient base without further disturbing the effective ground cover. The effectiveness of sub-soiling continues to be monitored. Surveys of subsoiled areas have shown that the sub-soiled areas, while initially releasing the compaction, ultimately become more compacted than their immediate surroundings. The furls formed by the rippers become beds for invasive plants. Loss of effective ground cover is also dramatic in comparison to the immediate surroundings (*Assessing The Use of Sub-Soiling Within the Upper Chewaucan Watershed.* Report of June 4, 2004).

Surveys of landings and decommissioned roads using vegetative recovery as an indicator of soil recovery indicate that lightly scarified areas (4 – 6 inches) recover 1.8 times faster than blocked areas which recover 4 - 8 times faster than subsoiled areas. Many subsoiled areas are still predominately bare after 30 to 40 years. (www.lcri.org/monitoring/reports/road decommissioning (2 reports)).

The Chewaucan Biophysical Monitoring Crew began analyzing soils in all sites using a LaMotte Smart 2 Soil Colorimeter in 2006. This spectrophotometer is highly reliable, giving repeatable results in concentrations of parts per hundred million (mg/100L). This tool is revealing soil nutrient levels following wildfire, prescribed fire, juniper treatment, harvest, and wood decomposition. Trend studies using this tool will be invaluable in determining soil health. Current data and discussions can be accessed at www.lcri.org/monitoring/reports/soil chemistry.

Ecosystem Changes

The Chewaucan Biophysical Monitoring program is addressing system mosaics along the sub-watershed gradients to provide insight into compositional changes and potential gains or losses of biodiversity and ecological complexity within the Unit. The changes coming into view are synergistic, as plant assemblages seem to be simplifying due to climate change and invasive species incursions. Predictable plant associations are less dominant, giving way to varying plant assemblages on similar sites. Stand types have become compromised because of species incursions due to fire suppression. Site capacities have been exceeded because of large populations of trees and prolonged drought. Appropriate thinning in critical areas will give needed relief in many stands as well as reduce their fuel and fire hazards.

One of the consequences of past logging has been an interruption of the natural process of dead wood formation by altering the rates of formation and the number, size, and species of woody substrates. These alterations have affected natural reproduction, the mix of vascular and non-vascular plants, and fungi populations. Past logging has also modified the rates and amounts of nutrient cycling, carbon sequestration and soil development, primarily through compaction and displacement. Whole tree harvesting has the potential to increase nutrient removal because of the concentrations of nutrients in branches and needles, which are higher than in the stems.

Stream Functioning

The stream system that has been monitored shows an average of high water clarity, high macroinvertebrate diversity, fair to good channel stability and warm to very warm water. Increased width to depth ratios in stream channels and reduced shading from loss of riparian vegetation are the primary causes of elevated temperatures. (Deep Creek WA, p. C-6). Stream degradation in the Unit and elsewhere in the Interior West has been caused by the cumulative effects of overgrazing, road development, logging, water diversion and impoundment, and other human activities.

Fish, especially redband trout, seem to have acclimated to the temperature, but fish passage is still an issue that is being addressed. Between 2002 and 2007, culvert replacements have opened up many miles of streams to redband trout. The Chewaucan Biophysical Monitoring Team has been monitoring many of these culverts and streams for upstream fish use. A notable success has been Puppydog Creek, where the crew observed successful fish migration for more than two miles upstream, using freshwater mussels as an indicator of fish migration. The glochidia (mussel larva) attach to redband trout gills to move upstream. Redband trout have been observed in many of the streams above replaced culverts.

Peak flows appear to be higher currently than in historic times. The Chewaucan River experienced peak flows exceeding the 100-year event during extreme rain-on-snow events in 1964 and 1997. Peak flows have the potential to be higher with increased drainage efficiency from roads. Current drainage efficiency increases have been calculated in the range of 35% to 170%. Also, high levels of compacted soils are contributing to higher peak flows. (Upper Chewaucan WA, p. C-3)

Riparian Areas

Present riparian vegetation generally occurs in narrow bands along the streams, springs, seeps, and lake shores due to lowered water table caused by stream incision or reduced contributions from upland sources, sometimes resulting from increased density of conifer cover. Generally, willows and other deciduous species such as black cottonwood are lower in extent, density and cover than in historic times. Stream downcutting resulting from overgrazing and, to a lesser extent, recreational pressure, is very evident in some areas. (Upper Chewaucan WA, p. CC-10). Areas that have been resurveyed show a marked improvement in vegetative stabilization and bank healing as grazing practices change or are enforced.

Soil and Water Guidelines:

- Initiate Unit-specific research to determine the distribution of nutrients in different parts (needles, branches, boles) in trees of various sizes so that nutrient removals from logging can be determined and reflected in the biomass harvest plans. Answers are needed for the following: What would be the magnitude of loss of nutrients, snag and down wood habitat under the proposed biomass utilization within the Unit? How sustainable are these losses of nutrients and large down wood? Will natural weathering rates and other inputs compensate for nutrient removal in the harvested logs within the Unit? Baseline surveys by the Chewaucan Biophysical Monitoring Team show a slight decrease in soil nutrient levels. Will soil nutrient levels increase to pre-harvest levels over the next few years? If not, the decrease becomes significant. Over the next few years as soil nutrients cycle, a clear picture of nutrient cycling will begin to emerge to answer these questions. Baseline data can be accessed at www.lcri.org/monitoring/reports/soil chemistry.
- Timber sale planning needs to address both the spatial distribution and intensity of disturbance to the soils and their vegetative cover. Baseline data in the Bull Stewardship and Jakabe Project areas (46 sites) have been analyzed for soil and vegetation changes. They have also been modeled in Landscape Management Systems (LMS). The preliminary data can be viewed at www.lcri.org/monitoring/ queries and www.lcri.org/monitoring/reports/LMS.
- Restore and enhance the Unit's effective ground cover. A disproportionate amount of bare mineral soil within the Unit has been subject to wind and water erosion.
- Utilize old skid trails to the extent necessary, limiting new permanent logging skid trails to approximately 7% of the total area. Survey and choose those skid trails where the soils are shallow, rocky, and/or on previously disturbed ridge areas. The sales administrator or contract field officer needs to convey to the logging boss and crew the necessity to stay on flagged roads and away from recovering soils, with the exception of well developed grass areas. Monitoring by the Chewaucan Biophysical Monitoring Team indicate that these practices **are** being implemented and **are** responsible for monitoring data showing less damage to soils than older timber sale the team has monitored.
- Accurately map and record the areas that are or will be occupied by a permanent road system and retain this information in the monitoring records.
- Sub-soiling needs to be monitored and analyzed before more area is treated to determine the effectiveness of the treatment. Present monitoring data show that many disturbed areas that haven't been sub-soiled are repairing themselves and are showing similar conifer growth as the treated areas. Sample monitoring of treated areas should continue.
- Continue to improve fish passage and habitat. Aquatic macroinvertebrate sampling shows healthy diversity and populations in all sub-sheds within the Upper Chewaucan. Sampling needs to extend to the rest of the Unit.
- Map and protect from grazing and OHV use those riparian and stream channel areas that are vulnerable to adverse effects or are not recovering at optimal rates.

C. Fish and Wildlife

Objectives:

- *Reduce road density and improve remaining roads to minimize impacts on water quality and flow.*
- *Maintain and improve aquatic and riparian habitat for native species.*
- *Lower stream temperature and sediment loads.*
- *Improve opportunities for people to fish, hunt, and view nature.*
- *Maintain and restore habitat for focal species.*

The Lakeview Stewardship Unit is the home of many mammals, birds, fish, and other species that are typically found in the relatively dry, high elevation forests, rangelands, streams, and lakes of south-central Oregon, as well as some species that are unique to the area. Threatened and endangered species within the Unit are the northern bald eagle and Warner sucker; American peregrine falcon was de-listed in 2000. Species that have administrative status are the redband trout (USFS Region 6 sensitive, ODFW sensitive), Goose Lake sucker (USFS Region 6 sensitive, ODFW sensitive), Goose Lake lamprey (USFS Region 6 sensitive, ODFW sensitive), and pit roach (USFS Region 6 sensitive-proposed, ODFW sensitive). Indicator species associated with old growth forests include the pileated woodpecker, goshawk, American marten, three-toed woodpecker and black-backed woodpecker. White-headed woodpeckers, while not currently abundant in the area, should benefit from protection and restoration of old-growth ponderosa pine. The Red-naped Sapsucker is an indicator species for aspen groves. Other important species in the Unit include elk, deer, California bighorn sheep, and beaver.

The Forest Service Regional Office is currently leading an effort to identify focal (or surrogate) species to be used in the process of revising forest plans. Information from that effort may be incorporated into future versions of this long-range strategy.

Terrestrial Species and Habitats

Big Game: Elk started reestablishing themselves in the 1960s, and their population for a long time seemed to be on the increase. Those increases have leveled off due in part to a disease known as red water. The deer populations seem to have stabilized from the lows of the 1960s. Reducing forest stocking levels and reintroducing fire should provide habitat favorable to both these species. Variable-density thinning and road closures will help provide hiding cover and security.

Northern Bald Eagle, Pileated Woodpecker, Goshawk, American Marten, Three-toed Woodpecker and Black-backed Woodpecker: These species have been affected by timber harvest, plant succession, fire suppression and road density. Managing according to the Unit objectives and goals will improve habitat availability for these species by variously favoring the retention and development of large trees and snags and the development of complex forest landscapes. Snags are an essential habitat component, both as nesting and foraging sites for woodpeckers and for a variety of birds and mammals that secondarily make use of woodpecker nesting and roosting cavities. Snag-retention guidelines for both green and post-fire stands need to be updated to reflect current understanding of the needs of species associated with this habitat component. Encouraging firewood cutting in lodgepole pine versus taking large ponderosa pine snags will also help.

Red-naped Sapsucker: Aspen is gradually being replaced by conifers over time as a result of plant succession and fire suppression. Livestock and big game grazing on aspen is setting back regeneration. Reintroduction of fire and conifer management is needed to restore stands to later structural stages. Some stands will need temporary or full livestock exclusion in order to reach the desired future condition.

White-headed woodpecker: Like other woodpeckers, this species nests in snags but generally forages for insects on the bark rather than drilling into trees for beetle larvae. It is unique among woodpeckers in using the seeds of ponderosa pine as a winter food source. Larger, older ponderosa pine are particularly important because they produce more cones and seeds. Populations of this species are depressed throughout eastern Oregon. Unit objectives of retaining large, old ponderosa pine, improving their vigor, and growing more large pine should benefit this species over time.

Aquatic/Riparian Species and Habitats

Forest Vegetation Conditions: Over 50% of the forested community is outside recommended canopy ranges and are functioning inappropriately. Conifers have expanded into nearly every meadow and most riparian areas throughout the Unit, promoting competition with riparian vegetation (willows, aspen, cottonwood, alder) necessary to maintain proper stream types and bank stability. The woodlands are replacing numerous vegetative types, leaving soils prone to erosion and reducing late summer stream flows. The increased conifer densities are likely contributing to lower base flows, but the extent is unknown.

The Unit goals of restoring natural stand structures and fire regimes will improve these conditions. Conifers that have encroached into riparian areas should be thinned and fire reintroduced.

Road Density, Location and Drainage: Road density and location are for the most part causing streams to be in a “functioning appropriately but-at-risk” condition. Goals for the Unit should be a maximum road density of 1.7 mi/mi^2 and a priority placed on removing or fixing roads within 300’ of streams. The remaining roads should be properly drained to reduce hydrological connection to stream channels, resulting in less water and sediment flowing down roads and their ditches. This will also improve spawning gravel fines in most streams.

Riparian Vegetation and Associated Bank Stability: Within the Unit the majority of type B and E streams are functioning appropriately and characterized as having an abundance of late seral vegetation and high bank stability. The Upper Chewaucan Watershed Assessment reports that Type C streams that are predominately associated with large meadows are not functioning appropriately because of low bank stability and lack of sedge, rush and willow. Because gravel point bars are common in C stream types, greater densities of willow are expected relative to other stream types. Grazing standards need to promote willows and late-seral plant conditions to solve this problem on type C streams.

There is evidence that some of the large meadows with type C streams may never have had an abundance of willows. Several long-term livestock exclosures in these large meadows have not resulted in willow re-establishment. On numerous sites as these large meadows narrow into smaller draws, we find an abundance of willows with the same level of livestock grazing occurring. It appears that the soils combined with higher water tables may be the main reason willows never established in these large meadows. In the past, private land meadows were sprayed to control willows. This, along with the lack of beaver activity, may be another reason for low populations of willows in these large meadows under private ownership. Considering these differences, each meadow needs to be evaluated as to whether or not willows ever grew there and can be restored.

Large Woody Debris (LWD): Large wood in streams is important for controlling sediment transport, stabilizing stream banks, creating channel structure, and dissipating energy of water. Almost all streams in the Unit have low LWD numbers. This is probably due to past timber harvest practices and removal of LWD from streams. In the short term LWD needs to be artificially put into streams. In the long term LWD recruitment will be achieved by following Unit goals.

Fish Passage: In the original 2005 Strategy the three irrigation weirs on the Chewaucan River were identified as blockages for redband trout for over 50 years. Since that time the major ranches involved in the project -- the J-Spear, ZX, Murphy and O'Leary ranches -- undertook a major project to remove the Paisley Weir. The Oregon Department of Fish and Wildlife installed fish ladders on the Redhouse and Narrows weirs. The ranches undertook an almost $3 million dollar project to remove the Paisley Weir and install a new diversion that did not block fish passage. In total this project has opened up over 120 miles of stream to Redband Trout. The next immediate blockage is the down cut on Thomas Creek that currently prevents fish migration into the Unit. On other streams in the Unit, culverts are barriers.

Macroinvertebrates: The Chewaucan River has excellent macroinvertebrate populations and diversity, the Thomas Creek watershed has low populations, and we lack information on other streams. Macroinvertebrate diversity is an indicator of water quality. More data are needed to determine what water quality parameters are causing the decline of macroinvertebrates in Thomas Creek.

Beaver: Beavers provide a number of benefits to riparian and aquatic ecosystems. Higher stream levels and water tables due to beaver dams increase and diversify vegetation adjacent to streams. In summer, the increased woody vegetation shades and cools the water, improving fish habitat. Pools behind beaver dams provide more living space for trout, while improving water quality in the stream. Water is re-oxygenated as it falls over beaver dams. By backing up and deepening water, beaver dams help keep it from freezing solid in winter and reduce its temperature in summer. They also allow cooler groundwater to enter the stream from adjacent land. It percolates back into the stream during low-flow periods, increasing water in the channel. In addition, beaver dams reduce the stream's energy by slowing its velocity. Spring runoff is retarded, and its scouring effect reduced. Instead of causing streambank erosion, sediment is deposited. Responding to new water elevations, channels are constantly forming and old ones are filling in.

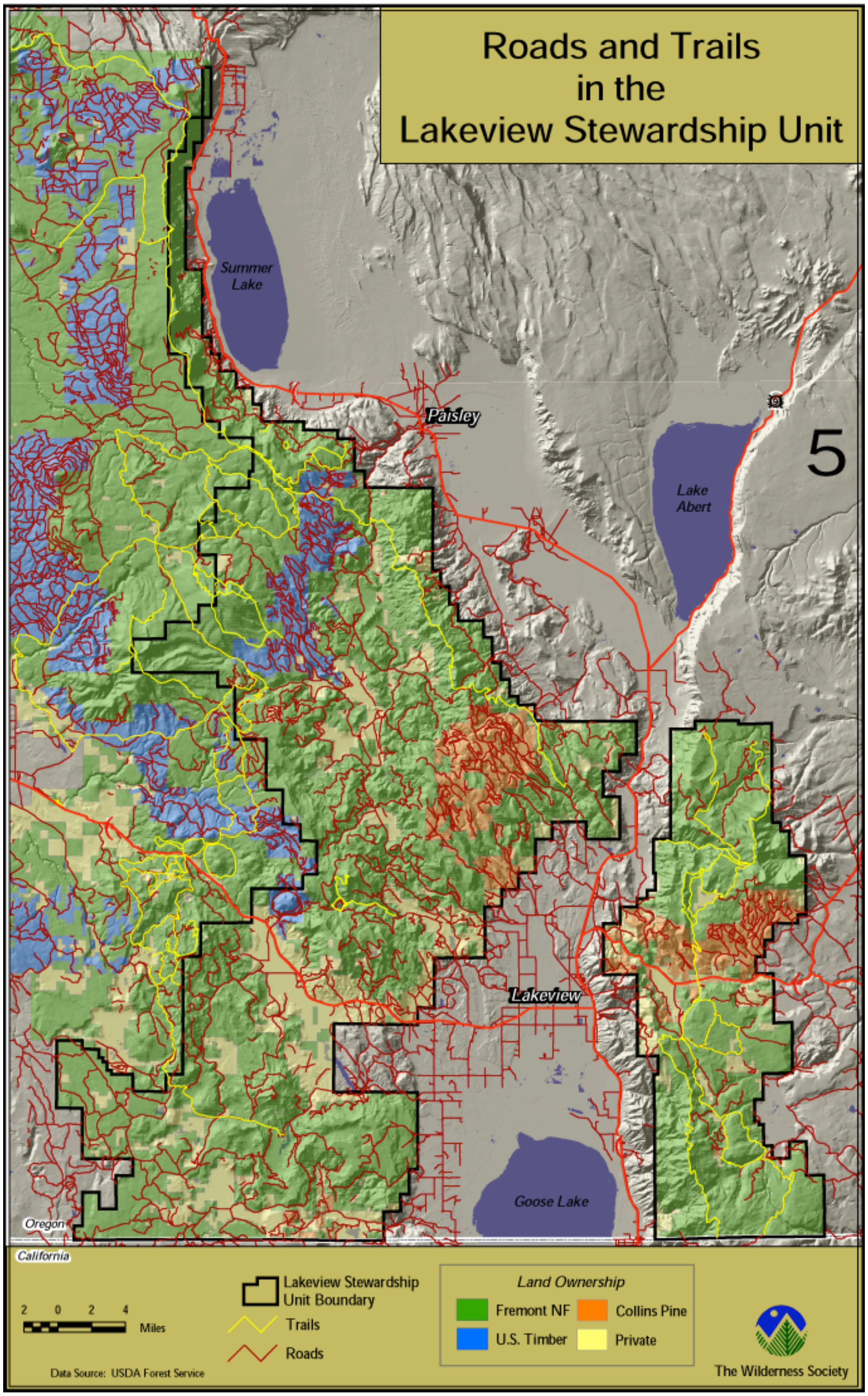
Beginning in the 1800s, beaver populations were systematically decimated by trapping and their habitats were degraded by overgrazing. Populations and habitats have been slowly improving for several decades, but some currently suitable habitat remains unoccupied and more habitat can be restored.

<u>Fish and Wildlife Guidelines:</u>

- Implement recommendations for big game and old-growth associated species contained in the Forest Service watershed analyses.
- Restore native riparian vegetation (willows, aspen, shrubs) and improve water quality through appropriate grazing standards, careful thinning and burning of encroaching conifers, and reintroduction of beaver.
- Reduce road densities and improve road drainage, particularly near streams.
- Complete fish passage improvements (e.g. replacing road culverts) to restore fish populations in the Unit.

D. Roads

Objective: Reduce road density and improve remaining roads to minimize impacts on water quality and flow.



High density of open roads is a critical issue for the area. (Deep Creek WA, p. SI-2).
Roads are producing the highest rates of soil loss on a per acre basis and are partially responsible for decreased base flow in perennial streams. (Upper Chewaucan, p. SI-1, SI-7).

Data contained in Forest Service watershed analyses indicate that high road densities are prevalent in much of the LFSU. In the Upper Chewaucan watershed the average road density is 2.9 miles per square mile. In the Lower Chewaucan, average road density is 2.8 miles per square mile. In Deep Creek, average road density is 2.4 miles per square mile. The Forest Service watershed analyses recommend reducing road densities to 1-2 miles per square mile. (Upper Chewaucan WA, p. R-2; Lower Chewaucan WA, p. R-1).

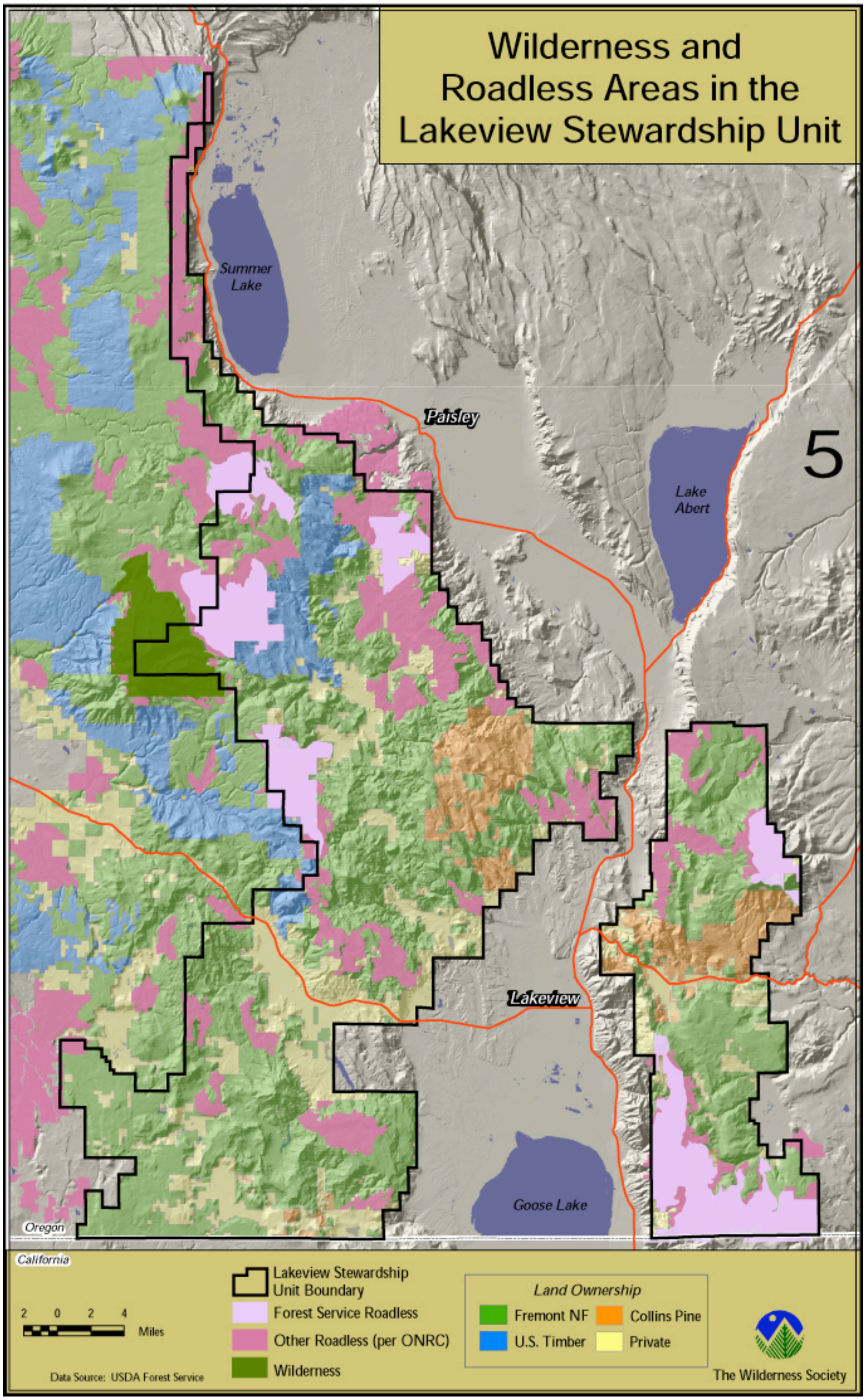
The existing road system was designed and constructed primarily to accommodate logging systems that required a significantly denser road network than is required by the systems commonly used today. Furthermore, funding for road maintenance is insufficient to sustain the existing road network. Consequently, the Forest Service rarely builds new roads and instead has begun to close and decommission many roads in order to restore hydrological function and reduce maintenance costs.

During the late 1990s, the Lakeview Ranger District completed transportation plans for the North and South Warner Mountains and Thomas Creek Watershed. The plans identified numerous roads that were no longer needed for the forest transportation system. The Forest Service subsequently decommissioned 100 miles of old roads in 2001 and another 20 miles in 2002. (LFSU 2001-2002 Annual Report). Additional road decommissioning has been planned, approved, and partly implemented in subsequent restoration projects such as West Drews where 90 miles of roads have been identified for decommissioning or closure.

Road Guidelines:

- Identify road access needs for restoration work, fire control, private land management, recreation, and other uses.
- Identify priorities for road closures and improvements, including relocation of roads away from streams. Consider opportunities for road closures to improve habitat connectivity and enlarge roadless areas. Wherever possible, replace problem culverts with broad-based dips.
- Design restoration treatments to avoid any permanent road construction. Avoid temporary road construction to the extent feasible.
- Provide adequate funding or contract stipulations to ensure that temporary access roads are promptly decommissioned as part of the project.
- Reduce overall road density initially to less than 2 miles per square mile, with a long-term goal of reducing roads to the minimum necessary to achieve Unit goals and objectives.

E. Wilderness and Roadless Areas



Wilderness

The Fremont National Forest has one designated wilderness area, Gearhart Mountain Wilderness (22,809 acres), of which about 30 percent (6,832 acres) is located within the LFSU. Gearhart Mountain Wilderness was originally designated in the Wilderness Act of 1964, and the Oregon Wilderness Act of 1984 added 4,114 acres.

In wilderness areas, allowable recreational uses include hunting, fishing, hiking, horse riding, backcountry camping, and cross-country skiing. However, motorized and mechanized recreation vehicles, including ATVs, snowmobiles, and mountain bikes are not allowed. Livestock grazing is permitted in wilderness areas, but not logging or mining.

According to the 1989 Fremont Forest Plan EIS, recreation use in Gearhart Wilderness is concentrated in a few small areas, with Blue Lake receiving 70 percent of use, mostly fishing. The EIS estimated 3,100 RVDs of wilderness use in 1981 and predicted that recreation demand would exceed carrying capacity by year 2000.

The Forest Service will consider recommending additional wilderness areas for the Fremont National Forest when it revises the Fremont-Winema National Forests plan in the coming years. The review of potential wilderness areas is required by the Oregon Wilderness Act.

Roadless Areas

The 1989 Fremont National Forest Plan EIS evaluated 10 inventoried roadless areas, totaling 83,360 acres. Of these, all or parts of 7 are within the LFSU, for a total of 64,259 acres. Three are located in the Warner Mountains east of Lakeview: Crane Mountain (23,261 acres), Mount Bidwell (4,679 acres adjacent to Crane Mountain), and Drake-McDowell (5,768 acres). Four are located west of Lakeview and Paisley: Deadhorse Rim (12,420 acres), Coleman Rim (8,393 acres), Hanan Trail (9,039 acres), and Brattain Butte (5,880 acres).

The 1989 Fremont National Forest Plan allocated the roadless areas to a variety of management areas, such as semi-primitive motorized recreation, semi-primitive non-motorized recreation, timber/forage production, etc. The 2001 Roadless Area Conservation Rule generally prohibited road building and commercial logging within inventoried roadless areas, with various exceptions such as logging to reduce fire risk. In May 2005, the Roadless Rule was replaced with a state petition process that allows governors for 18 months to request roadless area protection or management changes within their respective states. If no petition is filed, roadless area management direction reverts to the local forest plan.

Additional areas larger than 1,000 acres have been identified by Oregon Natural Resources Council. These unroaded areas are shown on the Wilderness and Roadless Areas map along with the Forest Service inventoried roadless areas.

Within the Upper Chewaucan watersheds are two inventoried roadless areas, Deadhorse and Coleman, and a portion of the Gearhart Mountain Wilderness. These vast primitive and semi-primitive areas provide a unique recreation experience for the forest user and offer an undisturbed habitat for the growing deer and elk herds. (Upper Chewaucan WA, p. C-12-13)

Of the 64,219 acres of inventoried roadless areas, 4,294 acres (7%) are low-elevation ponderosa pine stands, while another 5,984 acres (9%) are high-elevation ponderosa pine on southwest-facing slopes. Most of the low-elevation pine is located in portions of the Coleman and Brattain Butte inventoried roadless areas. As discussed in the Fuels and Fire section, 25% of the total Unit is low-elevation ponderosa pine and another 10% is high-elevation ponderosa pine on southwest-facing slopes. Thus, a relatively small amount of the inventoried roadless areas appears to be in priority areas for treatment to reduce fuels and fire risk. Of course, what types of treatment, if any, are needed and appropriate will depend on site-specific inspection and analysis of actual stand conditions and other factors.

Organizational Views of LSG Members

In seeking to find common ground on the often-contentious wilderness and roadless area issues, it is important to understand the positions that organizations represented in the Lakeview Stewardship Group have taken in the past.

For example, The Collins Companies' Position Statement on Federal Land Management (January 2001) includes the following statement – "We believe that the U.S. National Forests should be looked upon as providing both wilderness preserves and sustainable resources for the benefit of all. To this extent, we offer the following recommendations: 1. Maintain as wilderness areas, those areas that have been so designated through 1996. 2. Maintain as roadless areas, those areas of at least 5,000 acres that were roadless in 1996." The full Collins position statement on federal land management is at
http://www.collinswood.com/M4_MediaEvents/Resources/PositionStatement.htm

On the other hand, The Wilderness Society's National Forest Vision Statement (February 1999) contains the following recommendations –

- "Designate substantial additional wilderness to conserve biological diversity, ensure representation of all ecosystem types, meet recreation needs, and protect other wildland values."
- "Identify and protect from disruption all roadless areas larger than 1000 acres and other landscapes with high ecological integrity."

Wilderness and Roadless Area Guidelines:

- Identify and evaluate potential wilderness areas based on compatibility with existing motorized and non-motorized recreation uses, fuels reduction/fire restoration needs, wildlife habitat values, etc.
- Avoid road construction and commercial logging in roadless areas >5,000 acres. The roadless values and characteristics of areas between 1,000 and 5,000 acres should be evaluated on a case-by-case basis and protected where appropriate.

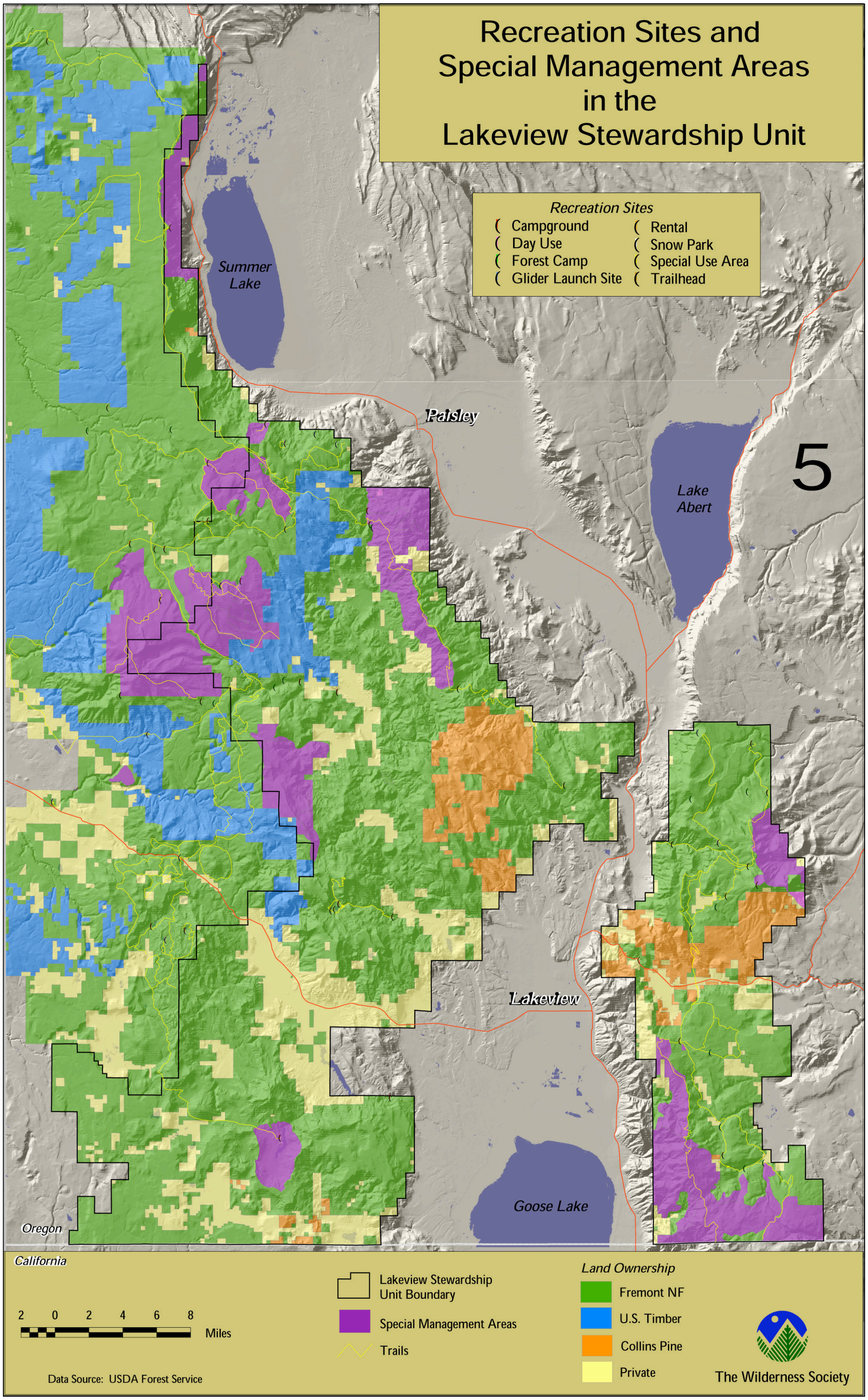
F. Recreation

Goal: Provide opportunities for people to realize their material, spiritual, and recreational values and relationships with the forest.

Objectives:

- *Protect and maintain areas of cultural significance within the forest.*
- *Improve opportunities for people to fish, hunt, and view nature.*
- *Promote environmentally responsible recreation.*

The Lakeview Federal Stewardship Unit has many recreational opportunities and growing numbers of visitors. Outstanding features that attract recreational visitors to the area are the lakes and streams, the roadless semi-primitive areas, the trail systems, and big game hunting opportunities. (Upper Chewaucan WA, p. S&I-38). Recreational activities include hunting, fishing, hiking, horse riding, motorized recreation, backcountry camping, and cross-country skiing. In some areas, use of dispersed and developed recreation sites is increasing at a rate of 10-20% per year, and this trend is expected to continue for the foreseeable future. (Lower Chewaucan WA, p. CC-41).


Recreation Sites and
Special Management Areas
in the
Lakeview Stewardship Unit
Recreation Sites
Campground
Day Use
Forest Camp
Glider Launch Site
Rental
Snow Park
Special Use Area
Trailhead
Summer Lake
Paisley
Lake Abert
5
Lakeview
Goose Lake
Oregon
California
2 0 2 4 6 8
Miles
Lakeview Stewardship Unit Boundary
Special Management Areas
Trails
Land Ownership
Fremont NF
U.S. Timber
Collins Pine
Private
The Wilderness Society
Data Source: USDA Forest Service

Presently, the Unit contains the following recreation sites and facilities:

- 12 trailheads accessing a total of 381 miles of trails (of this total, only 8 miles are motorized trails for ATV use).
- 3 rental cabins.
- 2 hang glider launch areas (Tague's Butte and Hadley Butte).
- Warner Canyon Ski Area (privately-owned)
- Hike-in rustic camping at Slide Lake and the semi-primitive recreational areas in Drake-McDowell Basin and the Crane-Bidwell area.
- 4 day-use/picnicking areas at Clear Springs, Withers Lake, Can Springs and Overton Reservoir.
- 6 forest camps located at Upper Jones, Twin Springs, Mud Creek, Dismal Creek, Deep Creek and Deadhorse Creek with a total of 28 campsites.
- 15 fully developed campgrounds with 105 camp sites along with outhouses, water, picnic areas, fireplaces and fishing at Willow Creek, Marster Springs, Happy Camp, Dog Lake, Drews Creek, Deadhorse Lake, Dairy Point, Cottonwood, Campbell Lake and Chewaucan Crossing.
- 118.5 miles of groomed snowmobile trails, 30 miles of nordic trails and 142.7 miles of summer hiking trails.
- 2 snow parks with toilet facilities, one at Moss Meadow and the other at Camas Prairie.
- A variety of low-impact activities, including bird-watching, wildlife viewing, rock-hounding, archaeological sites, petroglyphs, pictographs and dendroglyphs.

The LFSU has 93,331 acres of Special Management Areas, including the North Brattain, South Brattain, Fort Bidwell, and Crane Mountain Semi-primitive Motorized Recreation Areas; Drake-McDowell Semi-primitive Non-motorized Recreation Area; Dog Lake Special Management Area; Gearhart Mountain Wilderness; and Coleman Rim, Deadhorse Rim, and Hanan Trail Roadless Areas. Covering nearly 20 percent of the Unit, these Special Management Areas contain many of the trails and other recreational attractions.

In 2004, the Forest Service reconstructed and maintained the 24-mile trail system in the Deadhorse Rim Roadless Area, including the Cache Cabin Trail, Dead Horse Rim Trail, Dead Cow Trail, and Lakes Loop Trail. This trail system is an integral part of the highest use recreation area on the Fremont National Forest, providing loop trails between two high elevation lakes and their very popular campgrounds. The trails also provide public access to scenic vistas of the lakes and surrounding country and to some of the largest stands of white-bark pine and old-growth ponderosa pine in Oregon.

Also in 2004, volunteers from several equestrian groups built a horse camp at Moss Meadows near the Fremont Trail. The project was partly funded by a grant from the Oregon State Parks and Recreation Department.

<u>Key Recreation Issues</u>

With recent budget constraints, the LSG is concerned that maintenance of these recreation sites and facilities could be jeopardized. In the past, the Regional Office had given direction to implement a fee demo program, but this has not been accomplished. A fee program could ease the potential impact of possible budget cuts on maintenance of recreation sites.

Current conditions, trends, and development needs should be identified to assist the LSG in making recommendations for the upcoming forest plan revision.

Consideration must be given to the growing use of ORVs and the resulting impact on lands within the Unit. In 2005, the USFS Washington office adopted new policies for ORV use in the national forests. The Fremont-Winema National Forest has traditionally been open to ORV use except in places that are specifically closed to such use, such as the Gearhart Mountain Wilderness. Under the new policies, ORV use may be allowed only on designated routes. Since the Unit currently has just 8 miles of motorized ATV trails, a much more extensive system of designated ATV/ORV trails could be established.

In April 2010, the Fremont-Winema released for public comment an environmental assessment of several alternatives that would prohibit cross-country travel by ORVs and establish a system of designated routes for ORV use. The Forest Service preferred alternative would convert 177 miles of currently closed roads to motorized trails forest-wide, while closing 136 miles of roads that are currently open to motorized use.

Recreation Guidelines:

- Identify funding needs to maintain and improve recreational sites.
- Evaluate ORV recreation opportunities and establish a system of designated routes.

G. Community Benefits

Goal: Provide opportunities for people to realize their material, spiritual, and recreational values and relationships with the forest.

Objectives:

- *Provide opportunities for local people to realize economic benefits from innovative contractual mechanisms and technologies focused on linking stewardship activities and community well-being.*
- *Pursue compensation of local workers at a state-average family wage or higher to accomplish ecosystem management.*
- *Design contracts to promote opportunities for year-round, long-duration, stable employment.*
- *Design unit product sales and service contracts to promote participation (e.g. bidding and contract awards) by local vendors, purchasers, and contractors.*
- *Promote a local business environment that can take advantage of the products and services of ecosystem management (e.g. small diameter and under-utilized species).*

Timber

The wood products industry has been a mainstay of the local economy since World War II. The Lakeview Federal Sustained Yield Unit was established in 1950 to maintain community stability by providing wood products firms in Lakeview and Paisley the exclusive right to bid on timber sales within 500,000 acres of the Fremont National Forest. During the 1980s, local mills bought and processed about 60 million board feet of federal timber per year. However, declining federal timber sales and other economic factors during the 1990s resulted in mill closures.

Currently, the Collins Companies Sawmill is the only sawmill operating in the area. The Collins Sawmill has 80 hourly employees, and about 100 total employees, and operates two shifts daily, markets permitting. The company has spent about $10.3 million in new capital equipment over the last nine years. Part of this investment, $6.8 million, was for a small diameter sawmill in 2007. This investment was possible because the Collins Companies obtained a 10-year Stewardship contract for timber sales and associated work within the Unit. The Collins mill processes about 60 million board feet of lumber annually, with about 70 percent being ponderosa pine and 24 percent white fir. About 15 to 20 percent is harvested from Fremont-Collins lands, with the rest from public and private sources. The Collins Companies owns and sustainably manages 47,500 acres of private timberland adjacent to the Fremont National Forest in Lake County. Collins is widely regarded as a timber industry leader in environmental stewardship. The Collins Company forests are one of the largest blocks of forest land in Oregon certified by the Forest Stewardship Council.

During the past decade, the Forest Service has sold a total of 87 million board feet (mmbf) of timber in the Lakeview Federal Stewardship Unit. The annual totals have ranged from a high of 21.7 mmbf in 2007 to nearly zero in 2001. During the first half of the decade, the timber sale program focused on post-fire salvage logging. Major salvage sales included Cub in 2003, Winter in 2004, and Grassy in 2005. Subsequently, the timber sales program shifted to “green” thinning projects, starting with Bull Stewardship and two Jakabe project sales in 2006. More recently, major stewardship thinning projects have included Burnt Willow and Trail in 2007, Abe in 2008, and Launch and Dent North in 2009.

LAKEVIEW FEDERAL STEWARDSHIP UNIT TIMBER SALES, 2000-2009

Year offered /awarded	Green (mbf)	Salvage (mbf)	Harvest Acres	Value in $/ccf
2000	**0**	**5,349**	**2,600**	**$23.05**
2001	**0**	**36**	**737**	**$13.50**
2002	**0**	**5,053**	**556**	**$64.54**
2003	**0**	**11,348**	**1,579**	**$58.79**
2004	**1**	**10,539**	**1,360**	**$6.09**
2005	**462**	**4,229**	**736**	**$36.20**
2006	**8,791**	**95**	**2,750**	**$53.43**
2007	**21,623**	**0**	**5,644**	**$17.22**
2008	**9,900**	**1,358**	**4,013**	**$26.28**
2009	**8,334**	**1**	**2,164**	**$2.21**
Grand Total	**49,111**	**38,008**	**22,139**	**$29.18**

Timber Guidelines:

- Design thinning projects to ensure they are marketable to local mills.
- Estimate potential long-term supply of small and medium-sized trees as restoration by-products.
- Evaluate additional agency resources and funding to prepare sufficient timber sales or stewardship contracts to accomplish needed restoration.
- Annually monitor and report statistics on the timber supply on the stewardship unit, including sold vs. planned, no bids, and green vs. salvage sales.

Biomass and Other Small Wood Utilization

The 2002 University of Washington study on the Fremont National Forest showed that to restore the Fremont National Forest to natural stand conditions and fire regimes would require an extensive thinning and under-burning program resulting in tremendous volumes of small diameter material. The only proven technology that could consume this large volume would be a biomass plant. Following this study the Governor made the Lakeview Biomass Project an Oregon Solutions project with Hal Salwasser, Dean of Forestry at Oregon State University, convener of the process. At the end of one year industry, agencies (local, State and federal), environmental groups and non-profits signed on to a declaration of cooperation to assist in moving the Lakeview Biomass project to completion. In 2009 the Governor again endorsed the project by making it an Oregon Way Project to compete for stimulus dollars.

However, biomass energy is less competitive in the market than the traditional fossil or hydro energy sources. The technologies for biomass fuels are relatively new and mostly in the prototype stage with little economic incentive for industrial production. A 2004 study in Washington State looked at biomass fuels (forestry residues, dairy industry wastes, and municipal solid wastes) and biomass technologies (combustion, gasification and anaerobic digestion). The report concludes, "Unless entities such as the USDA Forest Service were to make a long-term commitment (for example, for the life of a power plant) to supply a significant volume of forestry residues at a fraction of the cost of collection and transportation, a Yakima County biomass-to-energy project would be a significant gamble." With this in consideration, a 20-year MOU for supply was developed between the Forest Service, BLM, Lake County, DG Energy, The Collins Companies, Town of Lakeview, City of Paisley and Lake County Resources Initiative.

Following the 20-year MOU, the Forest Service developed a 10-year stewardship contract within the Unit and the Collins Companies successfully bid on that contract. The 10-year contract and 20-year MOU gave more of an assurance than had been seen in the past that there would be supply for the sawmill and biomass plant so these companies could justify their investments. Similarly, the BLM is currently issuing a new stewardship contract for the Lakeview District which will allow for multiple task orders to be issued over the next 10 years.

Knowing the poor economics for biomass, Lake County Resources Initiative contracted with CH2MHill to develop a business plan, complete preliminary engineering, and investigate the influence of carbon credits, energy credits, and Forest Service Stewardship contracts on the economics of a biomass plant. A fundamental point of agreement within the Lakeview Stewardship Group and the Lake County Resources Initiative is that a biomass plant must be a tool to meet the goals of the Unit and not an industrial facility that creates an unsustainable demand for resources. The State of Oregon Business Energy Tax Credit (BETC) and federal energy credits are key factors in making a biomass plant an economically viable enterprise.

Scientists differ on whether thinning to reduce uncharacteristically large fires is actually a carbon savings. The 2002 study by the University of Washington on the Fremont National Forest reported on the benefits of restoring natural stands on CO_2 storage in the forest, forest products, the displacement value of using biomass over natural gas, and product substitution. However, more recent research indicates that net carbon benefits from fuel reduction treatments are unlikely and will be small at best, since many treated acres will not subsequently burn while the treatment is still effective (Mitchell et al. 2009). Other research suggests that carbon benefits are most likely to be realized when treated stands are fire-prone and contain large fire-resistant trees, which is fully consistent with other objectives of this strategy (North et al. 2009). Lake County Resources Initiative is under contract with Winrock International under a program by the West Coast Regional Carbon Sequestration Partnership to help determine if there is a carbon savings from forest thinning to restore more natural fire events. Spring of 2010 will be the fourth year of collecting data.

One area that may be especially appropriate for the carbon market is tree planting following uncharacteristically large fires. The monitoring in the Unit has shown that there is virtually no regeneration in some areas following these large fires because of the impact on the soils. Since monitoring plots only go back 10 years, the duration of this condition is unknown, but tree planting would provide at least 10 years of carbon reforestation credits. This does not mean that the Lakeview Stewardship Group supports salvage logging; the group's priority is to have a steady green program.

Biomass Guidelines:

- Implement the 10-year Stewardship contract for a minimum of 3,000 acres of thinning per year within the Lakeview Federal Stewardship Unit and an additional 3,000 acres per year outside the Unit.
- Develop a 10-year Stewardship contract with BLM for 2,000 acres per year of Juniper treatment.
- The contracts should go to a biomass company investing in a plant located in association with the Collins Companies sawmill.
- If Congress passes a cap and trade bill on carbon emissions and recognizes forest management and preventing uncharacteristic large fires as methods of carbon emission mitigation, develop a second 10-year contract that would record, verify, monitor and sell carbon credits to reduce uncharacteristically severe fire events through meeting the Unit goals.
- Ensure that the size of the biomass plant is sustainable for the life of the plant and used as a tool to achieve this strategy's goals.

Non-Timber Forest Products

The LFSU provides many non-timber forest products to the community on a permit basis for non-commercial purposes. While the fees collected for these permits are not a significant source of revenue for the Forest Service, the benefit to the community is significant. From 2004 through 2009, public use permits were issued on the Paisley and Lakeview Ranger Districts for the following:

Public Use Permits Issued at Lakeview & Paisley Ranger Districts from 2004 through 2009		
	# of Permits	**Value**
Free Use Firewood	1,174	$19,554
Personal Use Firewood	2,210	$49,860
Commercial Boughs	14	$460
Commercial Christmas Trees	4	$765
Commercial Firewood	55	$5,170
Personal Use Christmas Trees	88	$8,265
Commercial Mushrooms	6	$200
Free Use Cones	2	$7
Free Use Limbs & Boughs	6	$101
Free Use Mushrooms	119	$1,744

Personal Use Post & Poles	131	$2,966
Vendor Christmas Trees	12	$1,530
Free Use Transplants	35	$441
Free Use Mountain Mahogany	2	$10
Plant Collection--Washington Herbarium	1	$20
Totals	**3,859**	**$91,094**

Key Issues

Issuing permits for non-timber forest products is generally compatible with Unit goals. For example, permits for harvesting pushed-down juniper complements juniper removal projects and provides a healthy benefit to the community. Issuing firewood permits helps remove unmarketable wood products from the forest. Harvesting of all these products helps meet the goal of "providing opportunities for people to realize their material, spiritual and recreational values and relationships with the forest."

Guidelines:

- Continue to issue permits for non-commercial personal use of non-timber forest products where compatible with ecological objectives.
- Promote environmentally responsible removal of non-timber forest products.

Grazing

Most livestock grazing on Lakeview Federal Stewardship Unit lands has occurred in the areas currently grazed, in a variety of forms, for over a hundred years. Typically during that time numerous grazing systems have been implemented along with accompanying range improvements. Stocking rates and seasons of use have been adjusted, and the timing, intensity, frequency, and duration of grazing have been continually fine tuned over time. More recently, further adjustments have been made on many allotments to provide for the needs of species listed under the Endangered Species Act.

Livestock production is an important industry in Lake County. The emphasis in livestock production has been based on the cow-calf operations. Unit lands are important because they provide high quality forage during the period that home pastures are growing or being harvested for hay. Many local ranch operations are dependent for some part of their yearly operation on lands within the Unit.

Currently, all or a significant part of 38 allotments are located in the Unit. About 33,900 AUM's (Animal Unit Months = a cow and calf for one month) are permitted every year within the Unit. This equates to about 5,600 head of adult livestock every year, assuming an average 6-month season of use. About 34 business or family ranching operations have grazing permits within the Unit.

Riparian areas are an important attribute of the Unit, providing important habitat for a host of fish and wildlife species as well as forage and water for cattle. Many of these riparian areas are vulnerable to damage from grazing. Accordingly, livestock use of these areas must be carefully managed.

Grazing allotments have been classified according to the level of intensity at which they are managed. These levels include intensive, deferred, and season-long grazing. Twenty-nine of the allotments in the Unit are managed intensively. Under such management, livestock are regularly rotated among pastures in coordination with different stages of plant growth. Four allotments are operating under deferred grazing systems. Under this type of system, livestock are not moved onto an allotment until plant growth has reached the stage of maximum nutrient reserve in the root system. Livestock are generally free to choose their own foraging areas unless constrained by topography and/or boundary fences. Season-long grazing is in effect on five allotments. Typically, livestock enter these allotments on a specific date in spring or summer and forage at random until removed at a specific date in fall, or when monitoring shows use standards have been met.

On thirteen of the allotments in the Unit, grazing of private land is done in conjunction with the owners' federal land permit. This "Private Land Permit" arrangement allows the private land owner flexibility in management and movement of livestock. Private land can be incorporated into grazing systems to provide proper management of plant growth.

Successful grazing management requires that standards and guidelines for allowable ("proper") use be established – i.e., a set of measurable benchmarks that, when reached, trigger moving livestock. Proper use is defined as a degree of utilization of current year's growth that if continued, will achieve management objectives and maintain or improve long-term productivity of the site (Society of Range Management 1979). For federal lands within the Unit, standards and guidelines have been established in the forest plan and modified in Biological Opinions as required by the Endangered Species Act. Of the thirty-eight allotments in the Unit, eighteen are under consultation Biological Opinions for Warner, Shortnose, and Lost River Suckers. Standards and guidelines vary from allotment to allotment, and pasture to pasture depending on the condition, trend, and goals for the various resources in the allotment/pasture. For example, a pasture with a riparian area that is functioning at risk with a downward trend would not be allowed as much use as a riparian area functioning at risk with an upward trend.

The frequency and intensity of monitoring varies depending on the condition of the resources to be monitored and the goals to be achieved for identified resources. More monitoring is done in pastures with less than desirable resource conditions and/or the presence of very sensitive resource conditions or issues such as Threatened and Endangered (T&E) species. Monitoring guidelines can be found in the Fremont Forest Plan, the Meadow Riparian Monitoring Guide produced by the Fremont National Forest in 1997, and the Biological Opinions for Warner, Shortnose, and Lost River suckers (May 1997) on file with the Fremont National Forest.

The goal of modern livestock grazing is to maintain or improve rangeland health. Rangeland health is the degree to which the integrity of the soil, vegetation, water and air, as well as the ecological processes of the rangeland ecosystem, is balanced and sustained. Integrity is defined as the maintenance of the functional attributes characteristic of a locale, including normal variability. In the case of livestock grazing lands within the Unit, health has mostly been defined as the condition of riparian areas as measured against desired future condition. Riparian areas have been described as the weak link in our arid ecosystem.

<u>Guidelines</u>

- Continue the use of modern grazing systems and grazing techniques within the Unit. As opportunity arises, convert or incorporate season-long grazing allotments to deferred/rotational grazing systems.
- Practice adaptive management. Make adjustments to grazing based on monitoring results.
- Further define rangeland health and the desired future condition for riparian areas in the Unit.

H. Forest Restoration Implementation and Economics

Introduction

It is the specific intent of the Lakeview Stewardship Group to chart new ground, develop holistic solutions, and establish a standard of excellence in the implementation of forest restoration work. Considering the Restoration Planning Overview and the other Key Issues of this strategy, an integrated approach to forest restoration is warranted. Restoration objectives, prescriptions, and equipment should be designed to integrate multi-resource objectives for forest vegetation, soils and water, road density, wilderness and roadless areas, recreation opportunities, and other forest values. Economic and contracting strategies and mechanisms should be designed to facilitate ecosystem restoration and capture the greatest benefit for the local economy.

Implementation Principles & Guidelines

- It is implicitly understood that management actions will likely have both short- and long-term effects on a compendium of forest resources and attributes. The decision to take action acknowledges that impacts will occur and tolerance of such impacts, expected and unexpected, positive and negative, will be necessary to make progress. Monitoring and adaptive management tools will be consistently used to assess the effects of management implementation and to make informed changes.
- Forest restoration prescriptions will be designed to achieve desired conditions, at the forest stand level, suitable for the habitat type present.
- Restoration prescriptions will accommodate existing forest plan and regional direction, unless such direction is modified as a result of acquiring new, scientific information and codified through the normal public and environmental review process.
- Restoration prescriptions will define soil and water protection standards in a performance-based manner at the forest stand level. Real-time Monitoring and Adaptive Management will be used to validate compliance and improve protection performance.
- Meeting the habitat needs of forest wildlife during management implementation will be defined in a performance-based manner. Monitoring will reveal effects and Adaptive Management will improve performance.
- Management implementation strategies and desired or suggested equipment configurations to be used will be designated based on integrated criteria of desired protection levels and economic opportunity, to effectively manage overall management costs and impacts.
- Management implementation strategies and equipment used will be integrated to allow for efficient and economical implementation of subsequent management actions to be performed.
- Trees harvested during forest restoration operations will be fully utilized consistent with Unit goals and objectives. This will include small diameter trees, downed wood and other previously underutilized material, all the while satisfying necessary fire risk reduction, soil structure protection, soil nutrient cycling capability and large woody debris for soil and habitat objectives.
- Local processing of derived raw materials and the use of local employment for forest management services will be strongly encouraged to foster the development of new, local, economic opportunities for wood products manufacturing and other businesses associated with forest restoration.

Logging Systems & Machinery

The availability and skillful use of appropriate logging equipment will be critical to achieving the restoration goals of the Lakeview Stewardship Unit. There is a huge disparity in actual soil impacts with different ground-based timber harvesting and wood extraction systems and equipment. Consideration of *how* the particular equipment systems are to be used and the level of operator skill, care, and attention to detail are critical factors in limiting adverse impacts. Different operators on the same machine can have disparate levels of impacts. This issue can be addressed with training and education workshops for forest restoration operators.

An example to illustrate the trade offs and attributes of different systems could be the consideration of building a temporary access road to reduce skidder travel distances to 1500', or the consideration of a forwarder extraction system, which would not need the additional temporary road and shorter travel distance to be cost effective. In this case, the expense of the temporary road and its subsequent negative impacts on soil productivity, water infiltration, etc., coupled with the expense of the skidder system, would be weighed against the additional expense of the forwarder system and no need for the expense or impacts of the temporary road.

Another example could be the desired underburning of the treated forest stand after designated trees have been removed. The use of a tree length harvesting system in this situation would necessitate that landing logging slash be returned to the forest, so that sufficient surface fuels were present to carry the underburn and to facilitate the return of nutrients from the cut trees' limbs and needles. In this scenario, it would make sense to use a different harvest method and equipment systems to reduce soil impacts (traveling back over the same ground again with the skidder), leave the needles and branches in the forest in the first place and to improve the economics of the overall operation.

With many of the anticipated forest restoration treatment areas in the Stewardship Unit, machinery and logging systems will need to be selected relative to the anticipated soil protection, road density, snag retention, tree removal, follow-up underburning, and nutrient retention guidelines. New, affordable machinery systems, different from those currently available with existing contractors in the Unit's geographic area, may be best suited to meet these objectives. Training, education, and re-tooling of the current contractor workforce may also be needed, as well as availability of financial assistance enabling local contractors to procure the new equipment systems and integrate these new systems into their businesses.

Actual choices of suitable timber harvesting and extraction systems should be made on a site-specific basis and should include specific consideration of the forest type, soil type, desired implementation prescriptions, desired snag density, follow-up prescribed fire, season of operation, existing road density and many other site and area specific parameters. Off-site impacts also need to be considered. For example: helicopter extraction does not require a high density road network, but because helicopters have to work at a very high extraction rate to be economical, the resulting volume of log truck traffic and the wear and tear, and erosion, on the road system may lead to other, negative environmental impacts.

Many innovative developments are occurring with respect to relatively new machinery systems and the pairing of various machinery platforms. For example: the pairing of excaliners (excavators fitted with winch drums) and high capacity forwarders can negate the need for additional road networks, as would be required with conventional cable extraction systems.

With respect to salvage harvesting and extraction after wildfire events, the season of operation becomes the most critical aspect for consideration. Harvesting systems that can operate during frozen winter conditions (where they exist) and which do not require any new roads or road upgrades will likely have the least negative impacts on soil resources and potential additional erosion and subsequent sediment delivery to streams. This is a particular conundrum at the moment as analysis timeframes often negate the possibility of authorizing salvage harvesting the first winter season after a wildfire, when the additional negative impacts caused by the salvage harvesting will be at their most benign and the remaining economic value of the burned timber remains relatively high.

Helicopter extraction operations have few negative effects on soil and water resources and are a valuable salvage tool. However, they are limited in application, particularly as burned timber rapidly loses its economic value when springtime conditions arrive. Helicopter operations are also very hazardous in burned areas, requiring the removal of nearly all the burned trees, including the desirable snags, which provide a critical resource for many wildlife species.

Logging Systems Guidelines:

- Utilize an integrated approach to match logging systems to topography, road access, soil attributes, treatment prescriptions, and seasons of operation.
- Provide the financial and technical assistance necessary for local contractors to procure and operate new logging equipment appropriate for restoration implementation.
- Provide training and education workshops for forest restoration equipment operators to minimize negative impacts on soils and other resources.

Monitoring

V. MONITORING

Biophysical Monitoring Component

The purpose of inventorying and monitoring is to periodically collect direct information about the composition, structure and functional condition from hundreds of permanent plots located across the Unit. Direct information reduces assumptions and second-hand information about an area of the Unit and how it is performing. Such information supports adaptive and effective management. The Upper Chewaucan River drainage was chosen by the Lakeview Stewardship Group as the location to begin the biophysical monitoring, since it reflects many characteristics found across the Unit. Since May, 2002, the Fremont-Winema Resource Advisory Committee (RAC) has authorized Forest Service Title II funding to pursue the following objectives:

1) Inventory the critical ecosystem indicators across the 275 square mile watershed by establishing a large sample population of tenth-acre permanent plots.
2) Establish permanent plots throughout restoration project areas to monitor the effectiveness of the treatments over time.
3) Analyze the acquired data to determine the present condition of the Chewaucan and its trend toward health, given sufficient time to determine such trending.
4) Make a geographic information system (GIS) database, a narrative and methods employed to gather that data available to the Forest Service, the community and the general public through a website.
5) Perform surveys of specific ecosystem information needs requested by the Forest Service and report them to the Forest Service and the community.

An 8- to 12-member monitoring team is recruited annually from high school students and recent graduates in the Lakeview and Paisley communities. Generally two new high school students are added yearly as apprentices. On average 60 percent of the crew is in college or post college and 40 percent are in high school. Their training has been provided by Clair Thomas, past Lakeview High School science teacher and presently Natural Resource Coordinator for Tillamook School District #9. Richard Hart, forest ecologist and soil scientist, designed the original protocols and directed the monitoring effort through 2005. Clair Thomas began directing the monitoring effort in 2006. The administration of the project is provided by the Lake County Resources Initiative (LCRI), with Jim Walls as its executive director.

A selection of 35 indicators[*] was chosen to measure and record on more than 300 tenth-acre permanent plots spread across the Upper Chewaucan. More than 800 1/50-acre plots have been established and put into Landscape Management Systems (LMS) to model forest structure and behavior. Plots were established to seek answers to the questions about the effectiveness of restoration projects and the general health of the watershed. These questions are currently being answered. Many of the insights gained from these surveys have been included in this update of the Long-Range Strategy for the Lakeview Unit. The Forest Service, the community, and environmental organizations who have participated in the Unit's resurgence and reauthorization provided these questions.

The eight years of collected data is stored on a dedicated server in the form of a relational GIS database and narratives. The address is www.lcri.org/monitoring. With enough time and essential data, trends toward Unit health and treatment effectiveness can be identified, and adaptive measures can be implemented.

The data from the 35 indicators will soon be analyzed to determine which core biophysical indicators give us the best information and choose those to proceed with. This proposed reduction will allow the present team to establish permanent plots across the entire Unit. What has been learned from the 35 indicators will be extrapolated where appropriate to give an enhanced understanding of the data collected and analyzed from the rest of the Unit.

Biophysical Monitoring Guidelines

- Continue and build on the successes of the Chewaucan Biophysical Monitoring Project.
- The collaborative monitoring program should be spread across the whole Unit.
- Integrate Forest Service staffing and finances for monitoring to the extent feasible.
- Basic information about how the Unit functions has been skimpy, with historical data that is not easily retrievable. Thus, the Unit needs a databank that is accessible to anyone who has need of it.
- Continue the formal partnership created by the community and the Forest Service, through the RAC and the LCRI, that supports the monitoring program financially and by appropriate policy.
- Indicator information needs to be collected in a systematic and continuous basis across the whole Unit with regards to the restoration activities.
- The indicator data collection needs to be continued by a trained and paid crew whose membership is bonded to the landscape and the community.
- The biophysical monitoring program needs an advisory committee composed of community, agency and team members.

Socio Economic Status of Lake County

[*] The monitored indicators cover the following: type and percentage of effective ground cover; vegetation species ID and populations; soil texture and chemistry; rhizosphere zone level, soil temperature and available moisture; soil compaction; stand structure (tree species, rates of growth, girth, stem health, canopy structure, down woody material, pathogenic activity); stream channel morphology; water chemistry; benthic macroinvertebrate feeding group inventory; and pebble counts performed. Each permanent plot is GPS identified, their coordinates measured to the nearest landmark, permanent tags installed and the plot's surface and surroundings are photo-documented.

The economy of Lake County is fairly typical of natural resource dependent counties in the Pacific Northwest. However, the county's geographic isolation poses special challenges. Although other counties with similar economic profiles have managed to diversify their economic bases, Lake County has continued to lag behind.

In a recent report by the Sonoran Institute entitled "Profile of the Rural Inland Northwest" Lake County was rated number 35 in a list of the most stressed rural counties in the Inland Northwest. This ranking comes from a composite of ratings comparing the 104 rural inland northwest counties on their placement in such indicators as unemployment rates, housing affordability, families living in poverty, educational attainment and employment change.

In order to get a better picture of Lake County's socio economic status consider the following economic statistics gleamed from the Profile of the Rural Inland Northwest:

- Percent Population Change 1970-2002 – 16% (25 out of 104)
- Long Term Employment Change 1970-2002 – 40% (24 out of 104)
- Short Term Employment Change 2000-2002 – 0.5% (36 out of 104)
- Annual Average Unemployment Rate 2003 – 10.4% (13 out of 104)
- Per Capita Income 2002 - $21,854 (43 out of 104)
- Families living in Poverty 2000 – 13% (12 out of 104)
- Adult Population with College Degree – 15% (47 out of 104)
- Housing Affordability Index 2000 – 195 (index of 100 is affordable) (101 out of 104)

The 2000 United States Census provides the following additional economic information:

- Employed Population Engaged in Agriculture, Forestry, Fishing and Hunting, and Mining – 20.4%
- Employed Workers in Private Industry - 54.8%
- Employed Government Workers – 28.1%
- Self Employed Workers – 15.6%

The 2000 United States Census reveals the following social information about Lake County:

- 2003 Estimated Population – 7440
- 1990-2000 Population Change – 3.3% (Oregon 20.4%)
- Persons with Disability Age 5+ - 1,519 or 21% of total population
- Civilian Veterans - 19.8%
- People Living in Same House as in 1995 – 55.1%
- People Who Lived In a Different County in 1995 – 25.2%
- People Living in a Home With English as the Only Language – 95.2%
- People Who Were Born Outside the United States – 3.4%
- School Enrollment (K-12) 1,497
- School Enrollment (College or Graduate School) 101

Although many factors contribute to Lake County's distressed socio-economic status none has a greater impact than the County's geographic location. Consider the relative isolation of Lake County. Lack of transportation alternatives are often cited as reasons that new businesses hesitate to locate in Lake County. The closest commercial airport to Lakeview is Klamath Falls, 90 miles away. The closest freeway access is at Medford, 170 miles away. In order for trucks over 60 feet in length to travel legally east to west on Highway 140, costly renovations will be required. Freight can travel to Alturas, California on Lake County's railroad, but capacity is limited and connections are not timely. Many rural counties that are experiencing economic vitality have a healthy tourism sector. Lake County, however, has not yet proved to be a tourism draw.

Construction of a minimum-security prison near Lakeview has provided a significant economic boost for the County. Since it opened in September 2005, the Warner Creek Correctional Facility has brought approximately 140 new jobs and an annual operating budget of $25 million.

Renewable energy development is a promising long-term economic opportunity for the Lakeview area. It became clear as work began on the Lakeview Biomass Project that Lake County sits in a very unique position for other renewable energy projects including wind, solar, hydro and geothermal. In 2006 the Town of Lakeview, City of Paisley, Lake County, South Central Oregon Economic Development District, Lake County Chamber of Commerce, the Oregon Renewable Energy Center at Oregon Institute of Technology (OIT) and Lake County Resources Initiative came together to form the Lake County Renewable Energy Working Group. Realizing all the renewable energy potential, the group set as their goal to be fossil fuel-free from an energy standpoint in five years. Since that time:

- in 2007 the Town of Lakeview completed feasibility studies for a small hydro project, a geothermal heating district and geothermal electricity production;
- the Surprise Valley Electrification Corporation and a local landowner are in the final stages of a feasibility for geothermal electricity production and a geothermal heating district;
- Nevada Geothermal has leased the Grump Geyser in Plush;
- Lake County is pursuing solar and wind in conjunction with the Oregon National Guard at the outdated Backscatter Radar Site in Christmas Valley;
- Lake County Resources Initiative (LCRI) is working with Obsidian Finance Group, LLC to install the State's largest solar farm in Christmas Valley;
- in 2007 the Lake County Chamber of Commerce held meetings throughout the county on renewable energy potential and out of these meetings a great interest developed from ranchers and farmers in ground source heat pumps, solar watering pumps and small on-farm wind generation.

As a result of all this interest, LCRI hired a Renewable Energy Director (RED) position to lead this effort, working with local units of government, industry and landowners in developing these renewable energy potentials and to achieve the vision of being "*Oregon's Most Renewable Energy County*." Bob Rogers, who helped establish the Oregon Renewable Energy Center at OIT, is working under contact to Lake County Resources Initiative to assist in developing these resources on an industrial scale, as well as for smaller businesses, homes and ranches. In 2009 LCRI developed a renewable energy implementation plan that would make Lake County a net exporter of renewable energy. In 2010 LCRI and others are already discussing a revision of that plan to double the original goals. LCRI is also completing a carbon footprint analysis of Lake County to determine whether it is possible for renewable energy to offset Lake County's entire carbon footprint.

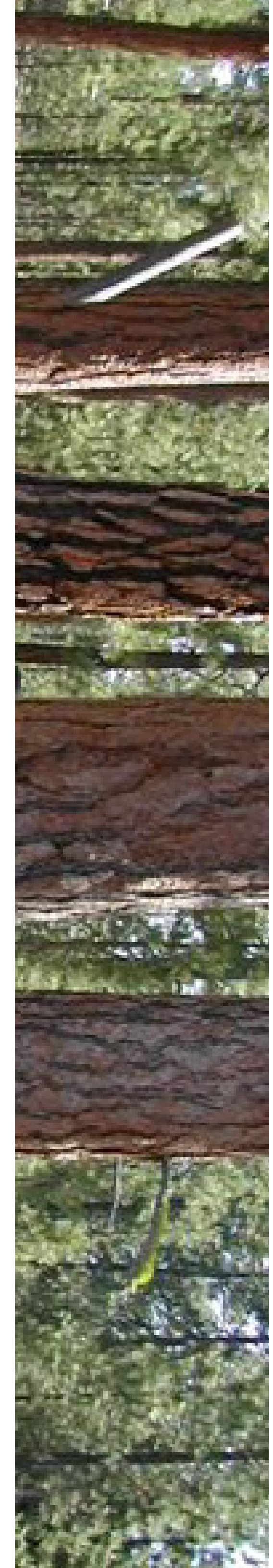
All in all, however, Lake County's socio-economic status is not likely to change rapidly. Natural resources in the form of timber and agriculture will most likely remain the economic mainstays of the County. With over 78% of Lake County's land base in government ownership, changes in federal land policies will continue to have a great impact on Lake County's socio-economic status.

Key Issues

- Decline in natural resource based jobs over the past generation has had a significant impact on the socio economic stability of Lake County's communities
- Inability to replace or improve natural resource based jobs has caused a significant decrease in the available workforce

Socio-economic Monitoring Guidelines

- Continue to work towards restoring natural resource based industry such as biomass plant, ten-year stewardship contracts, geothermal industries such as greenhouse and other agricultural based businesses.
- Utilize Oregon Economic and Community Development Department's annual review of County Economic Data
- Review and analyze upcoming Oregon State University Extension study of Lake County.
- Review and analyze 2010 census data when available.



Ten-Year Schedule Of Activities

VI. TEN-YEAR SCHEDULE OF ACTIVITIES

Vegetation and Fuels

The Forest Service considers the use of mechanical thinning and prescribed fire as its primary forest restoration tools, capable of accomplishing a broad range of resource goals beyond fuel reduction. Restoring fire to the landscape is needed to improve wildlife habitat and water flows, reduce insect and disease damage, protect large old growth trees, restore and reinvigorate forage plants and riparian vegetation, etc.

The Forest Service has been working toward fully integrating vegetation and fuels management into project planning, focusing on areas in greatest need of restoration and on using landscape scale treatments to make forests resilient to fire and other natural disturbances. The Forest Service has a 10-Year Vegetation Management Planning Schedule for the lands within the Lakeview Stewardship Unit. In total, the schedule includes 53,773 acres of commercial thinning treatment, 77,423 acres of fuels reduction with potential biomass removal, and 128,570 acres of prescribed fire. The agency anticipates that the schedule will be updated to reflect any changes due to funding, priorities and to incorporate new information (i.e. TNC Values Mapping) as it becomes available.

FOREST SERVICE 10 YEAR VEGETATION MANAGEMENT PROJECTS SCHEDULE

Fiscal Year	Unit	NEPA Planning Area	Project Name	Acres Commercial Treatment	Acres Fuels Reduction -Biomass	Acres Prescribed Fire
2010						
	LKV	Upper Thomas Creek	UTC Underburn	-	-	2,000
	LKV	West Drews	Dent North Stewardship	777	324	
	LKV	Abe	Abe Stewardship	590	439	
	LKV	Burnt Willow	Burnt Willow Stewardship	2,597	1,198	
	LKV	West Drews	Dent South Stewardship	1,110	1,110	
	LKV	West Drews	Stack Stewardship	1,400	1,400	
	PAI	Launch Fuels & Veg	Launch Stewardship	512	512	
	PAI	Jakabe	Kava Stewardship	395	395	
	PAI	Jakabe	Jakabe Plantation Thinning	-	352	
	PAI	Jakabe	High	202	202	
TOTALS				***7,583***	***5,932***	***2,000***
2011						
	LKV	West Drews	Straw Stewardship	1,500	1,500	
	LKV	Abe	Camp Creek Thinning	500	500	
	LKV	Abe	Abe Projects		700	2,700
	LKV	Strawberry Underburn	Strawberry Underburn	-	-	5,000
	LKV	Upper Thomas Creek	UTC Underburn	-	-	1,010
	LKV	N Warner Sage/Shrub	N Warner Sage/Shrub		300	200
	LKV	Booth Thin/Underburn	Booth Thin/Underburn		160	160
	PAI	Launch Fuels & Veg	LA Stewardship	1,750	500	
	PAI	Red Zone Safety	Mad	600	600	
	PAI	Red Zone Safety	Clear	440	440	
TOTALS				***4,790***	***4,700***	***9,070***

FOREST SERVICE 10 YEAR VEGETATION MANAGEMENT PROJECTS SCHEDULE (CONTINUED)

2012						
	LKV	East Drews	Green Dog Stewardship	1,300	3,500	
	LKV	Abe	Abe Projects	-	700	1,000
	LKV	Burnt Willow	Burnt Willow Projects	-	-	1,500
	LKV	West Drews	West Drews Projects	-	2,400	
	LKV	McCoin Underburn	McCoin Underburn	-	-	5,400
	LKV	Strawberry Underburn	Strawberry Underburn	-	-	4,000
	LKV	N Warner Sage/Shrub	N Warner Juniper	-	300	500
	PAI	Deuce	Day Stewardship	2,100	1,730	
	PAI	Jackabe	Trail Underburn	-	-	1,000
	PAI	Jackabe	Kava Underburn	-	-	1,000
TOTALS				***3,400***	***8,630***	***14,400***
2013						
	LKV	West Drews	Last Stewardship	1,500	1,000	
	LKV	West Drews	West Drews Projects	-	2,100	5,600

	LKV	Strawberry Underburn	Strawberry Underburn	-	-	6,700
	LKV	N Warner Sage/Shrub	N Warner Juniper	-	-	300
	LKV	Burnt Willow	Burnt Willow Underburn	-	-	1,500
	LKV	East Drews	Horseshoe Stewardship	1,000	2,800	
	PAI	Deuce	Senior Stewardship	2,100	2,841	
	PAI	Red Zone Safety	Cycle	1,200	500	
	PAI	Red Zone Safety	Ring	1,200	500	
TOTALS				***7,000***	***9,741***	***14,100***
2014						
	LKV	West Drews	Hay Stewardship	1,400	1,050	
	LKV	West Drews	West Drews Projects	-	4,400	10,000
	LKV	N Warner Sage/Shrub	N Warner Juniper	-	-	500
	LKV	Burnt Willow	Burnt Willow Underburn	-	-	2,000
	LKV	Camas Horse	Camas Horse Stewardship	1,800	6,000	
	PAI	Deuce	Drill Stewardship	2,100	1,730	
TOTALS				***5,300***	***13,180***	***12,500***
2015						
	LKV	N Warner Sage/Shrub	N Warner Juniper	-	-	500
	LKV	West Drews	West Drews Underburn	-	-	5,000
	LKV	East Drews	East Drews Underburn	-	-	5,000
	LKV	Wild Dry Rock	WDR Stewardship	3,600	7,700	
	PAI	Deuce	Shoe Stewardship	2,100	1,730	
	PAI	Launch Fuels & Veg	LA Underburn	-	-	1,000
TOTALS				***5,700***	***9,430***	***11,500***
2016						
	LKV	Muddy Cottonwood	MC Stewardship	2,000	3,500	
	LKV	West Drews	West Drews Underburn	-	5,200	5,000
	LKV	East Drews	East Drews Underburn	-	-	10,000
	PAI	Launch Fuels & Veg	LA Underburn	-	-	1,000
	PAI	Deuce	Camp Stewardship	2,100	1,730	2,000
	PAI	Shake/Merritt	Shake Stewardship	2,600	400	
TOTALS				***6,700***	***10,830***	***18,000***

FOREST SERVICE 10 YEAR VEGETATION MANAGEMENT PROJECTS SCHEDULE (CONTINUED)

2017						
	LKV	Crooked Mud	CM Stewardship	2,600	4,350	
	LKV	Upper Thomas Creek	Thomas II Stewardship	1,800	3,100	
	LKV	East Drews	East Drews Underburn	-	-	5,000
	LKV	Camas Horse	Camas Horse Underburn	-	-	5,000
	PAI	Launch Fuels & Veg	LA Underburn	-	-	1,000
	PAI	Deuce	No Name Stewardship	1,600	1,250	2,000
TOTALS				***6,000***	***8,700***	***13,000***
2018						
	LKV	Deep	Deep Stewardship	2,500	2,700	
	LKV	East Drews	East Drews Underburn	-	-	5,000
	LKV	Camas Horse	Camas Horse Underburn	-	-	5,000
	LKV	Muddy Cottonwood	MC Underburn	-	-	5,000
	PAI	Deuce	No Name Stewardship	1,300	730	2,000

TOTALS				***3,800***	***3,430***	***17,000***
2019						
	LKV	Camas Horse	Camas Horse Underburn	-	-	5,000
	LKV	Muddy Cottonwood	MC Underburn	-	-	5,000
	LKV	Crooked Mud	Crooked Mud Underburn	-	-	5,000
	LKV	Horse Whiskey	Horse Whiskey Stewardship	2,000	2,600	
	PAI	Deuce	Deuce Underburn			2,000
	PAI	Baja	Baja Stewardship	1,500	250	
TOTALS				***3,500***	***2,850***	***17,000***
10-YEAR TOTALS				***53,773***	***77,423***	***128,570***

Appendix A

APPENDIX A: GOALS AND OBJECTIVES OF UNIT

1) Sustain and restore a healthy, diverse, and resilient forest ecosystem that can accommodate human and natural disturbances.

- Restore stand-maintenance fire regimes where they historically occurred.
- Maintain and restore habitat for focal species.
- Sustain and restore healthy soils.
- Restore forest conditions that approximate historical species composition and stand ages.
- Eliminate, where possible, and control the spread of invasive, non-native species (especially noxious weeds).

2) Sustain and restore the land's capacity to absorb, store, and distribute quality water.

- Manage upland vegetation to maintain and restore water and moisture absorption, retention, and release capacity over time.
- Reduce road density and improve remaining roads to minimize impacts on water quality and flow.
- Maintain and improve aquatic and riparian habitat for native species.
- Lower stream temperature and sediment loads.
- Improve biophysical structure of soils.

3) Provide opportunities for people to realize their material, spiritual, and recreational values and relationships with the forest.

- Provide opportunities for local people to realize economic benefits from innovative contractual mechanisms and technologies focused on linking stewardship activities and community well-being.
- Pursue compensation of local workers at a state-average family wage or higher to accomplish ecosystem management.
- Design contracts to promote opportunities for year-round, long-duration, stable employment.
- Design unit product sales and service contracts to promote participation (e.g. bidding and contract awards) by local vendors, purchasers, and contractors.
- Promote a local business environment that can take advantage of the products and services of ecosystem management (e.g. small diameter and under-utilized species).
- Protect and maintain areas of cultural significance within the forest.
- Improve opportunities for people to fish, hunt, and view nature.
- Promote environmentally responsible recreation.

Appendix B

APPENDIX B: METHODS TO ASSESS OLD GROWTH ACRES IN THE LAKEVIEW STEWARDSHIP UNIT

Gradient Nearest Neighbor data was compiled in treelists from the master tree list database Lemma_data.mdb were evaluated using SPMCDBH compute function in FVS.
For each tree in the list the following attributes were calculated:

1. Trees / Acre (TPA)

2. Percent Cover (Cover)

The TPA values were then summed for each species and each size class. Cover by species and size class was summed using the cover extension to FVS.
In addition, Total Cover for all trees regardless of species or size class was estimated for the density class analysis.
Note the cover estimates by species and size class do not equal total cover for the plot which was calculated summing all trees per plot. This is due to the random overlap built into the cover extension.

Species Composition (Seral State)

1. For each Plant Association Group (PAG) rate every possible species (all species in the tree dataset) as shade tolerant or shade intolerant.
2. Sum the cover of shade tolerant vs. shade intolerant species.
3. If shade intolerant relative cover is >75% then Seral State is Early Seral (1)
4. If shade intolerant relative cover is between 25-75% then Seral State is Mid Seral (2)
5. Shade intolerant relative cover is <25% then Seral State is Late Seral (3)

Size Classes (Structure Stage)

1. 2 sets of size classes were evaluated for each pixel.
2. The 1st set has 5 classes and was used to compare to local HRV estimates for each state:
    1. Grass/Forb/Shrub
    2. Seedling/Sapling (.1 - 4.9" dbh)
    3. Pole (5 - 9.9" dbh)
    4. Small (10 – 20.9" dbh)
    5. Large (21+" dbh)

3. The 2nd set has 7 classes and was developed primarily for wildlife habitat analysis. This set also matches the IMAP size classes.

    1. Grass/Forb/Shrub
    2. Seedling/Sapling (.1 - 4.9" dbh)
    3. Pole (5 - 9.9" dbh)
    4. Small (10 -14.9" dbh)
    5. Medium (15 -19.9" dbh)

6. Large (20 – 29.9" dbh)
7. X-Large (30+" dbh)

The size classes for each set of classes were evaluated from the largest size classes down to the smallest. Large and X-Large classes were tested 2 times.

1. If canopy cover of the X-Large class is the greatest cover by % then class = 7 else if the TPA for the X-Large class > the threshold in the R6 Interim Old-Growth definitions for the PAG then Class = 7.
2. If canopy cover of the Large + X-Large class is the greatest cover by % then class = 6 else if the TPA for the Large + X-Large class > the threshold in the R6 Interim Old-Growth definitions for the PAG then Class = 6.

The Medium – Seedling/Sapling classes were evaluated based on the largest class with a plurality of cover.

3. If the Size Class is not Large or X-Large, then cover of the Large and X-Large are added to first the Medium class and tested for plurality of cover. If Plurality is medium then Class = 5
4. If Size class is not Medium then cover of the Medium + Large + X-Large are added to the Small class and tested for plurality of cover. If Plurality is small then Class = 4.
5. If Size class is not Small then cover of the Small + Medium + Large + X-Large are added to the Pole class and tested for plurality of cover. If Plurality is pole then Class = 3.
6. If Size class is not Pole then cover of the Pole + Small + Medium + Large + X-Large are added to the Seed/Sap class and tested for plurality of cover. If Plurality is Seed/Sap then Class = 2.
7. Total tree cover < 10% = Class 1

The Density Class is based on a total cover class threshold for each PAG. This threshold changes from 25% in the Juniper and Dry PP PAGs to 55% cover in the Moist Mixed Conifer and Mountain Hemlock PAGs. If the total cover is greater than or equal to the threshold then Density Class = 1 Else if the Cover is less than the threshold Density Class = 2.

Memorandum of Understanding
Federal ID: 2008 MU11060200-001

Lake County Resources Initiative, Lake County, Town of Lakeview, City of Paisley, Marubeni Sustainable Energy, Inc., The Collins Companies, Oregon Department of Forestry, U.S.D.A. Forest Service Fremont-Winema National Forests; Bureau of Land Management- Lakeview District

I. Authorities

A. This Memorandum of Understanding (MOU) is hereby made and entered into by and among the above listed parties under the authorities noted below.

B. The activities addressed herein may occur under the following principal authorities:

1. <u>Forest Service.</u> Multiple Use Sustained Yield Act of 1960, National Environmental Policy Act of 1969, and the National Forest Management Act of 1976.
2. <u>Bureau of Land Management.</u> Federal Land Policy and Management Act of 1976 and O&C Act of August, 1937. .
3. <u>Oregon Department of Forestry.</u> SB 1072 of 2005

C. The following additional authorities guide implementation of this MOU:

1. Memorandum of Agreement among Department of Energy, Department of Interior and Department of Agriculture of January 21, 2005
2. Lakeview Biomass Energy Facility Oregon Solutions Declaration of Cooperation of January 12, 2006
3. Healthy Forest Restoration Act of 2003
4. 16 U.S.C. 2104 Note (Revised February 28, 2003 to reflect Sec. 323 of H.J. Res. 2 as enrolled)
5. Energy Policy Act of 2005

II. Scope

The scope of this MOU is the lands of the Lakeview, Bly, Silver Lake and Paisley Ranger Districts of Fremont-Winema National Forests, and the Klamath and Lakeview Resource Areas of the Bureau of Land Management.

III. Purpose and Objectives

A. The purpose of this 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.

B. The parties to this MOU intend to work together to achieve the following objectives:

1. Improve and protect
   a. The vitality of forest and range ecosystems and the resiliency of such ecosystems to threats from fire, disease and invasive and noxious species, including maintaining soil productivity and the use of

prescribed fire or vegetation removal to promote healthy forests and rangelands;
   b. Water resources including watershed health and productivity, water quantity and water quality;
   c. Habitat for wildlife and fish;
   d. Air quality, including minimizing air quality impacts by removing excess biomass before the introduction of fire; and
   e. The commercial value of forest biomass for producing electric energy and other beneficial uses
2. Reduce
   a. Hazardous forest fuels on federal lands;
   b. Fire hazards to private lands, at-risk communities, and municipal water supplies; and
   c. Prevalence of noxious and exotic plants and promote reestablishment of native species.
3. Facilitate
   a. The re-introduction of fire in fire-dependant ecosystems by removing unnatural accumulations of fuel prior to re-introducing fire;
   b. A market-based solution for hazardous fuel reduction and biomass removal on federal, private and tribal lands;
   c. Generation of renewable and sustainable energy;
   d. Economic opportunities in an economically depressed area;
   e. The systematic gathering of information to improve forest and range management;
   f. The continued economic vitality of the existing forest products industry infrastructure, including emphasizing the best and highest markets for forest products;
   g. Implementation of sustainable forestry practices and restoration forestry principles on a landscape scale; and
   h. Explore options relative to the potential for stewardship contracting to generate revenue back to counties in lieu of timber receipts or in lieu of the Secure Rural Schools Act as it is phased out.

IV. Mutual Interests and Benefits

A. The federal agencies have identified many acres of forest land that have vegetative stocking in excess of sustainable levels, primarily as a result of successful fire exclusion over several decades and limited silvicultural intervention. Available Congressional appropriations have not been sufficient to rectify this situation. The creation and retention of viable and sustainable markets for this excess biomass would allow additional acres to be treated within anticipated levels of appropriations. Thus, it is to the advantage of the federal agencies to support a viable wood products industry, woody biomass energy generation and other projects that would provide these markets.

B. It is in the interest of the citizens of Lake County to support and foster a positive environment for the wood products industry to continue operation and to expand in Lake County, maintaining and increasing employment, and supporting local governments through taxes.

C. In January 2005, Oregon Governor Kulongoski designated the Lakeview Biomass Project an Oregon Solutions project to help insure its successful implementation. In January 2006, the Governor's project team agreed to a series of objectives in support of long-term economic viability for the biomass project. A key objective is to secure a predictable, economically and ecologically sustainable supply of biomass. Since the primary source of this biomass is federal land, it is to the advantage of the State of Oregon to support efforts of the federal agencies to achieve their goals of healthy forests by helping to create viable markets for the excess biomass on those lands.

V. Commitments

A. The U.S.D.A. Forest Service and the Bureau of Land Management shall:

1. Offer woody biomass for utilization as a component of all applicable contracts or agreements. Such contracts and agreements would contain an optional provision that would allow the contractor to remove woody biomass for utilization where ecologically appropriate. Removal may require payment of a minimum appraised value or payment for services if such removal is required by the government. This option would be contained in any type of contract or agreement the federal agencies utilize for vegetation management projects which are expected to generate woody biomass, unless such biomass was reserved for ecological reasons.
2. Utilize the full variety of contracting methods available under current statutes and authorities. These include competitive integrated resource stewardship contracts, traditional service and timber sale contracts, and sole source agreements.
3. To the extent feasible, offer indefinite duration, indefinite quantity (IDIQ) clauses (for example, consider a 10-year IDIQ contract with annual minimum and maximums accomplished through task orders) in contracts with the expectation that retained receipts will assist in increasing acreage treated.
4. Present a plan showing the different authorities and mechanisms that will be utilized to meet acreage goals, 90 days following signing of this MOU.
5. Meet with parties to this MOU a minimum of once a year and report on progress towards implementing this MOU.
6. Share per-acre yield and utilization data and costs from on-going treatments that are generating sawlog and biomass material to update biomass projections for proposed forest and rangeland treatments.
7. Using the Southern Oregon/Northern California CROP model as background information, update vegetation management project information and scheduling to coordinate planning, implementation and monitoring of projects that generate both timber products and biomass.
8. Consider the purpose and objectives of this MOU during development of all projects that fall within its scope, using adaptive management principles.
9. Strive to assess the best scientific and other credible information available as relevant to the purpose and objectives of this MOU and other considerations used by the agencies in making their decisions on projects within the scope of this MOU.
10. Coordinate and communicate with stakeholders in a timely manner in order to coordinate management activities across political and social boundaries and focus management on proactive activities for ecosystem health.

B. The Fremont-Winema National Forests shall:
   1. To the extent permitted by and consistent with all applicable laws and land use plans, offer a minimum of 3,000 treatment acres per year outside of the Lakeview Federal Stewardship Unit. Treatments on these acres will be designed to support the objectives presented above.
   2. To the extent permitted by and consistent with all applicable laws and land use plans, offer a minimum of 3,000 treatment acres within the Lakeview Federal Stewardship Unit. Treatments on these acres take into consideration the goals and recommendations outlined in the Long-Range Strategy for the Lakeview Federal Stewardship Unit and are consistent with the Chief of the Forest Service's policy for the Unit.
   3. Test ways of reducing the cost of business through utilization of designation by description, sale by weight and conducting environmental analyses on a landscape scale, including contracting out portions of NEPA work.

C. The Lakeview District of the BLM shall:
   1. To the extent permitted by and consistent with funding, all applicable laws, and land use plans, offer a minimum of 2,000 treatment acres per year District-wide. Some of the District acres offered may not be economically feasible for the Lakeview biomass plant to acquire, thus the material utilized by the Lakeview plant may be less than that offered.
   2. Design treatments on these acres which support the Bureau's land treatment objectives.
   3. Offer contracts and/or agreements through a competitive process.
   4. Continue to seek improvement in environmentally friendly juniper removal methods.

D. Lake County Resources Initiative shall:
   1. Work with the Central Oregon Intergovernmental Council (COIC), Mater Engineering, the U.S.D.A. Forest Service, the Bureau of Land Management, and other partners to create a sustainable long-term supply system focused on the Lakeview community (CROP).
   2. Provide local coordination between the Collins Companies, Jeld-Wen and Forest Service on the WESTCARB project with the goal of establishing a carbon credit system for reducing uncharacteristically large fire events to assist with paying for restoration activities.
   3. Work with the Collins Companies and Forest Service to gather field data from the Bull Stewardship Contract to verify economic assumptions utilized in the pro forma for the Lakeview Biomass Project.
   4. Work with the Lakeview Stewardship Group to assure that the long-term Strategy for the Lakeview Federal Stewardship Unit is considered when restoration activities are implemented.
   5. Work with Marubeni Sustainable Energy in any appropriate manner necessary to construct an appropriately sized (estimated to be 10-15 megawatts) facility in Lake County.
   6. Seek out fire plan, implementation grants, biomass and other funding that will assist in meeting the objectives of this MOU.
   7. Help coordinate the pre- and post-treatment monitoring of forest and rangeland treatments.

8. Serve as primary coordinator for monitoring that will focus on (1) economic performance of the CROP initiative; and (2) environmental performance of the projects implemented.

E. Lake County shall:
   1. Use the County's Resource Advisory Committee review process to give priority ranking to Title II County projects that result in forest products utilization.
   2. Work with Lake County Resources Initiative to get the Long-term Strategy for the Lakeview Federal Stewardship Unit working to get supply to the sawmill and biomass plant.
   3. Support both the Fremont Sawmill and Lakeview Biomass Plant at the state and national level.
   4. Support the efforts of the Town of Lakeview, City of Paisley, LCRI and State and Federal Agencies to promote resource management that will result in restoration of healthy forest and rangeland ecosystems and stronger community economies.
   5. Use the Title II process of the Secure Rural Schools and Communities Act to promote projects that support improved forest and rangeland health while strengthening the economies of local communities
   6. Work with all parties to develop and implement a long-term strategy to secure a sustainable supply of forest products and biomass to support the local wood products industry.

F. The Town of Lakeview shall:
   1. Work with all parties to implement strategies which will result in stewardship contracting for the purpose of accomplishing the ecologic, biologic and economic restoration of the forest and rangelands and affected surrounding communities.
   2. Pursue all reasonable political avenues to accomplish the goals and objectives of this MOU.
   3. Work with private businesses to secure the necessary land use and air quality permits to locate facilities in Lakeview.
   4. Work with private businesses to access available state and federal funding sources
   5. Promote this project at all levels as a successful solution to the management needs of the federal agencies and the development needs of the local communities.

G. The City of Paisley shall:
   1. Work with LCRI to identify businesses that can utilize small diameter sawlogs to expand or locate in the Paisley area.
   2. Pursue all reasonable political avenues to accomplish the goals and objectives of this MOU.
   3. Pursue funding to utilize beetle-killed trees for higher market value than chips.

H. Oregon Department of Forestry shall:
   1. Utilize the authority of SB 1072 to help address the beetle outbreak occurring on the Fremont-Winema National Forests.

2. Utilize the authority of SB 1072 to facilitate 10-year stewardship contracts, and other similar contracts and agreements, resulting in a positive partnership with private enterprise and not direct competition.
3. Develop a cooperative state-wide MOU among state agencies and the Forest Service and Bureau of Land Management to combine elements of existing state programs under the following departments: Energy, Economic and Community Development, Fish and Wildlife, and Forestry, to support the work of federal agencies to develop stewardship contracts, and other similar contracts and agreements, to promote bio-energy at competitive prices with market rates for heat and energy.

I. Marubeni Sustainable Energy shall:

1. Execute detailed documents outlining the terms of provisions including Land Lease, Steam Purchase, Water Supply, Sawmill Waste, Chip Sale, and Log Purchase.
2. Arrange for the study of detailed biomass fuel supply, contracting with and providing the majority of funding for Mater Engineering to advance on matters critical to the development of a reliable fuel supply plan for the Lakeview Biomass project.
3. Work with other Oregon Solutions team members to maximize and secure Business Energy Tax Credits, Renewable Energy Credits, Carbon Mitigation Credits, and other applicable local and federal production or investment tax credits to facilitate the development and financing of the Lakeview Biomass project.
4. Lead the advancement of the planning, permitting, design, commercial contracting, financing, construction and long term operation of the Lakeview Biomass project, bringing the majority of the equity capital required to develop and construct the project.
5. Work cooperatively with The Collins Companies on developing supply mechanisms that get sawlogs to Fremont Sawmill and chips from the Lakeview Federal Stewardship Unit at the lowest price possible.
6. Investigate developing a supply merchandizing company that can obtain supply for Forest Service lands both in the Unit and out, as well as supply from BLM lands and private lands.

J. The Collins Companies shall:

1. Work with Marubeni Sustainable Energy on a land lease at their facility, Fremont Sawmill in Lakeview, OR.
2. Work with Marubeni Sustainable Energy on a steam purchase agreement, taking the boiler at the Fremont Sawmill off line.
3. Provide access to an existing well on Fremont Sawmill property for the biomass plant usage.
4. Negotiate the sale of hogfuel from the Fremont Sawmill to the Lakeview Biomass Plant.
5. The Collins Companies will develop a long-term contract to sell chips generated from normal logging operations at a negotiated price to the biomass plant.
6. Should the biomass developer or a subsidiary fuel supply company be developed and long-term contracts obtained by them from the Forest Service

and BLM, the Collins Companies will purchase suitable sawlogs from them at a fair market value.

7. Work cooperatively with Marubeni Sustainable Energy on developing supply mechanisms that get sawlogs and chips from the Lakeview Federal Stewardship Unit at the lowest price possible.
8. Investigate retooling the Fremont Sawmill to process small diameter logs.

VI. Mutual Agreements and Understandings

It is mutually agreed and understood by and among the parties that:

A. Any information furnished to the Forest Service or Bureau of Land Management under this instrument is subject to the Freedom of Information Act (5 U.S.C. 552).
B. Modifications within the scope of the instrument shall be made by mutual consent of the parties, by the issuance of a written modification, signed and dated by all parties, prior to any changes being performed.
C. This instrument in no way restricts the Forest Service, the Bureau of Land Management or the Cooperators from participating in similar activities with other public or private agencies, organizations, and individuals.

D. The principal contacts for this instrument are:

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E. This instrument is neither a fiscal nor a funds obligation document. Land treatment commitments may be dependent on annual appropriations. Any endeavor or transfer of anything of value involving reimbursement or contribution of funds between the parties to this instrument will be handled in accordance with applicable laws, regulations, and procedures including those for Government procurement and printing. Such endeavors will be outlined in separate agreements that shall be made in writing by representatives of the parties and shall be independently authorized by appropriate statutory authority. This instrument does not provide such authority. Specifically, this instrument does not establish authority for noncompetitive award to the cooperator of any contract or other agreement. Any contract or agreement for training or other services must fully comply with all applicable requirements for competition.

F. The commitments of the Fremont-Winema National Forests and the Lakeview District, Bureau of Land Management to offer a total annual minimum of 8,000 acres recognizes the intent of all parties to facilitate the purpose and objectives of this MOU to maximize the capability to address hazardous forest fuel treatment needs and forest/rangeland ecosystem, watershed, wildlife and fish restoration needs. Building and maintaining a healthy localized market for biomass material is one critical element to maximizing this capability. All parties further recognize that circumstances beyond the control of all participating groups in this MOU such as delays due to litigation, broad-reaching court decisions, competing markets and demand for biomass in the surrounding area, Congressional appropriations and funding, may impact the timing, scope, amount of acres and methods of implementing the MOU and may require flexible responses to achieve the intent of the MOU on an ongoing basis. All parties also recognize that there is already a demand for forest products, including sawlogs and biomass, from the existing forest products infrastructure presently in place in the western half of Klamath County and surrounding areas which could impact the total availability of forest products deliverable to the new biomass plant.

G. All parties to this MOU recognize that the purpose of the biomass utilization component of this MOU is to create a local and a financially viable use and market for woody biomass material. The parties recognize that, currently, the cost of biomass removal exceeds the market value, if any, for such material and that the mutual success of developing an economically viable market for such material will depend on a long-term supply, reliable markets, and mutual financial feasibility for removing and utilizing the material. In building this market, the parties will use a fair and transparent process for assigning value to woody biomass material.

H. All parties to this MOU understand that the project development processes of the federal agencies are open to everyone and that the federal agencies have neither established nor do they manage or control the operations of any group that may participate in these processes. The ongoing collaboration efforts of the Lakeview Stewardship Group, Lake County Resources Initiative and Oregon Solutions Team will inform federal decision makers on any topic related to the scope of this MOU in any manner deemed appropriate by these organizations. Recommendations from these collaborative planning efforts shall not abrogate or limit the approval authority of USFS or BLM as relevant to their management responsibilities and requirements to comply with federal law including their respective Resource Management Plans or to the terms of this MOU.

I. The Parties expect that individuals and groups participating in project planning collaborative efforts will assist by providing recommendations regarding the development of phased implementation, project identification and development of project protocols. Participating stakeholders will define their own participation in such planning efforts, but it is expected that the Parties will desire and request consultation for the following:

1. Development of MOU implementation phased plans and schedule;
2. Development of project plans and protocols;
3. Identification of project implementation agreements/contracts; and
4. Development of annual reports related to MOU and project implementation.

J. The Parties expect that stakeholders participating in environmental monitoring collaborative planning will assist in the development of environmental monitoring protocols, implementation and reporting. Participating stakeholders will define their own participation in such planning efforts, but it is expected that the Parties will desire and request consultation for the following:

1. Preparation of annual reports related to monitoring;
2. Preparation of project-specific monitoring reports;
3. Preparation of project-level monitoring plans and protocols; and
4. Implementation of the monitoring plans.

K. The Parties expect that recommendations from collaborative planning efforts will be primarily based on solid scientific and credible information and post treatment monitoring results.

L. This MOU will be implemented through projects completed in phases in conjunction with federal and CROP resource planning efforts. Phased projects plans will be developed through a collaborative planning process described above. While individual projects including monitoring efforts may be identified and entered into under this MOU, it is anticipated that individual projects and monitoring efforts will be planned and grouped in distinct phases to facilitate coordinated longer-term management. It is anticipated that a typical phased projects plan will cover multiple years, from 3 to 10 years. However phased projects plans may be longer or shorter as appropriate to planning objectives. While it is anticipated that phases will be consecutively implemented, phases may be planned for consecutive, overlapping or concurrent implementation.

M. Phased projects plans will be implemented through a variety of contracting and agreement vehicles, including but not limited to, the vehicles authorized under the Healthy Forests Restoration Act, Stewardship End-Result contracting authority, traditional service or timber sale contract authorities, and cooperative agreements. Phased projects plans will be awarded on an open-competitive basis, on a best-value (stewardship) basis, or on a sole-sourced basis to an appropriate entity, depending on the specific circumstances and authority used. Where STATE OF OREGON and/or a sole-source entity administers a phased projects plan, unless specifically provided otherwise, STATE OF OREGON and/or a sole-source entity may use a variety of tools for implementation, including subcontracts as consistent with federal law. It is recognized that most contract holders intend to merchandise and sell merchantable saw log volumes other than incidental volumes associated with forest fuels treatment and restoration to the highest and best markets as most appropriate for the circumstances of the project and in the best interests of the contract holder.

N. As noted above, project planning and monitoring efforts shall be conducted through a collaborative planning process, described above. This process will be primarily implemented and administered through the LAKEVIEW Stewardship Group process. Lake County Resources Initiative shall take the lead to ensure that collaborative efforts are initiated with interested stakeholders at desired consultation points.

O. All parties agreed to meet at least every five years and preferably every year to review this MOU and progress towards the purpose and goals of this MOU.

P. This instrument is executed as of the date of last signature and is effective for a twenty-year term through **November 1, 2027** at which time it will expire unless extended.

Q. Any of the parties may terminate, in writing, this instrument in whole, or in part, at any time before the date of expiration.

AUTHORIZED REPRESENTATIVES. By signature below, the cooperators certify that the individuals listed in this document as representatives of the cooperator are authorized to act in their respective areas for matters related to this agreement.
THE PARTIES HERETO have executed this instrument.

__________________________	__________________________
Karen Shimamoto	Shirley Gammon
Forest Supervisor	District Manager
Fremont-Winema National Forest	Lakeview District

Chuck Graham
Co-Chair
Lake County Resources Initiative

Brad Winters
County Commissioner
Lake County

Marvin Brown
State Forester
Oregon Department of Forestry

Rick Watson
Mayor
Town of Lakeview

Dale Roberts
Mayor
City of Paisley

Wade Mosby
Senior Vice President
The Collins Companies
Portland, OR

John Wood
Secretary
Marubeni Sustainable Energy

The authority and format of this instrument has been reviewed and approved for signature.

Midori C Raymore
FS Grants & Agreements Specialist

Date

Annex D

Press Release

January 10, 2007

Governor Kulongoski Announces New Biomass Plant in Lakeview

Plant marks first new biomass facility in Oregon in more than ten years

Salem — Today Governor Ted Kulongoski announced that DG Energy will build a biomass power plant in Lakeview, Oregon — marking the first new biomass facility in Oregon since 1992.

"Using biomass from overstocked forests, this innovative project will produce electricity while helping restore forest health, reduce fire risks, and create jobs," said Governor Kulongoski. "This project serves as a model for collaboration between industry, conservationists and state government in enhancing forest health, developing renewable energy and creating jobs."

DG Energy will invest $20 million in the facility and it will produce nearly 100,000 MWHr of renewable energy to the regional Oregon grid annually. In addition, the facility will supply steam to the Fremont Sawmill, owned by the Collins Companies of Portland Oregon. Permits for the plant will be filed in mid-Spring and the facility is expected to be operational in 2008.

The Lakeview Biomass Project was designated an Oregon Solutions project by Governor Kulongoski in 2005. The Oregon Solutions Process resulted in a collaboration of nearly 70 public, private and community organizations to develop an economically viable, ecologically sustainable power plant. The fuel sources for the plant will become a key part of an integrated solution to a multi-faceted forest health problem.

Key partners include: Oregon State University, Portland State University, The Collins Companies, Oregon Economic and Community Development Department, Oregon Department of Forestry, United States Forest Service, Friends of the Winema/Fremont, Bureau of Land Management, Oregon Department of Fish and Wildlife, The Wilderness Society, Oregon Natural Resource Council and Defenders of Wildlife. The Lake County Resources Initiative is the project sponsor.

"We appreciate the support of the Governor and are pleased to have the opportunity to work with the community in the development of this innovative project," said Steve Mueller, President of DG Energy.

The plant will create local jobs in harvesting and hauling the once-unwanted biomass. The salvaged materials that are suitable for solid wood products will be milled, another boon to job development. Additional project benefits will include enhanced water resources, fish and wildlife habitat and renewable energy from a resource that was once a threat to forest health and potentially reduced costs in fire fighting.

"The whole community is pleased that DG Energy is going to build the biomass plant in Lakeview. It will mean approximately 15 jobs at the plant and another 70 in the woods and that is considerable for a community of 2600. Just as important, the biomass plant along with Fremont Sawmill provide the necessary infrastructure to restore the local forests and rangelands back to natural conditions, something many other communities in the West have totally lost," said Jim Walls, Director, Lake County Resources Initiative.

For more details on the project please contact Melissa Moehrke with DG Energy LLC at: 619-232-6564.

Contact:

Anna Richter Taylor: 503-378-6169
Kristina Edmunson: 503-378-5040

Annex D

<u>NEWS RELEASE</u>
FOR IMMEDIATE RELEASE
March 7, 2007

Contacts:
Anna Richter Taylor: 503.378.6169
Jake Weigler: 503.378.6496
Kristina Edmunson: 503.378.5040

Governor Kulongoski Announces New Saw Log Mill in Southern Oregon

Facility made possible by biomass project will sustain mill jobs in town of Lakeview

Salem - Today Governor Ted Kulongoski announced that the Collins Companies will expand their Lakeview Saw Mill operation by adding a new $6.6 million dollar small log mill at their existing facility.

"This expansion is another example of the tremendous economic opportunity for rural Oregon with the expansion of renewable energy in this state," said Governor Kulongoski. "Whether it is the nation's largest solar manufacturing facility to open in Hillsboro or a small log mill to be co-sited with a biomass facility in Lakeview, we are seeing jobs and new economic opportunity being created across Oregon. I applaud the Collins Companies for their partnership in this project and for their continued investment in the Lakeview community."

The expansion was made possible by the siting of a biomass facility at the existing Collins Pine location and will ensure that the mill facility will remain open and sustainable over the coming years. The wood stream for the biomass facility will create enough small log wood volume to justify the addition of the small log mill.

In January, the Governor announced that DG Energy will build a biomass power plant in Lakeview - marking the first new biomass facility in Oregon since 1992. Both the DG Energy and Collins Companies projects were facilitated by the Governor's designation of an Oregon Solutions project to develop a viable biomass facility in Lakeview.

The Oregon Solutions Process resulted in a collaboration of nearly 70 public, private and community organizations to develop an economically viable, ecologically sustainable power plant. Fuel sources for the plant will become a key part of an integrated solution to effective management of forest health and reducing fire danger in the Freemont 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.

#

Lakeview Biomass Energy Facility:
An Oregon Solutions Project

January 12, 2006

Declaration of Cooperation

1. Project Description and Background

The Lakeview Biomass Oregon Solutions Project is a community-based, multi-stakeholder effort to create an ecologically sound solution to forest restoration that includes an economically viable biomass energy facility.

The biomass energy facility (approximately 10-15 megawatts in size) would be adjacent to the Fremont Sawmill in Lakeview, Oregon. The sawmill is located in the center of the 492,642 acre Lakeview Stewardship Unit on the Fremont –Winema National Forest.

DG Energy is working with The Collins Companies, the owner of the Fremont Sawmill, to pursue the development of the biomass facility, and Collins and DG Energy have entered into initial development agreements and are progressing accordingly. DG Energy has participated in and contributed to the Oregon Solutions Project Team since its inception, and is supported by the Oregon Solutions Team in development of the project as long as DG Energy continues commercially reasonable pursuit of the success of the project as further addressed in this document.

2. Problems Addressed by the Biomass Energy Facility

The Lakeview biomass energy facility would have significant positive impacts on several pressing problems including:

- Improving resilience in forest and range lands
- Reducing CO_2 emissions into the atmosphere
- Creating a source of clean, sustainable energy
- Reducing the risk and cost of wildfire in and around human communities
- Revitalizing a struggling local economy

More than 90 million acres of western dry forests are at moderate to high risk of severe drought stress, insect and disease epidemics and uncharacteristically severe fires due to excessive levels of small diameter biomass from forest floor to canopy. In addition, thousands of acres of rangeland are being degraded by encroachment of western juniper due to fire suppression. The absence of utilization options for small diameter trees and western juniper makes its removal prohibitively costly, and therefore, this material is usually left on the site where it perpetuates unhealthy forest conditions. The biomass energy facility would provide a utilization option for small diameter trees and western juniper. Removing excessive fuel loads would improve forest and rangeland health.

Currently, the piled material is often disposed of in the forest in open burns that degrade air quality and release significant amounts of carbon into the atmosphere. The biomass energy facility would channel that carbon into long-term storage as wood products or offset it by reducing the need for fossil fuel energy sources and their associated carbon emissions.

The facility would generate clean, sustainable energy that would be sold to a utility, and would provide an important model for biomass energy development across the state. Biomass energy is likely to be a significant component of our transition from a fossil fuel based to a sustainable energy system. With dwindling oil reserves, increasing instability in global energy markets, and energy costs that are likely to continue to rise into the foreseeable future, there has never been a better time to develop effective, sustainable community energy projects.

The biomass energy facility would have a direct positive impact on local economic and community development. In Lake County, the local forest sector industry is dwindling. The biomass energy facility would revitalize the economy by creating jobs suited to the skills of forest sector workers. Furthermore, by providing a cost effective way to remove wildfire fuels, it would reduce the currently escalating risks and costs associated with severe wildfire in a region experiencing increasing urbanization and residential development near forested areas.

The Lakeview Biomass Energy Facility is a different resource management model than the model that contributed to the conditions that now place these forests and rangelands and, in urbanizing areas, human lives and property at risk. It entails creation and application of new governance models, new resource management techniques and tools, new processes for utilizing what have historically been unmerchantable forest and range products, and new methods to contain costs and account for the full array of benefits derived from forest restoration. This model will be of value to other western communities facing large magnitude forest health challenges.

3. Oregon Solutions Collaboration

Project success will depend on overcoming several economic and policy challenges through the collaborative efforts of a diverse group of stakeholders. To facilitate this collaboration, in January 2005, Governor Theodore Kulongoski designated the Lakeview Biomass Project an Oregon Solutions project, and appointed OSU College of Forestry Dean Hal Salwasser and Lakeview County Commissioner JR Stewart to serve as project co-conveners. The mission of Oregon Solutions is to develop sustainable solutions to community-based problems that support economic, environmental, and community objectives and that are built through the collaborative efforts of businesses, governments, and non-profit organizations.

The Oregon Solutions designation will help ensure successful implementation of the Lakeview Biomass Project. The Governor has assured participation of his staff and appropriate state agencies with other partners through the designation of this effort as an Oregon Solutions project. It is expected that the creation of an Oregon Solutions Team for this initiative will help make efficient use of available resources, accelerate the pace of the project, overcome potential impediments early on, raise awareness of the initiative on a statewide level and bring effective partners to the table. In this fashion, the Team will commit resources and time to develop and implement an integrated action plan focused on achieving a predictable and stable supply of small diameter material to enable investments in related timber-utilizing technologies and businesses.

To this end, a Lakeview Biomass Project Team was created, composed of individuals, agencies and organizations with a "stake" in ecosystem restoration, renewable energy production, and employment/job creation in Lakeview. Team members and contact information is presented in Appendix B. The team developed a set of ground rules, presented in Appendix A, which assisted them in developing an integrated and inclusive solution. During the course of four meetings, from May through November 2005, the CROP Team agreed on a series of Project Purpose and Goal Statements, and an Implementation plan. These documents were used to build sections 1, 2, 4, and 5 of this Declaration of Cooperation. Section 6 outlines the commitments and contributions to project success of project participants.

4. Goals and Objectives

Goals of the Lakeview Biomass Energy Facility Project include:

- ✓ Development of a biomass-based, renewable energy resource;
- ✓ Recovery of watershed health, including enhanced water flows and quality, improved fish and wildlife habitats, and resiliency to drought, insects, fire and invasive species;
- ✓ Return of natural ecosystem processes including restoring fire's natural role in forest and rangeland ecosystems;
- ✓ Reduced threats to forest and rangeland values, property, and human lives from uncharacteristically severe fire;
- ✓ Reduced future costs of fire suppression;
- ✓ Improved understanding of the role of forest and rangelands, forest and rangeland products and biomass energy as mitigation for carbon dioxide emissions;
- ✓ Creation of forest-based jobs and wealth for long-term residents of rural communities;
- ✓ Enhanced and improved economic resiliency and viability of the regional lumber mill and surrounding communities;
- ✓ Improved efficiency and efficacy of state and federal agencies to carry out their missions (e.g. ecosystem restoration, community economic development, renewable energy development, etc.);
- ✓ Enhanced social capacity to solve problems in ways that build and sustain desired environmental, economic and community conditions.

The product of the Lakeview Biomass Oregon Solutions process will be an Oregon Solutions Declaration of Cooperation signed by all of the partners including state and federal agencies, local government, businesses and non-profits. The Declaration of Cooperation includes an implementation plan for achieving the following objectives necessary to meeting project goals:

- ✓ Secure a predictable, economically and ecologically sustainable supply of biomass;
- ✓ Agree on expedited permitting processes, if appropriate, to avoid project delays
- ✓ Support increased valuation of biomass within energy incentives; maximize utilization of existing financial incentives;
- ✓ Designation of the Lakeview biomass project as a pilot project under various initiatives;
- ✓ Engage in a transparent process that encourages active public/community participation;

- ✓ Ensure a viable energy project by addressing key issues including: power purchase agreement, thermal demand, secondary products, and cost-effective interconnection;
- ✓ Create conditions necessary to make this an attractive investment to secure construction and operation for at least twenty years;
- ✓ Support the development and utilization of ecologically-friendly extraction techniques;
- ✓ Create a replicable template for similar future projects;
- ✓ Integrate into implementation of the Governor's Renewable Energy Action Plan goals.

During early discussions, the Project Team realized that the proposed biomass power facility may not be economically viable in the absence of "intermediate" small diameter tree utilization infrastructure[1] (the Fremont Sawmill cannot currently profitably process small diameter logs), due to the relatively high cost of transporting small diameter biomass from the forest to a site, and the relatively low prices that a biomass power facility can pay for this material. Therefore, the development of intermediate small diameter processing infrastructure is considered critical to the success of the Lakeview Biomass Project, and has been added to the list of project objectives:

- ✓ Identify partners and investors to develop "intermediate" small diameter processing capacity, to derive maximum value and to assist in paying for the transport of biomass material from the woods to the biomass power site.

The graphic model in Appendix D illustrates the interconnection of many of these objectives.

5. Project Implementation Plan

The implementation plan addresses all of the key considerations for project success, and includes the following sections:

I. Stakeholder Collaboration and Community Engagement
II. Supply, Scale, and Design
III. Associated Economic Opportunities
IV. Power Purchase Agreement and Interconnection
V. Credits and Incentives
VI. Permitting
VII. Implementation Team

The full Implementation Plan is presented in Appendix E.

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[1] "Intermediate" SDT infrastructure would be able to profitably process approximately 4-12" DBH trees, such as a post and pole processor or a dedicated small diameter timber primary breakdown line at the Fremont Sawmill, and provide an additional residual fuel stream for the biomass power facility.

6. Commitments and Contributions

These commitments represent a public statement of intent to participate in the project, to strive to identify opportunities and solutions whenever possible, to contribute assistance and support within resource limits, and to collaborate with other Team members in promoting the success of the project.

The Oregon Solutions Project team agrees to provide project policy oversight and to engage in efforts to enhance project visibility and acceptance.

The following commitments to the success of the project are made by the Project Team members:

Governor Theodore Kulongoski's Office

General Project Support and Policy Development

The Lakeview Project is an excellent example of a "lasting solution that simultaneously addresses economic, environmental, and community well-being," as stated in the Governor's 2003 Sustainability Executive Order. The Governor's Office created the Oregon Solutions approach to help address complex issues with sustainable solutions. To this end, Governor Kulongoski's Office will continue to support the Oregon Solutions Lakeview Project. In addition, the Governor has convened a blue ribbon work group from the public and private sectors to assess the barriers to financing and building forest biomass projects in Oregon. That work group has been charged with developing and coordinating proposed policy, in partnership with federal agencies, for long-term levelized small diameter timber supply from public and private lands, and more generally, finding solutions that simultaneously improve forest health, reduce wildfire risk, and benefit local economies. Furthermore, the Governor adopted a Renewable Energy Action Plan (REAP) for the state that identifies the development of forest biomass to energy as one priority. The Governor's Office will continue to work with state agencies and stakeholders to accomplish the goals set out in the REAP.

David Van't Hof, Sustainability Policy Advisor,
Governor Kulongoski's Office

Lakeview District Bureau of Land Management

The Lakeview District of the Bureau of Land Management, within constraints of available funding, will commit resources and personnel to:

- Participate in and support the development of a Coordinated Resource Offering Protocol (CROP) supply projection by providing data on juniper stand locations, volume, and size classes and other associated data to the contractor.
- Pursue the use of Stewardship Contracting Authorities in planning restoration of ecosystems where juniper encroachment has reached a point requiring treatment. The use of these long term contracting authorities may help level the supply.
- Work with collaborators to seek techniques for biomass removal that will minimize short term environmental damage.
- Participate on the ongoing Lakeview Biomass Implementation Team, which will meet once monthly in the Lakeview area.

Shirley Gammon

Shirley Gammon, District Manager
Lakeview BLM

Fremont-Winema National Forest

The Fremont-Winema National Forests, within the constraints of available funding, will commit resources and personnel to:

- <u>CROP Development:</u> participate in and support the development of Coordinated Resource Offering Protocol CROP supply projection:
  - Volume, species, size classes
  - Location of supply

  CROP will identify a minimum annual supply commitment.
- <u>Stewardship Authorities:</u> Pursue the use of stewardship authorities
  - to normalize annual supply of biomass – multi year contracts
  - facilitate the restoration of ecosystems and natural fire regimes – goods for services
- <u>Collaboration:</u> Work with collaborators:
  - for development of efficient small diameter trees extraction techniques
  - for the development of new markets for small diameter material
  - maintain involvement through the implementation phase of this project

Karen Shimamoto

Karen Shimamoto, Forest Supervisor
Fremont-Winema National Forests

Lake County

Lake County has always encouraged worthy productive projects for the benefit of the entire County. We readily assist projects by helping in planning and project permitting. Lake County is continually working for a long term solution for supplying the lumber mill and also the biomass plant when built.

JR Stewart, Commissioner
Lake County, Oregon

The Collins Companies

The Collins Companies commits the following support for the Lakeview Biomass project:

- Land Lease: Work with any energy developer on a land lease at our facility, The Fremont Sawmill in Lakeview, OR.
- Steam purchase: Work with any energy developer on a steam purchase agreement, taking the boiler at the Fremont Sawmill off line.
- Water: Provide access to an existing well on Fremont Sawmill property for the biomass plant usage.
- Sawmill Hogfuel: Negotiate the sale of hogfuel from the Fremont Sawmill to developer of Lakeview Biomass Plant.
- Chips: The Collins Companies will develop a long term contract to sell chips generated from normal logging operations at a negotiated price to the biomass plant.
- Log purchase: Should the biomass developer or a subsidiary fuel supply company be developed and long term contracts obtained by them from the Forest Service and BLM, the Collins Companies will purchase suitable sawlogs from them at a fair market value.

Paul Harlan, Vice President Resources
The Collins Companies

Oregon State University

Oregon State University will support the Lakeview Biomass Project in the following ways:

- Grants and Research: Seek grants to support research on major outcomes anticipated by implementation of the Project, including but not limited to water quality, fish and wildlife habitat, fire risk reduction, carbon sequestration, and biomass utilization.
- Project Implementation Assistance: Assist project implementers to secure scientific, technical, and educational assistance as requested.

Hal Salwasser, Dean
Oregon State University College of Forestry

Defenders of Wildlife

Defenders of Wildlife commits the following support for the Lakeview Biomass project:

- Long-Term Strategic Plan for the Lakeview Federal Stewardship Unit: Defenders will work with the Lakeview Stewardship Group to develop, publicize, and implement a long term strategy for the Lakeview Federal Stewardship Unit (Unit) that meets both the ecological and social goals of the Unit, as outlined in the 2001 reauthorization language.
- Outreach: Defenders will inform policy makers, media, and other environmental organizations of our support for an appropriately sized biomass facility that contributes to ecological sustainability of the Unit by utilizing biomass material generated as a by-product of restoration-oriented treatments consistent with the Long-Term Strategic Plan for the Unit.
- Monitoring: Defenders will work with the Lakeview Stewardship Group to encourage and help oversee environmental monitoring programs designed to gauge the effectiveness of thinning and other treatments in achieving restoration objectives.
- Treatment Regimes: Defenders will work with the Lakeview Stewardship Group to identify appropriate types, scale and location of restoration-oriented treatments to achieve objectives of the Long-Term Strategic Plan.

Rick Brown, Senior Resource Specialist
Defenders of Wildlife

Lake County Resources Initiative

The Lake County Resources Initiative commits the following support for the Lakeview Biomass project:

- CROP/Supply Program Development: Work with COIC, Mater Engineering, the USDA Forest Service, the Bureau of Land Management, and other partners to create a sustainable long-term supply system focused on the Lakeview community.
- WESTCARB terrestrial carbon sequestration project: LCRI will provide local coordination between The Collins Companies, Jeld-Wen and Forest Service on this project.
- Goods for Services contracting: LCRI will work with The Collins Companies and Forest Service to gather field data off the Bull Stewardship Contract to verify economic assumptions utilized in the pro forma for the Lakeview Biomass Project.
- Long Term Strategic Plan for the Lakeview Federal Stewardship Unit: LCRI will work with the Lakeview Stewardship Group on a long term strategy for the Lakeview Federal Stewardship Unit that meets both the ecological and social goals of unit, as outlined in the 2002 reauthorization language.
- Pilot designation: LCRI will work with Sustainable Northwest and key congressional staff people on legislation for several pilots across the country to demonstrate biomass utilization.
- Energy Development Companies: LCRI will contact potential energy companies that can build and operate a biomass plant about locating a plant in Lakeview.
- Local Liaison: LCRI will serve as a liaison between energy company developer, The Collins Companies, and Federal, State and Local agencies for the purpose of establishing a biomass plant in Lakeview.
- Monitoring: LCRI will enter into a reciprocal agreement with COIC to share resources and findings regarding environmental, economic, community benefits, and programmatic monitoring related to CROP specifically and, as appropriate, ecosystem restoration projects in general.

Jim Walls, Executive Director
Lake County Resources Initiative

DG Energy Solutions LLC

DG Energy Solutions commits the following support for the Lakeview Biomass project:

- Support and guidance for Oregon Solutions: DG Energy Solutions has provided and will provide a dedicated executive to serve on the Oregon Solutions team assembled to support the Lakeview Biomass project effort, including providing first-hand knowledge of biomass project requirements, and participation in follow-up efforts as appropriate.

- Development Agreements: DG Energy Solutions has executed a preliminary development agreement with the Collins Companies for development of the Lakeview Biomass project on the site of The Fremont Sawmill in Lakeview, OR. DG Energy has drafted or executed detailed documents outlining the terms of provisions including Land Lease, Steam Purchase, Water Supply, Sawmill Waste, Chip Sale, and Log Purchase.
- Biomass Supply Study/CROP: DG Energy Solutions has arranged for the study of detailed biomass fuel supply, contracting with and providing the majority of funding for Mater Engineering to advance on matters critical to the development of a reliable fuel supply plan for the Lakeview Biomass project.
- Green Credits and Incentives: DG Energy Solutions will work with other Oregon Solutions team members to maximize and secure Business Energy Tax Credits, Renewable Energy Credits, Carbon Mitigation Credits, and other applicable local and federal production or investment tax credits to facilitate the development and financing of the Lakeview Biomass project.
- Project Implementation: DG Energy Solutions anticipates leading the advancement of the planning, permitting, design, commercial contracting, financing, construction and long term operation of the Lakeview Biomass project, bringing the majority of the equity capital required to develop and construct the project.

John Wood, Vice President
DG Energy Solutions, LLC

Town of Lakeview

The proposed Lakeview Biomass Plant will be located on Fremont Sawmill land both lying within the city limits of the Town of Lakeview. The Fremont Sawmill is a major employer and very important to the economic well being of the town. The Lakeview Biomass Project is a great economic opportunity for the town and we are here to support its reality in any manner we can. Restoring forest and range health are both environmentally and economically beneficial for the citizens of Lakeview, and to the Fremont Sawmill and the Lakeview Biomass Project.

- The Town of Lakeview will actively participate in Lakeview Biomass Project implementation team.
- As it deems appropriate, the Town will assist the Lakeview Biomass Project in seeking funding opportunities at the state and federal level.
- The Town Planning and Air Quality Committees will assist the project through the permit process.

Rick Watson, Mayor
Town of Lakeview

Central Oregon Intergovernmental Council

The Central Oregon Intergovernmental Council commits the following support for the Lakeview Biomass project through September, 2007 (support after this timeframe will be subject to additional funding availability):

- CROP/Supply Program Development: Subject to available funding, COIC will provide facilitation and technical assistance services, as needed, in association with LCRI, Mater Engineering, the USDA Forest Service, the Bureau of Land Management, and other partners to help create a sustainable long-term supply system focused on the Lakeview community.
- Monitoring: COIC will share available resources and findings regarding environmental, economic, community benefits, and programmatic monitoring related to CROP specifically and, as appropriate, ecosystem restoration projects in general.

Tom M. Moore, Executive Director
Central Oregon Intergovernmental Council

Oregon Natural Resources Council

As part of its mission to protect and restore Oregon's wildlands, wildlife and waters, ONRC is committed to the conservation and restoration of:

(1) *ponderosa pine and mixed conifer forests*, which have, as a result of logging, grazing and fire suppression, had their structure and composition degraded; and
(2) *sagebrush steppe*, which has suffered primarily from livestock grazing and fire suppression.

The reintroduction of natural fire regimes and modification of commercial logging and grazing practices are necessary to conserve and restore these forest and steppe ecosystems. Because of the unnatural build-up of small-diameter ponderosa pine, white fir and other tree species in forests and the invasion of western juniper into sagebrush steppe, it may be appropriate for large-scale, and intensive efforts to remove undesirable biomass from these ecosystems, using environmentally appropriate methods. In some cases, the reintroduction of fire without prior silvicultural treatment is appropriate. In other cases, the careful execution of a scientifically based thinning regimen is desirable before the reintroduction of fire. Any forest and steppe restoration regime must strictly conserve soil, water, biodiversity, roadless areas, and large and/or old trees.

The utilization of this surplus biomass material in the generation of electricity and steam can be consistent with such conservation and restoration. A power plant could also help diversify the southern Lake County economy, produce electricity from non-fossil fuel sources and can make industrial processes more efficient. In the short term, biomass energy generation could also improve the economics of forest and steppe restoration.

A biomass energy facility should be scaled to size and duration commensurate with the amount of material that is ecologically desirable and economically feasible to remove from the forest and the steppe over the next few decades. As forests and steppes are restored to again include a natural fire regime, unnatural increases of out-of-place trees and vegetation should be regulated more by fire than logging. Given the slow growth rates of vegetation in the area, it is neither feasible nor desirable, to consider large-scale cultivation of biomass on public or private lands to supply such a facility. However, over the next few decades, a biomass energy plant could reduce the large backlog of vegetation on public lands that has accumulated through previous mismanagement practices. Based on current information, it appears that the amount of available biomass that is ecologically desirable to remove from the forest and steppe is adequate to amortize the facility and indeed, to operate the facility for the length of its engineered design life

The establishment and implementation of a comprehensive landscape conservation and restoration strategy is essential for development of a successful biomass energy facility and the achievement of a stable biomass sale program. Such a plan would specify which areas are available for thinning to achieve forest and steppe restoration and which areas are not. By agreeing beforehand as to the conservation and restoration of the LFSU:

- local residents can know with confidence as to how much biomass is technically, economically, socially and politically available for energy production and job creation;
- timber interests can know with reasonable certainty how much timber will be available; and
- conservation interests can gain increased confidence that the LFSU is being managed for conservation and restoration across the landscape and over time.

In exchange for a permanent landscape conservation strategy that places roadless areas, old-growth trees and other key resources off-limits to commercial logging, ONRC will support and defend:

- efforts (including legislative) to improve the administration and planning of restoration projects and timber sales; and
- new strategies to adequately fund public land administration, environmental restoration projects and commercial timber sales that are restorative in nature.

Andy Kerr, Senior Counselor
Oregon Natural Resources Council

Oregon Department of Energy

Oregon Department of Energy (ODOE) will support the Lakeview Biomass Project in the following ways.

- Grants: ODOE will help identify appropriate grant sources and assist with writing or compiling grants to support planning, research and development of the project.
- Incentives: ODOE can provide expedited access to 35 percent Oregon Business Energy Tax Credits for non-federally funded portion of the biomass utilization project.
- Financing: ODOE can provided fixed-rate, fixed-term financing for the project up to a limit of $20 million dollars for an appropriately secured risk adequate for public bond underwriting.
- Technical Assistance: ODOE will provide data, analysis or help find others with information necessary to employ international best practices in biomass power facility design for optimized biomass use and highest return on investment.
- Communications: Upon request, ODOE will assist with communications, education or co-negotiation with federal, state or local government, utilities, consumers or neighboring public.

Michael Grainey, Director
Oregon Department of Energy

Energy Trust of Oregon

Energy Trust of Oregon's Strategic Plan includes a strong commitment to biomass energy, congruent with the Governor's *Renewable Energy Action Plan* and *Strategy for Greenhouse Gas Reduction*. We act on our commitment by investing in renewable energy projects that use eligible biomass resources to produce electric power for the benefit of Oregon customers of PGE and Pacific Power.

Forest and range biomass may be capable of playing a significant role in Oregon's clean energy future, provided that projects can be developed in an environmentally sustainable and economically viable manner. The time is right to explore this concept further.

To support the Lakeview Biomass Project, Energy Trust of Oregon makes the following commitment:

- Adam Serchuk, manager of Energy Trust's Biopower program, will serve on the Oregon Solutions team assembled to support the Lakeview effort, and participate in follow-up efforts as appropriate.
- When the project is closer to initial operation, Energy Trust will evaluate it as a potential recipient of funding through the Biopower or other appropriate program.

- To assist the development of the Lakeview project during 2006, Energy Trust will provide a 1:1 funding match to the Lake County Resources Initiative, up to a maximum Energy Trust contribution of twenty-five thousand dollars ($25,000), to support specific, discrete tasks that remove barriers to the project's viability.

Margie Harris 1/31/06
Margie Harris, Executive Director
Energy Trust of Oregon

Oregon Department of Environmental Quality

The Oregon Department of Environmental Quality (DEQ) will support the Lakeview Biomass Project in the following ways:

- Assist in developing and reviewing air emission data to assess the extent of net emission reductions of biomass power facilities as compared to wildfires and open burning (e.g. slash burning).
- Provide regulatory assistance to the biomass power facility and small diameter timber-utilizing businesses through DEQ's Business Response Team and participation on the South Central Economic Revitalization Team.
- Contribute assistance and support, within resource limits, and provide applicable DEQ data to the Lakeview Biomass Project Team.

Stephanie Hallock

Stephanie Hallock, Director
Oregon Department of Environmental Quality

Oregon Economic and Community Development Department

The Oregon Economic and Community Development Department (OECDD) will support the Lakeview Biomass Project in the following ways:

- Appoint Larry Holzgang, Business Development Officer, to act as the agency's primary representative and serve on the Oregon Solutions team for the duration of the project; and appoint Glenn Montgomery, Sustainable Business Liaison, to assist in a supporting role.
- Assist project partners in identifying and developing economically viable small diameter timber processing operations to support an adequate feedstock supply for the biomass power facility.
- Work with and through the Governor's Economic Revitalization Team to assist with regulatory streamlining of the proposed biomass facility.

- Evaluate the Lakeview Biomass Project as a priority project for funding through the Department's Business Development and/or Community Development programs and other strategic financing alternatives.

Lynn D Beaton

Lynn Beaton, Interim Deputy Director
Oregon Economic and Community Development Dept.

West Coast Regional Carbon Sequestration Partnership (WESTCARB)

The West Coast Regional Carbon Sequestration Partnership (WESTCARB) has identified that reducing wildland fire fuel loads and reducing stocking levels to improve forest vigor and long-term productivity as a regional opportunity in reducing carbon dioxide emissions through the avoidance of emissions from uncontrolled, catastrophic wildfire and through improved terrestrial sequestration and storage in the residual, fire resilient forests. WESTCARB supports the Lakeview Biomass Project because the project will conduct forest fuel and stocking treatments to improve forest vigor, health and fire resilience. Such action provides WESTCARB the opportunity to conduct research and technology development around the question of how can the carbon dioxide emission reduction benefits accruing to the residual, treated forestland be estimated, measured, monitored and reported to provide enough quality assurance regarding additional, permanent and reliable carbon offsets with no leakage and desired co-benefits such that the resultant offsets could be used to mitigate carbon dioxide emissions.

Specifically, WESTCARB plans to accomplish the following:

- Develop Methodology for Determining Carbon Dioxide Emission Reduction Benefits for Fire Management **–** The task consists of researching fire and fuel models, fire occurrence in western forests and impact of fires on carbon stocks both with and without fuel management treatment. The objective is to develop a baseline against which the carbon benefit of fuel management can be measured.

- Coordinate Implementation of Fuel Management Plan – In collaboration with participating landowner and resource management agencies, review and classify lands where fuel treatments will occur and coordinate the schedule and timing of fuel treatments to meet research and technology development needs.

- Measure Carbon Dioxide Emission Reduction Benefits from Implementation – Design measurement and monitoring plan for measuring carbon dioxide emission reduction benefits based on the volume of fuels removed and the resultant changes in fire behavior and severity and then measure and report carbon dioxide emission reduction benefits that are additional to the baseline estimate without fuel treatment.

- Achieve Carbon Offset Market Recognition and Validation – This task has four components: development of acceptable methods and procedures for reporting carbon benefits from changing fire management, preparation of necessary documentation to register all pilot project activities on the California Climate Action

Registry, review and acceptance of carbon benefits by available markets (e.g. DOE 1605(b) voluntary reporting, Climate Trust, Chicago Climate Exchange, etc.), and outreach.

WESTCARB is led by the California Energy Commission and funded in part by the U.S. Department of Energy National Energy Technology Laboratory's Regional Carbon Sequestration Partnership Program. The WESTCARB partners participating in the Lakeview Biomass Project are: Lake County Resources Initiative, Winrock International, Oregon State University, USDA Forest Service Pacific Northwest Research Station, Oregon Department of Forestry and the Oregon Forest Resources Institute. WESTCARB will provide this support through $1.19 million of U.S. Department of Energy funding to participating WESTCARB partners over a 4-year period beginning in federal Fiscal Year 2006. In addition, participating WESTCARB partners will be providing an additional $540,000 in matching, non-federal funds.

Larry Myer, Technical Director, WESTCARB
California Energy Commission

Sustainable Northwest

Sustainable Northwest (SNW) will support the Lakeview Biomass Project in the following ways:

1. <u>Fundraising and Capacity Building:</u> SNW will help identify, secure and leverage financial resources. SNW will also assist local community groups to expand their knowledge base and network of peers on topics related to biomass utilization and associated community development at an appropriate scale.
2. <u>Secure Sustainable Supply of Biomass:</u> SNW will share successful models of stewardship contracting facilitating effective restoration and associated biomass removal
3. <u>Intermediate Small Diameter Processing:</u> SNW will provide assistance to help design and implement an integrated utilization network that encourages highest value use for material removed. This assistance may include training, product development, individual business & business cluster development, and marketing services largely delivered through SNW's *Healthy Forests, Healthy Communities Partnership.*
4. <u>Coordinated Federal Policy Development:</u> SNW will work to engage the Lakeview Biomass Project in the *Rural Voices for Conservation Coalition*, a regional policy advocacy network.

Ryan Temple, Program Director
Sustainable Northwest

Klamath County Economic Development Association

The City of Klamath Falls, together with Klamath and Lake Counties, launched the Southern Oregon Climate Sustainability Project as a means of exploring the emissions reduction opportunities associated with a wide-ranging portfolio of project, programmatic, and behavioral measures. The project was formally launched during the summer of 2005 in anticipation of procuring CO2 mitigation funding from the proposed COB and PPM natural gas projects

Preliminarily, project proponents expect to deliver a minimum of 3,000,000 metric tons of CO2 over a 15-year contract period, reflecting a combination of CO2 emissions avoidance and sequestration measures. As emissions reductions accrue they will be reported to the Climate Trust. The Project will require a combination of up-front and pay-on-delivery funding, as specified in the full project proposal.

- Commitment: KCEDA agrees to include the Lakeview Biomass Project in the package of projects submitted to the Climate Trust for mitigation credits as part of the Southern Oregon Climate Sustainability Project. These credits will be determined at $/ton basis of carbon offsets.

L.H. Trey Senn, Executive Director
Klamath County Economic Development Association

The Wilderness Society

The Wilderness Society commits the following support for the Lakeview Biomass project:

- Long Term Strategic Plan for the Lakeview Federal Stewardship Unit: TWS will work with the Lakeview Stewardship Group to develop, publicize, and implement a long term strategy for the Lakeview Federal Stewardship Unit that meets both the ecological and social goals of the Unit, as outlined in the 2001 reauthorization language.
- Outreach: TWS will inform policy makers, media, and other environmental organizations of our support for an appropriately sized and ecologically sustainable biomass facility that utilizes biomass material generated as a by-product of restoration-oriented treatments consistent with the Long Term Strategic Plan for the Lakeview Federal Stewardship Unit.
- Monitoring: TWS will work with the Lakeview Stewardship Group to encourage and help oversee environmental monitoring programs designed to gauge the effectiveness of thinning and other treatments in achieving restoration objectives.

Michelle Ackerman, Pacific Northwest Regional Director
The Wilderness Society

3EStrategies / Business Alliance for Sustainable Energy

3EStrategies, through our Business Alliance for Sustainable Energy project will continue to support the Lakeview Biomass Energy Facility through the following measures. The degree of this support will be contingent upon funding availability.

- Networking and Liaison Services: 3EStrategies will continue to assist in convening the various stakeholders necessary for successful implementation of this project. 3EStrategies will aid LCRI in strategically working with elected officials, economic development interests and the media.
- Educational Leveraging: 3EStrategies will assist LCRI in documenting the process and outcomes of this project and creating educational materials to fully capitalize on the pilot project and model potential of this project.
- Connection to Larger Sustainable Energy Industry: 3EStrategies will assist the Lakeview Biomass Energy Facility in staying well positioned within the larger sustainable energy industry so as to effectively harness political and economic development leveraging opportunities.

Cylvia Hayes, Executive Director
3EStrategies

Oregon Department of Forestry

The Oregon Department of Forestry and the Klamath-Lake District will work with LCRI acting as a conduit of information regarding opportunities for private landowners and others to participate in the Lakeview Biomass Project. This will include distributing print and other material relating to biomass, and helping in developing and announcing meetings.

Greg Pittman, Lake Unit Forester
Oregon Department of Forestry

The South Central Oregon Economic Development District (SCOEDD)

SCOEDD supports the Lakeview Biomass Project and will work with LCRI in the future, as they have in the past, to do part in helping to ensure the proposed power plant is a successful project. An integral part of the Klamath and Lake County Regions strategy encourages the development of renewable energy and natural resource based projects. The Lakeview Biomass Project supports both of those aspects of the strategy.

Andrew Stuedli
South Central Oregon Economic Development District

Appendices

Appendix A. Glossary

economically viable
A market, product, or business in which an acceptable return on investment is derived over an acceptable timeframe.

(Source: COPWRR Steering Committee)

ecosystem, forest, or rangeland health
A condition where the parts and functions of an ecosystem are sustained over time and where the system's capacity for self-repair is maintained, such that goals for uses, values, and services of the ecosystem are met.

One of the signs of a healthy ecosystem in good working order is its ability to respond to disturbances such as fires, insects, or floods in a dynamic way. The system absorbs and recovers from disturbances without losing its processes or functions, although recovery may take varying amounts of time, or specific conditions may look different afterward. If the ecosystem is healthy, it will continue to produce populations of plants and animals that are diverse and viable, waters that are clear, air that is clean, and soils that remain productive.

(Source: Adapted from ICBEMP Draft EIS)

regional forest and rangeland biomass *inventory*
The total stock of biomass currently present on forest and rangelands in a defined region and/or, given growth rates and expected disturbances expectations, the total stock of biomass anticipated to be available annually over a period of time (e.g. 20 years).

(Source: OS Staff)

regional forest and rangeland biomass *supply*
A subset of biomass inventory: the annual volume of biomass from forest and rangelands in a defined region that, given economic (e.g. harvest and transportation costs, land management budgets, etc.), biophysical (e.g. sensitive habitats, steep slopes, etc.), and political considerations (e.g. Wilderness Areas, appeals, local community expectations, etc.) can be reasonably expected to be made available for utilization.

(Source: OS Staff)

sustainability
Using, developing and protecting our social, economic and environmental resources in a way, and at a rate, that enables people to meet their current needs without compromising the ability of future generations to meet their needs. It means increasing economic opportunities and improving social conditions by employing environmentally sound measures.

(Source: 3EStrategies)

Appendix B. Project Team Ground Rules

At their first meeting on May 12, 2005, the Oregon Solutions Project Team agreed to adopt the following Ground Rules for Collaboration:

General Principles

- We agree to approach problems with humility and adaptability. We will inevitably make mistakes and we will learn from these mistakes, make corrections, and not place blame.
- We recognize that we each have a unique perspective and contribution to make, whether it is expertise, labor, money, in-kind services, etc.
- We recognize that we must endeavor to involve any person or group who could help or hinder us to achieve our goals.
- We agree to focus on taking incremental "do-able" steps towards success.

Ground Rules

1. We recognize that the best outcome depends upon cooperation and collaboration by all entities at the table.
2. We commit to openly communicate ideas, potential contributions, and concerns, and also commit to engage in respectful, active listening to each other.
3. We are willing to creatively explore solutions.
4. We agree to commit to the agreed-upon solution, in whatever way we can. If we, individually, are unable to make a commitment for our organization, we will work to identify the person that can and determine if the commitment is possible.
5. We commit to building trust by doing what we say we will do, over and over.
6. We agree to notify each other before taking outside actions that might impact the process. (This does not mean that we will provide information that it would be inappropriate to share in a public venue.)
7. We agree that everyone shares in the solution, everyone shares in the credit.
8. The co-conveners and project staff commit to ensuring that this process does not result in "just a bunch of meetings."

Appendix C. Project Team Member List

First Name	Last Name	Company	Phone	Email Address
Mike	Anderson	The Wilderness Society	206-624-6430	MAnderson@twsnw.org
Scott	Aycock	COIC	541-548-9549	ScottA@coic.org
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Peter	Brewer	Oregon State Department of Environmental Quality	541-388-6146 ext.243	brewer.peter@deq.state.or.us
Rick	Brown	Defenders of Wildlife	503-697-3222	rbrown@defenders.org
Janet	Brown	Central Corridor Revitalization Team	541-475-0557	Janet.L.Brown@das.state.or.us
Chuck	Burley	Oregon House of Representatives	503-986-1454	rep.chuckburley@state.or.us
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Cindy	Glick	U.S.D.A Forest Service	541-408-5941	cglick@fs.fed.us.
Chuck	Graham	Lake County Resources Initiative; Oregon Hunters Association	(541) 947-4406	cjgraham@presys.com
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Cylvia	Hayes	3E Strategies	541-617-9013	info@3estrategies.org
Doug	Heiken	Oregon Natural Resources Council		dh@onrc.org
Larry	Holzgang	Oregon Economic & Community Development Dept	541-882-9600	larry.holzgang@state.or.us
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Bill	VonSegen	U.S.D.A Forest Service	503-808-2348	wvonsegen@fs.fed.us
Jim	Walls	Lake County Resources Initiative	541-947-	jwalls@gooselake.com

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Chuck	Wells	Friends of Fremont/Winema	541-783-2866	cswells@alwaysonnetworks.com
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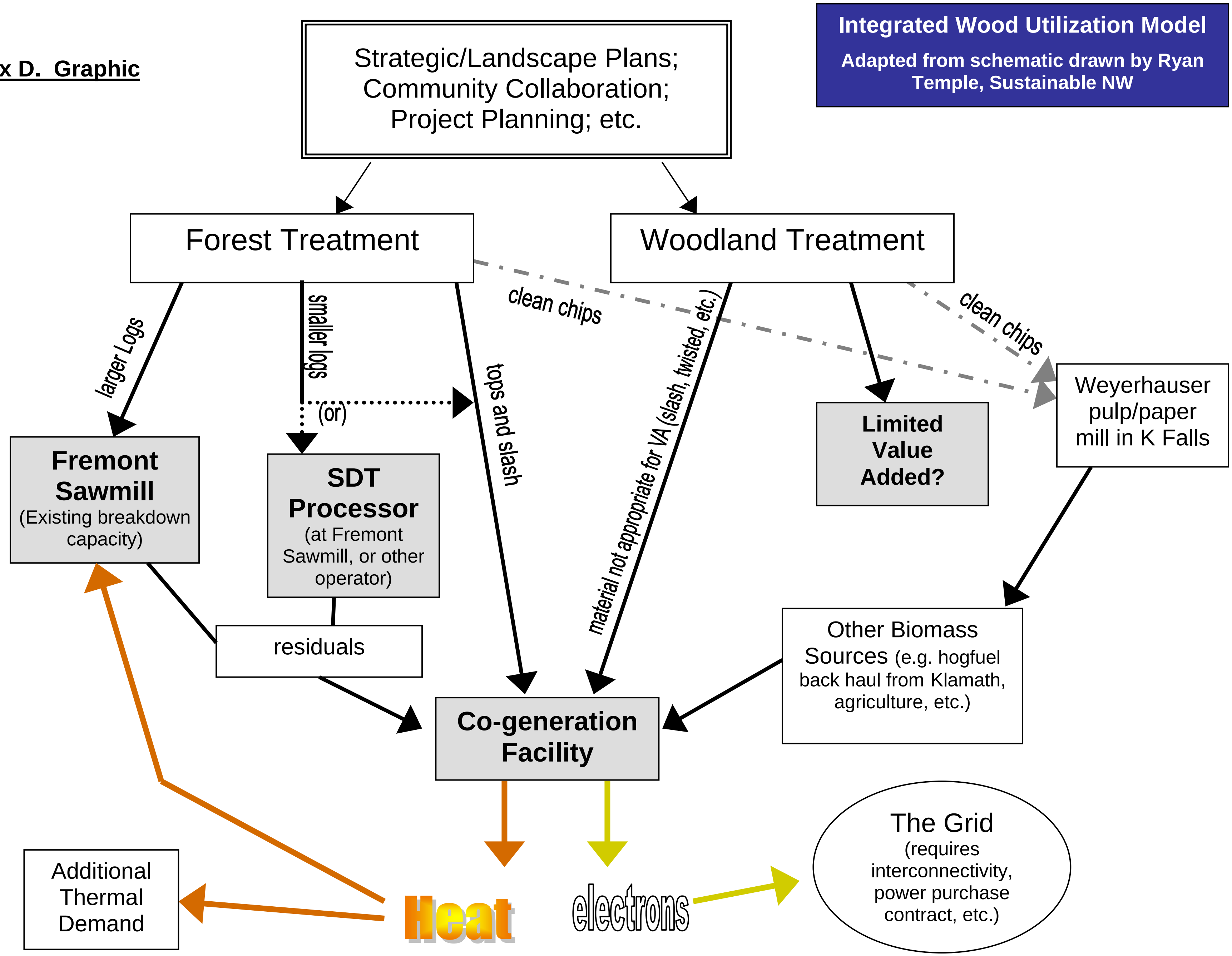
John	Wood	DG Energy Solutions, LLC	619-398-8446	John Wood <jwood@dg-energy.com>

Appendix D. Graphic



Appendix E. Implementation Plan

TASK OR CATEGORY	RESPONSIBLE PARTIES	TIME FRAME	POTENTIAL SUPPORTING ROLES
I. STAKEHOLDER COLLABORATION AND COMMUNITY ENGAGEMENT			
1) Identify "Ideal" Desired Future Condition; To help identify ideal treatment levels, regardless of current budgets, lack of markets, etc.	Public Land Agencies; Lakeview Stewardship Group, LCRI, Implementation Team	2006/2007	▪ COIC/The Nature Conservancy FLN process under way in Central OR. ▪ Planning resources ▪ Foundations
2) Ongoing Monitoring; Support existing monitoring effort, which may be threatened due to loss of Title II dollars. Ensure adaptive management by applying findings to practice (knowledge and technology transfer and uptake). Focus monitoring efforts on stewardship contracts, which already require it.	LCRI Implementation Team Lakeview Stewardship Group	Ongoing	▪ Lakeview Stewardship Group ▪ COIC – existing process in Central Oregon ▪ OSU, other research institutions
3) Community Outreach; Hold community and stakeholder meetings	LCRI, Public land Agencies	Ongoing	▪ Implementation Team
4) Pursue External Networks and Partnerships; Continue to work with external networks to leverage resources and share information	LCRI, Implementation Team, Lakeview Stewardship Group	Ongoing	▪ COIC/CROP ▪ BASE ▪ Sustainable NW
II. SUPPLY, SCALE, DESIGN			
1a) Perform CROP Supply Analysis; Identify supply most likely to be made available over at least a five year period, by at least species, diameter class, and source.	Mater Engineering; Fremont-Winema National Forest; Lakeview BLM (heretofore "public land agencies"); CA/NV USFS and BLM units; private sources	Fall/Winter 2005/2006	▪ COIC can help with next steps for CROP (e.g. database) ▪ DG Energy ▪ Energy Trust of OR
1b) Analyze projections; create Resource Offering Maps and apply business sensitivity/risk analysis to generate conservative estimates of supply.	Mater Engineering, DG Energy, other interested businesses	Winter/ Spring 2006	▪ Input/assistance from public land agencies, LCRI ▪ Implemen. Team

TASK OR CATEGORY	RESPONSIBLE PARTIES	TIME FRAME	POTENTIAL SUPPORTING ROLES
2) Appropriate Harvest Techniques; Support the development and utilization of ecologically-friendly extraction techniques suited to harvest and removal of small diameter material	Public land agencies; LCRI, Lakeview Stewardship Group	Spring 2006 – ongoing (monitoring)	▪ Research grants; OSU; other institutions ▪ Implementation Team ▪ Foundations ▪ USFS Equipment Development Ctrs.
3) Develop Public Land Supply; Develop stewardship contracts and other biomass contracts.	Fremont-Winema NFs, Lakeview BLM, LCRI, Implementation Team	Winter 2006 - ongoing	▪ Knowledge transfer/etc. from stewardship contracts around the country[2] ▪ Governor's Office ▪ ODF
4) Identify Sustainable Scale of Facility; based on work accomplished in tasks I.1-3, supply feasibility and costs, and business and power market considerations, etc.	DG Energy, Implementation Team, Lakeview Stewardship Group	Spring-Summer 2006	
5) Design Facility; Select technology (e.g. gasification vs. incineration).	DG Energy	as per DG timeline	
6) Funding for Supply; Develop additional resources to secure supply.[3]	Implementation Group, other beneficiaries of restoration work (e.g. communities, other agencies); Fremont-Winema NFs, LCRI.	Winter, 2006 - ongoing	▪ Foundations ▪ OR Delegation

[2] For example, the White Mountain stewardship project in Arizona helped to stimulate a biomass power facility.
[3] Including, potentially, the use of special legislation to reduce costs and increase funding as outlined in the ONRC support statement.

TASK OR CATEGORY	RESPONSIBLE PARTIES	TIME FRAME	POTENTIAL SUPPORTING ROLES
7) Secure Supply; Decide who will bid on the public land supply. Also develop and secure private land supply, waste stream sources, etc.	Collins Companies, DG Energy, LCRI	Winter, 2006 - ongoing	▪ Implementation Team ▪ ODF via SB 1072 (?) ▪ ODF could assist with private land supply
III. ASSOCIATED EC0NOMIC OPPORTUNITIES			
1) Develop an Economic Development Strategy; including a short list of SDT processing opportunities suitable to CROP-identified supply and supply costs.	LCRI; Implementation Team; Collins Companies; DG; local businesses; Chamber	February – Aug. 2006	▪ OECDD ▪ EDA ▪ USDA Forest Products Lab ▪ OSU College of Forestry ▪ Sustainable NW
2) Market Opportunities; If necessary (if local operators don't initiate on their own)	LCRI, DG Energy, Implementation Team	Summer-Fall 2006	▪ Sustainable NW ▪ OECDD ▪ KCEDA ▪ BASE
3) Secure Investments	LCRI, DG Energy	Summer-Fall 2006	▪ KCEDA ▪ OECDD ▪ BASE ▪ Collins Companies
4) Negotiate waste heat purchase by Fremont Sawmill	DG Energy, Collins Companies	Spring-Summer 2006	
5) Market Excess Waste Heat; Depending upon power facility capacity and volume required by Collins, ID additional waste heat capacity and market it.	DG Energy, LCRI	Spring-Summer 2006	▪ Tempo Foam, or other businesses ▪ OECDD ▪ KCEDA
6) Market Other By-Products; ash, etc.	DG Energy, LCRI	Spring-Summer 2006	▪ OECDD ▪ KCEDA

TASK OR CATEGORY	RESPONSIBLE PARTIES	TIME FRAME	POTENTIAL SUPPORTING ROLES
IV. POWER PURCHASE AGREEMENT AND INTERCONNECTION			
1) Negotiate Power Purchase Agreement/Sales Contract	DG Energy, Utility	as per DG timeline	▪ BASE ▪ Governor's Office ▪ LCRI
2) Negotiate Interconnection; Companies/model depends on the power purchaser	DG Energy, Utility, local utility (if required)	Upon completion of task III.1	
V. CREDITS AND INCENTIVES			
1) Secure Business Energy Tax Credit and Production Tax Credit	DG Energy, ODOE	as per DG timeline	▪ Energy Trust
2) Secure Business Development Incentives; including Enterprise Zone and Small City Income Tax Exemption	DG Energy, Lake County, OECDD	as per DG timeline	
3) Apply for Energy Trust Biomass RFP	DG Energy	as per DG timeline	▪ Energy Trust[4]
4) Secure Carbon Mitigation Credits for Direct Fossil Fuel Displacement at Facility	KCEDA, DG Energy, LCRI	as per DG timeline	▪ Climate Trust
5) ID Carbon Mitigation Credit Potential for Fuel Treatment Mitigation of Uncharacteristically Severe Wildfires	WESTCARB	2009(?)	▪ LCRI ▪ Climate Trust
6) Other Initiatives – e.g. designation of the Lakeview project as a pilot under the Governor's REAP	Depends on the initiative	ongoing	
VI. PERMITTING			
1) Secure Air Quality Permits	DG Energy, ODEQ	as per DG timeline	▪ With assistance of DEQ's Business Response Team
2) Secure Land Use Permits	DG Energy, City/County	as per DG timeline	

[4] ETO is agreeing to provide up to $25,000 in 1:1 match funds to help develop this project to become competitive for the RFP process.

TASK OR CATEGORY	RESPONSIBLE PARTIES	TIME FRAME	POTENTIAL SUPPORTING ROLES
VII. IMPLEMENTATION TEAM			
1) Develop Implementation Team, Tasks, and Meeting Schedule; this team will take on the resolution of outstanding multi-stakeholder issues – including supply, ecologically-sensitive harvesting techniques, SDT processing opportunities, develop additional treatment funds, etc (Team is listed in appropriate places above). An early task should be to revisit this Implementation Plan.	LCRI (team coordinator), Public Land Agencies, DG Energy, ODF, Collins Companies, Lakeview Stewardship Group/Environmental Group	After DOC Signing through completion	▪ BASE ▪ COIC ▪ Others

Appendix F. Background Reports, Documentation, Existing Efforts

(Placeholder)

- Reauthorization of the Lakeview Federal Sustained Yield Unit;
- Lakeview Stewardship Group collaborative effort since 1998;
- Long Range Strategy for the Lakeview Federal Stewardship Unit,
- Lakeview Biomass Feasibility Study;
- WESTCARB Grant;
- University of Washington Study;
- Investigation of Alternative Strategies for Design, Layout and Administration of Fuel Removal Projects;
- LCRI Monitoring program.

Preliminary Assessment of the Economic Impacts of the Collins Pine and Biomass Facility Project on Lake County
January 2010

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Oregon Business Development Department
Global Industry Strategies
121 S.W. Salmon
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Project Specifications[1]

Project Description

Collins Pine

- Retention of 65 jobs at Collins Pine sawmill

Biomass Facility

- Construction of a $70 million biomass facility
- Creation of 60 logging jobs to provide the feedstock for the biomass facility
- Creation of 10 sawmill jobs at the biomass facility
- Creation of 8 power generation jobs at the biomass facility

The following assumptions are made in analyzing the economic impact of the project on Lake County's economy:

- The company's inputs will originate from Oregon and workers filling the positions will reside within Oregon.
- The company's investments will not displace other investments in Lake County but instead will add to the total stock of economic activity in the county.
- The total biomass investment value of $70 million is not used in the model. A $70 million investment will support 250 direct jobs (IMPLAN implied sales equal $35 million) and $45 million in equipment purchases.

Methodology

This analysis considers the impact of investment and direct jobs created by the retention of Collins Pine and the construction of a biomass facility on total employment, labor income (wages), and state personal income tax. The total impact is the sum of the following three impacts:

- Direct Impact: impacts associated with the company's employment and wages
- Indirect Impact: impacts resulting from suppliers to the company
- Induced Impact: impacts resulting from purchases made with income earned from the company and its suppliers

To estimate the project's impact on personal income taxes, an effective state personal income tax rate of 5.67% is used to calculate the total tax revenue generated by this project. This rate is based on 2007 personal income tax estimates generated by the Oregon Department of Revenue. Although this rate is significantly lower than highest marginal personal income tax rate of 9%, it represents the actual share of a household's adjusted gross income that is ultimately received by the Oregon Department of Revenue.

[1] Data provided by Larry Holzgang on January 14, 2010.

Collins Pine Impacts

Table 1. Employment

Project	Direct	Indirect	Induced	Total
Collins Pine	65	29	15	110

Source: IMPLAN (2008, Lake County, Oregon

Table 2. Labor Income (Wages)

Project	Direct	Indirect	Induced	Total
Collins Pine	$4,267,046	$1,598,825	$388,000	$6,253,871

Source: IMPLAN (2008, Lake County, Oregon

Table 3. Estimated Personal Income Taxes*

Impact Type	Direct	Indirect	Induced	Total
Collins Pine	$241,942	$90,653	$22,000	$354,594

Source: IMPLAN (2008, Lake County, Oregon
*Based on a 2007 average effective income tax rate of 5.67%. Author's calculations based on Oregon Department of Revenue personal income tax data.

Biomass Facility Impacts

Table 4. Employment

Impact Type	Direct	Indirect	Induced	Total
Construction	250	36	30	316
Logging	60	18	13	91
Sawmill	10	5	2	17
Electricity Generation	8	1	3	12
Total	328	59	47	435

Source: IMPLAN (2008, Lake County, Oregon

Table 5. Labor Income (Wages)

Impact Type	Direct	Indirect	Induced	Total
Construction	$8,966,995	$1,571,861	$743,569	$11,282,430
Logging	$3,642,292	$966,130	$316,401	$4,924,823
Sawmill	$656,469	$245,973	$59,692	$962,134
Electricity Generation	$968,761	$27,598	$68,666	$1,065,025
Total	$14,234,517	$2,811,562	$1,188,328	$18,234,412

Source: IMPLAN (2008, Lake County, Oregon

Table 6. Estimated Personal Income Taxes*

Impact Type	Direct	Indirect	Induced	Total
Construction	$508,429	$89,125	$42,160	$639,714
Logging	$206,518	$54,780	$17,940	$279,237
Sawmill	$37,222	$13,947	$3,385	$54,553
Electricity Generation	$54,929	$1,565	$3,893	$60,387
Total	$807,097	$159,416	$67,378	$1,033,891

Source: IMPLAN (2008, Lake County, Oregon

*Based on a 2007 average effective income tax rate of 5.67%. Author's calculations based on Oregon Department of Revenue personal income tax data.

Combined Project Impacts

Table 7. Employment

Impact Type	Direct	Indirect	Induced	Total
Collins Pine	65	29	15	110
Biomass	328	59	47	435
Total	393	89	63	544

Source: IMPLAN (2008, Lake County, Oregon

Table 8. Labor Income (Wages)

Impact Type	Direct	Indirect	Induced	Total
Collins Pine	$4,267,046	$1,598,825	$388,000	$6,253,871
Biomass	$14,234,517	$2,811,562	$1,188,328	$18,234,412
Total	$18,501,563	$4,410,387	$1,576,328	$24,488,283

Source: IMPLAN (2008, Lake County, Oregon

Table 9. Estimated Personal Income Tax*

Impact Type	Direct	Indirect	Induced	Total
Collins Pine	$241,942	$90,653	$22,000	$354,594
Biomass	$807,097	$159,416	$67,378	$1,033,891
Total	$1,049,039	$250,069	$89,378	$1,388,486

Source: IMPLAN (2008, Lake County, Oregon

*Based on a 2007 average effective income tax rate of 5.67%. Author's calculations based on Oregon Department of Revenue personal income tax data.