MOKELUMNE WATERSHED AVOIDED COST ANALYSIS:

Why Sierra Fuel Treatments Make Economic Sense

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FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

Chapter 7: Treatment Costs and Impacts — Timber and Biomass

7.1 Introduction

In this chapter, we describe the fuel treatments scenario used to rerun the fire model to determine the effectiveness of modeled fuel treatments in the Mokelumne watershed. We apply typical fuel treatments implementation costs by treatment type and the land type where the treatment is placed, for the full implementation of the modeled treatments. Implementation costs are based on information provided by federal and local land managers in the Mokelumne watershed, with review and verification from published literature on fuel treatment costs. We also describe a scaled back approach to the full 100% coverage suggested by the model, based on the methods for fuel treatments used by local land managers and locals familiar with the use of fuel treatments within the watershed, including the Bureau of Land Management (BLM), U.S. Forest Service (USFS), Amador Fire Safe Council, and the Calaveras Foothills Fire Safe Council. We use scaled-back treatment percentages to give a secondary estimate of the costs of treatments according to treatment densities employed by locals in past projects, which are less than 100% of total land cover for an area. Because the level of resolution for our modeling utilizes full treatment (100% of area), and therefore we do not have modeling data to determine the modeled effectiveness of a scaled-back approach, we provide both costs in this chapter.

7.2 Treatment Scenario

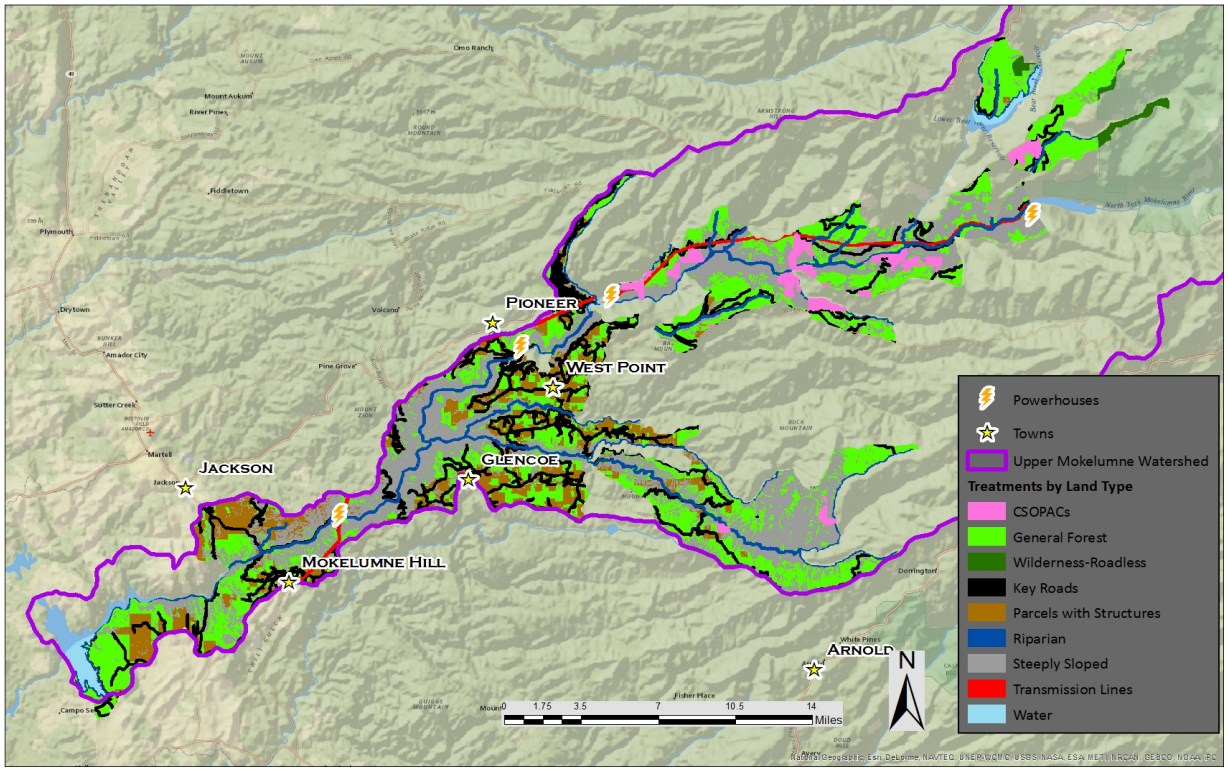
The Committee assigned with the task of designing the treatment scenario developed a treatment matrix to help identify specific treatment strategies for specific portions of the study area (see Table 7.1, or Chapter 2 for more information). Each treatment code corresponds to a specific treatment type, level of overall treatment, and level of canopy treatment, which are the required inputs for the fire model we used for this analysis (Appendix A). The committee then assigned specific treatment codes to Analysis Units (AUs) in the study area, and summarized the treatment scenario spatially in GIS.

The treatment scenario in Figure 7.1 and Table 7.2 assumes 100% treatment of the area for the treated AUs, or rather that within an AU every acre has been treated. In a later section, we discuss the implications from interviews with local land managers, based on their expert opinion and local knowledge, on the actual percentage of an AU that likely needs to be treated to achieve the desired treatment effect.

Table 7.1: Treatment code matrix

	Treatment type	*Level of treatment*	*Level of canopy treatment*
Land type	100 = Wildfire and prescribed burn	10 = Low under burns, light thinning	1 = Low, light under burns, piling of existing surface fuels
	200 = Mechanical mastication, lop & scatter, piling	20 = Moderate, mixed severity burns, moderate thinning	2 = GTR 220 type treatment
	300 = Mechanical timber harvest or biomass removal	30 = Stand replacing burns, clearcuts, seed tree	3 = Shaded fuel breaks, wildland-urban interface treatments

Figure 7.1: Map of treatment scenario



7.3 Costs, Revenues, and Impacts of Fuel Treatments

In this section, we discuss the costs, revenue, and economic impacts associated with fuel treatments in the study area, as identified and designed by the committees. As described in Chapter 2, the treatment scenario relies on several different treatment strategies (e.g., prescribed burns, mechanical harvest) on different land types. The committees considered the hazards and benefits associated with each of these treatment strategies and the locations they are applied to when developing the overall treatment scenario. This section has four parts. First, we discuss the costs of fuel treatments. Second, we discuss potential revenue of timber and biomass harvested during treatment. Third, we discuss how revenues and costs would change over time. Finally, we provide a brief discussion of the economic activity potentially supported by the modeled fuel treatments efforts.

7.3.1 Costs of Fuel Treatments

As previously described, during the development of the treatment scenario, the committees considered the potential hazards from fire and how implementing different treatment strategies might affect fire behavior. In section 7.7, we provide a literature review that informed our cost estimates for the treatment scenario. We also asked BLM, USFS, and local fire district representatives to review our cost estimates based on their experience implementing fuel treatments in the Mokelumne watershed. They also provided us with estimates of fuel retreatment requirements over time.

Table 7.2 summarizes the treatment scenario and aligns each treatment strategy with its potential costs based on local fuel treatment experience, augmented with literature review. These costs represent the initial treatment cost, but not total treatment cost over some time period (see section 7.5). The range in costs reflects a combination of literature-based estimates combined with estimates from local land managers as described above. Because the fire model was run at 100% treatment coverage of land in each AU, the literature review-based costs listed in Table 7.2 are based on 100% treatment of the AUs. In reality, local land managers report that not every acre needs to be physically treated for an area to be more resilient against fire, based on their experience. In Table 7.3, we contrast the cost implications for full treatment of an AU with the costs associated with an effective percentage of treatments, as described by locals.

Table 7.2: Treatment summary and costs

Land Type	*Treatment code*	*Total acres*	*Treatment cost ($/acre)*	*Total cost (millions)*
CSO PAC	111	3,076	$200–$390	$0.6–$1.2
General forest	322	30,740	$130–$1,100	$3.8–$35
Key roads	323	15,946	$300–$1,800	$4.7–$29
Parcels with structures	323	10,039	$300–$1,800	$3.0–$18
Riparian	311	7,542	$130–$1000	$0.9–$7.5
Steeply sloped	322	30,121	$130–$2,200	$60.9–$67.8
Transmission lines	323	1,557	$300–$1,800	$1.9–$2.8
Wilderness-roadless	111	873	$300–$900	$0.3
Total	*N/A*	*99,894*	*$130–$2,200*	*$17–$160*

Note: CSOPAC = California spotted owl protected activity centers.
Source: Input from William Haigh, BLM, and review by other local land managers, with literature review for verification. See 7.7 for the literature details.

7.3.1.1 Alignment with typical treatment coverage in the area

In total, the modeled treatment scenario covers nearly 100,000 acres and implementing this scenario would cost between $17 and $161 million. For the fire modeling conditions and to minimize the number of assumptions that are made, we must assume the entire treatment scenario is completed in one year. In section 7.5, we show cost estimates for a treatment process over time that is more realistic. To refine the cost estimate, we align the treatment types and coverage with costs for recent and ongoing fuel treatment projects in the Mokelumne, which results in an

estimate of $46 million, not including treatment maintenance costs later down the road (Table 7.3). Based on estimates by type of treatment and land type with appropriate share of total area treated, locals estimate that an actual strategy to achieve fire-resiliency results comparable with our modeled treatment scenario would cost $16 million.

Table 7.3: Treatment costs and coverage based on local feedback

Land type	*Local treatment cost ($/acre)*	*Total cost (100% treatment)*	*Share of land treated*	*Total cost (reduced coverage)*
CSOPACs	$250	$770,000	30%	$230,000
General forest	$210	$6,500,000	40%	$2,600,000
Key roads	$1000	$16,000,000	50%	$8,000,000
Parcels with structures	$1000	$10,000,000	10%	$1,000,000
Riparian	$700	$5,300,000	30%	$1,600,000
Steeply sloped	$210	$6,400,000	40%	$2,600,000
Transmission lines	$430	$660,000	40%	$260,000
Wilderness-roadless	$250	$220,000	40%	$87,000
Total		*$46,000,000*		*$16,000,000*

Source: ECONorthwest with input data from W. Haigh, BLM. Data rounded to 2 significant digits.

7.3.2 Factors influencing costs

In general, the costs of fuel treatments are site specific, therefore estimating an overall cost for the modeled treatment scenario is difficult. Among the factors that play an important role in determining treatment costs are: (1) public vs. private land, (2) inclusion of biomass collection efforts, (3) treatment method (e.g., prescribed fire, thinning, harvest), (4) harvest method (e.g., mechanical, manual), (5) topography and location (e.g., steep slope, WUI, riparian), and (6) proximity to roads. In some cases, a single factor can double treatment costs for a particular area (e.g., biomass collection efforts). Given the large and diverse area included in the modeled treatment scenario, the range of costs included in this analysis likely reflects the correct order of magnitude of potential costs of fuel treatments. It is important to point out that the costs portrayed here, for the most part, likely only capture a portion of the planning costs of implementing the treatments on the ground. Planning costs are highly variable, agency-specific, and intermingled with other efforts and staff responsibilities. Consequently, planning costs are not typically included in fuel treatment cost estimates from the literature for these stated reasons (e.g., Calkin 2006).[1]

7.4 Revenues from Fuel Treatments

The modeled treatment scenario has the capacity to generate revenue in two ways: (1) the merchantable timber removed in timber harvests can be sold to local mills, and (2) the biomass

[1] Note: We did request planning costs for inclusion in treatment cost estimates, but information is not readily available to fully estimate all planning costs at this scale of treatment implementation by agency staff.

collected can be sold to local facilities for value-added products, such as to generate electricity, as bedding for animals, or as landscaping materials. In order to quantify the potential value of these revenue sources, we must make several assumptions regarding the volume of each forest product collected for each of the modeled fuel treatments, as well as the average value of the forest products on the market.

7.4.1 Total available volume

To later consider the share of total potential timber and biomass harvested, here we first consider the total potential volume. This is helps frame consideration of the sustainability and feasibility of the later harvest and biomass assumptions.

According to the USFS's forest inventory database (FIDO), there are a total of about 983,000 acres of forestland and timberland in Amador and Calaveras counties. These forested areas contain a total of 3.1 billion cubic feet of live tree volume with at least a DBH (diameter at breast height) of 5 inches. Therefore the average acre of forested land in the two counties holds about 16 MBF (thousand board feet).[2] The material that would not be used for merchantable timber could be converted to chips for use in a biomass facility. We vetted these potential timber and biomass volumes with local land managers to assess the realistic potential from the treatment areas. In practice, they reported that volumes accessible under current practices in the region associated with fuel treatment activities are substantially less than these per acre potentials. Vegetation composition, age, density, and accessibility all contribute to reducing the potential volume to actual harvestable volumes. Our volume estimates in following sections are based on actual harvest volumes observed by land managers available during fuel treatments in the project area. Actual volumes are typically much less than these calculations suggest as volume potential, suggesting that relatively small shares of the trees and biomass volume are part of the harvest assumptions.

7.4.2 Per unit revenue

In 2011, the average value of timber harvested from public and private forests in these two counties ranged from $90–$*176* per MBF (California Board of Equalization 2011). A 2010 report from USFS states that existing biomass power plants in California typically pay $25-$45 per BDT for forest fuel (USFS 2010). These prices account for costs of transport and energy generation, as well as the revenue from the sale of the energy generated. We use these ranges of values to estimate the potential revenues derived from merchantable timber and biomass chips harvested during fuel treatments. These per unit values include existing subsidies. For example, the per BDT value for biomass represents the range in prices that biomass energy facilities typically pay for biomass in California. These businesses, however, often receive government subsidies to help bring revenues up enough to cover costs.

7.4.3 Potential harvest

BLM staff report that their maximum merchantable timber volumes have historically been 2-3 MBF/acre in the project area. USFS lands in the Mokelumne are generally considered to hold a

[2] There are about 5 board feet per cubic foot of timber volume for these timber stands.

higher harvest potential per acre. We apply 2 MBF to the BLM treatment areas with identified merchantable timber and compatible treatment techniques, and 3 MBF to the corresponding USFS lands.[3] Applying 2.5 MBF per acre of potentially harvestable timber to the general forest and steep slope areas as local land managers advised for non-federal areas, we estimate 152,000 MBF of total merchantable timber for those treatment areas with treatments compatible with timber removal.

For biomass volumes, we used the CAL FIRE database on existing forestry biomass (Geodatabase: BioVeg 2005; Methodology: Sethi 2005). The resulting average potential non-merchantable chip biomass in BDT per acre ranged from 4.5 to 5.3. Depending on the treatment type, some areas would yield both non-merchantable and merchantable timber, others would yield only non-merchantable timber, while other areas would not have any of its trees/biomass removed. Applied to the 95,946 acres of treatments from which biomass would be removed and 60,862 for which timber would be removed, the result in a total merchantable biomass removed of 464,000 BDT.

7.4.4 Total revenue of potential harvest

In order to calculate the total revenue associated with the modeled treatment scenario's harvests, we align the per unit revenues estimates with potential harvest volumes. With a per unit revenue of $90–$176 per MBF, the 152,000 board feet harvested during treatment could generate $14–$27 million in revenue. With a per unit revenue of $20–$45 per BDT, the 464,000 BDTs of merchantable biomass potentially collected during treatment could generate $12–$21 million in revenue. Due to access, market demand, and harvest capacity, it is unlikely that these full revenue potentials could be realized. Likewise, cultural and environmental sensitivity may require a reduction/relocation in the scope of treatments. Achieving these revenue levels would require carefully coordinated and staggered implementation over time.

7.5 Treatment Costs and Revenues over Time

In reality, the treatment scenario likely would play out over a multi-year period, as opposed to the single year of implementation that was required in the modeling scenario. To account for the potential effect of multi-year treatment implementation on the net present value (NPV) of treatment costs and revenues, we evenly distribute treatment costs and revenues over three time horizons: a 10-year treatment plan, a 20-year treatment plan, and a 30-year treatment plan. We also include a cost scenario involving maintenance every 5 years at a third of the initial cost for WUI areas and BLM-managed general forest, and at 20 years for all other land at 100% of the original treatment cost.[4] Table 7.4 summarizes these time horizons. For each scenario, we show the potential revenue from merchantable timber sales, the potential revenue from chip sales to biomass facilities, and the net treatment costs under four time horizons. All net present value calculations are based on a 3% discount rate.

[3] Timber harvest volumes based on BLM and USFS staff recommendations.
[4] From personal communication with W. Haigh from the Bureau of Land Management, in October 2013.

Table 7.4: Summary of treatment costs and revenues over time[a] in $ millions

Treatment time horizon	*Treatment costs*	*Treatment costs with retreatment*	*Potential revenue from merchantable timber*	*Potential revenue from chips*	*Net cost (with retreatment)[b]*
1-year treatment plan	$46	$46	$14–$27	$12–$21	$34–($2)
10-year treatment plan	$39	$42	$12–$23	$10–$18	$32–$1
20-year treatment plan	$34	$47	$12–$23	$10–$18	$37–$6
30-year treatment plan	$30	$68	$9–$17	$8–$14	$60–$37

a: 3% discount rate. b: Net based on low end is lowest of the two revenue sources, and high end is based on sum of the high estimates for each revenue source. Values in parentheses represent net revenue (revenues greater than costs).

Net potential revenue faces the most uncertainty. For one, there is no available inventory data for merchantable timber at the AU-specific level. Likewise, the market demand and price for timber can fluctuate significantly over time. Biomass revenue potential is currently constrained by regional generation capacity and high transportation costs. The Buena Vista biomass power plant in Ione currently has 19 MW capacity, and the proposed Wilseyville site would likely have between 1-3 MW of capacity. The typical burn rate in biomass facilities is 1 BDT per MW per hour. This would equate to a regional demand for between 20 and 22 MW of approximate 175,000-193,000 BDT per year or more. Therefore, the regional biomass generation capacity is likely sufficient to meet the fuel generated by the 10-30 year treatment plans, assuming little competition from other forest biomass value-added utilization opportunities.[5]

7.6 Economic Impacts of Fuel Treatment

This section describes the economic activity potentially supported by treatment-related activities. First, we describe what we mean by economic activity, economic impacts, and economic impact analysis. Second, we provide a brief summary of the economic conditions in Amador and Calaveras counties, to help put our analysis in context. Finally, we describe and summarize the economic activity supported by treatment-related harvests, biomass collection, and prescribed burns.

7.6.1 What is Economic Impact Analysis?

So far, we have focused on the costs and revenues associated with fuel treatments. In this section, we focus on how those costs and revenues translated into economic impacts. The term *economic impacts* has a very specific definition to economists: the economic activity (e.g., the number of jobs, total income, and tax revenues) supported by a specific action. Because the implementation of fuel

[5] Assuming a 10 year time horizon, the 464,000 BDT would equate to 46,400 BDT/year, well within the range of demand annually from current capacity.

treatments requires labor, materials, and other goods and services, it supports economic activity. The tools economists use to estimate economic impacts provide gross, rather than net, results. In other words, these results do not necessarily reflect new jobs or new earnings. After all, resources used to fund fuel treatments could have been used to fund other projects. Similarly, some of the individuals employed by treatment-related spending could have worked on some other project, or may have left an existing occupation to pursue treatment-related work.

There are two types of economic impacts:

- *Direct impacts* describe the economic activity directly tied to spending associated with fuel treatments (e.g., wages paid to workers).
- *Secondary impacts* include indirect impacts and induced impacts. Indirect impacts occur as businesses buy materials from other businesses. They begin with changes in economic activity for businesses that supply the businesses implementing the treatments (e.g., the welding supply business that rents equipment is a secondary impact from rentals by construction contractors) and continue as those businesses purchase the goods and services they need to operate. Induced impacts represent the economic activity supported by changes in household incomes generated by direct and indirect impacts.

Each type of impact (direct and secondary) is described in terms of two variables that measure economic activity:

- *Output* is the broadest measure of economic activity and represents the value of production. Output includes intermediate goods plus the components of value added.
- *Employment* represents full-and part-time jobs. In some instances, this analysis refers to "job years", which represents the equivalent of one full- or part-time job for one year. Ten job years, for example, could refer to one job for 10 years, five jobs for two years, 10 jobs for one year, etc.

7.6.2 Local Economic Context

Economic impact analyses help economists understand the total economic activity an action can support. In order to understand local economic impacts, we must first look at the local economies in Calaveras and Amador counties. Table 7.5 summarizes demographic and employment data in the two counties. In 2012, the counties combined for an unemployment rate of about 12.4% with a total of 4,491 unemployed individuals. These unemployment rates remain high relative to historical unemployment rates and have grown sharply over the last 5 to 10 years. However, the most recent monthly unemployment data (December 2013) suggests that unemployment in these two counties has declined to 9.0% in Amador County and 9.4% in Calaveras County (Bureau of Labor Statistics 2014). The U.S. Census Bureau compiles data on the industry that employed individuals are currently working in, as well as their occupations, which is summarized in the top section of Table 7.6. The second row of this table is of particular importance to this analysis. A total of 357 individuals in Calaveras County and 279 in Amador County were employed in the agriculture, forestry, fishing and hunting, and mining industry category. The bottom section of Table 7.6 summarizes the number of employed individuals in the two counties, compared to the rest of the country, by occupation category. Across the two counties, about 7,200 individuals (about 23% of all employed individuals) were employed in two occupation categories: (1) natural

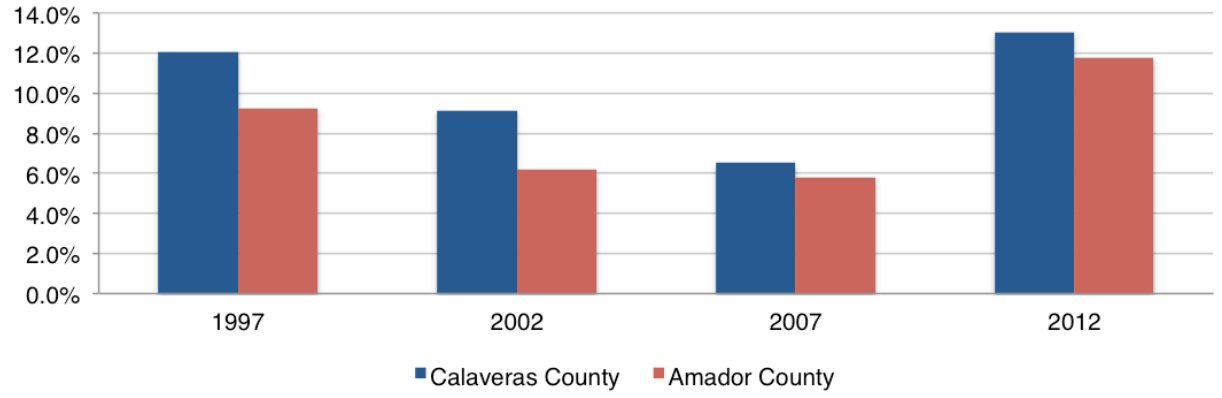
resources, construction, and maintenance occupations, and (2) production, transportation, and material moving occupations.

The existing economic conditions in these two counties confirm that a number of individuals rely on jobs in the fields of natural resources, construction, maintenance, production, and/or transportation. Furthermore, an additional 21% and 25% of employed individuals in Calaveras and Amador counties, respectively, have service-related occupations that are primarily supported by other employed individuals living and doing business in the two counties. Together, these three occupation categories account for about half of the jobs currently held in Calaveras and Amador counties.

Table 7.5: Demographic and employment summary

	Calaveras County	*Amador County*	*Total*
Total population (2012 Estimate)	44,742	38,091	82,833
Persons below poverty level (2007-2011)	8.3%	10.0%	9.1%
Median household income	$55,256	$56,180	
Total labor force (2012 annual average)	19,430	16,673	36,103
Employed (2012 annual average)	16,899	14,713	31,612
Unemployed (2012 annual average)	2,531	1,960	4,491
Unemployment rate (2012 annual average)	13.0%	11.8%	12.4%

County-level unemployment rate (1997–2012)

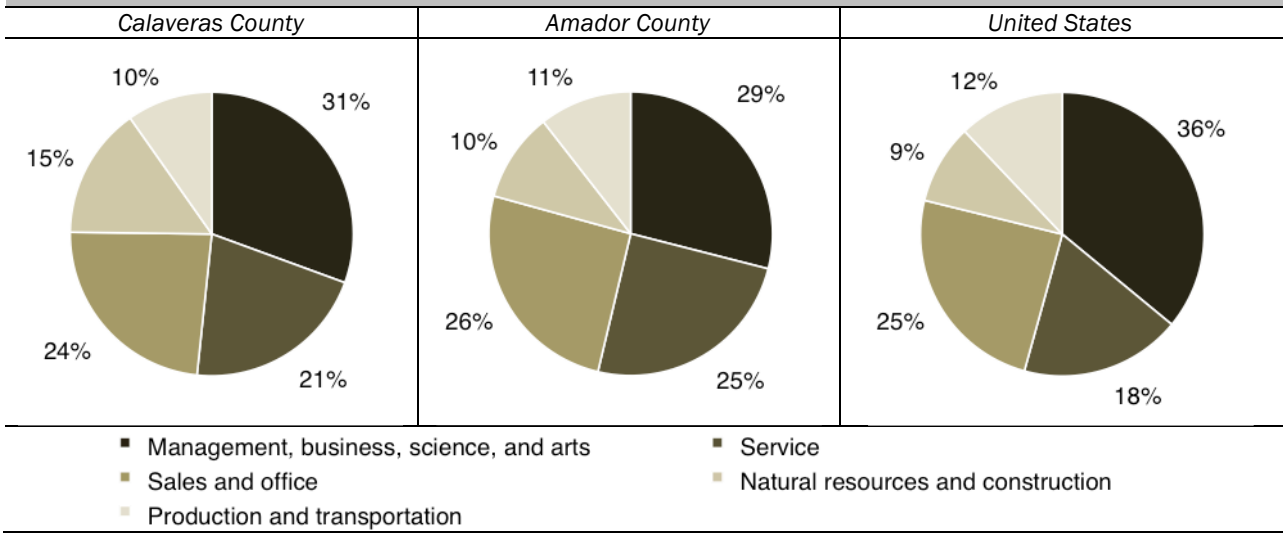


Source: U.S. Census Bureau. 2013. *State & County Quickfacts*. Retrieved on July 2, 2013; U.S. Bureau of Labor Statistics. 2013. *Local Area Unemployment Statistics*. Retrieved on July 2, 2013.

Table 7.6: Industry and occupation for employed individuals (2009-2011)

	Calaveras County	*Amador County*	*Total*
Civilian employed population 16 years and over	*17,962*	*13,202*	*31,164*
Agriculture, forestry, fishing and hunting, and mining	357	279	636
Construction	1,581	1,056	2,637
Manufacturing	781	752	1,533
Wholesale trade	523	170	693
Retail trade	2,262	1,878	4,140
Transportation and warehousing, and utilities	1,382	879	2,261
Information	489	135	624
Finance and insurance, and real estate and rental and leasing	579	422	1,001
Professional, scientific, and management, and administrative and waste management services	1,310	1,299	2,609
Educational services, and health care and social assistance	4,226	2,353	6,579
Arts, entertainment, and recreation, and accommodation and food services	1,474	1,970	3,444
Other services, except public administration	1,018	530	1,548
Public administration	1,980	1,479	3,459

Employed individuals, by occupation category (2009-2011)



Source: U.S. Census Bureau. 2013. *DP03: Selected Economic Characteristics, 2009-2011 American Community Survey 3-Year Estimates*. Retrieved on July 2, 2013.
Notes: Annual figures may differ slightly from other tables due to different data compilation methods by government agencies.

7.6.3 Treatment-related Harvests

The literature describing harvest-related economic impacts offers a range of job estimates that can be multiplied by harvest volume to estimate the number of direct jobs associated with harvest-

related activities.[6] For this analysis, we use a range of job estimates identified in the literature: 8–11 jobs per million board feet (e.g., Conway 1994; Bormann 2006). For this analysis, however, we are primarily interested in examining the local impacts of harvest-related activities specific to Amador and Calaveras counties. To convert the job estimates from the literature to local estimates relevant to the study area, we make a number of assumptions:

- Conway (1994) found that about 51% of the direct jobs associated with harvest-related activities are in secondary wood manufacturing and paper production industries (Conway 1994). Many, if not all, of those jobs would occur outside the two counties. After removing those jobs from our assumptions, the range of direct jobs estimate decreases to about 4–5.5 direct jobs per million board feet.
- Lippke and Mason (2005) found that only about half of the total direct employment related to forestry in rural areas occurs near the harvest site. After removing these jobs from our assumptions, the range of direct jobs estimate decreases further to about 2-3 direct jobs per million board feet (Lippke 2005).

As described earlier, a total of about 152 million board feet of merchantable timber would be harvested from treatment-related activities. Applying our range of estimated direct jobs (2–3 direct jobs per million board feet) yields an economic impact of about 300 to 450 direct job-years within the two counties. The distribution of harvest over time determines how many of these job-years would occur sequentially, but under a 10-year treatment plan, this equates to 30-45 jobs. In 2011, Amador and Calaveras counties supported 85 jobs in the logging industry.[7]

These direct, harvest-related jobs likely will support additional economic activity in the region, such as secondary jobs. Secondary jobs include activities that rely on spending from the logging industry. For example, forest management jobs are largely captured as secondary impacts and are based on the purchases made by the logging industry. Secondary jobs also include activities that rely on spending from individuals working for the logging industry. According to IMPLAN 2011 data for Calaveras and Amador counties, the employment multiplier for the logging industry is 1.4; in other words, 10 direct jobs in the logging industry support an additional 4 jobs throughout the economy. Applying this multiplier to the 30-45 direct jobs calculated earlier yields 12–18 local secondary jobs, or 42-63 total jobs supported.

The direct timber output of treatment-related harvests is the total estimated revenue from the activities ($14–$27 million), as described earlier in this section. The secondary output represents the logging industry's purchases from suppliers for goods and services, such as equipment and tools. It also includes those suppliers' purchases and employee spending. For Calaveras and

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[6] Jobs are measured in terms of full-year-equivalents (FYE). One FYE job equals work over twelve months in a given industry (this is the same definition used by the federal government's Bureau of Labor Statistics). For example, two jobs that last six months each in 2012 count as one FYE job in 2012. A job can be full-time or part-time, seasonal or permanent; input-output analysis counts jobs based on the duration of employment, not the number of hours a week worked. In other words, one job is twelve monthly paychecks. It may be a mix of several individuals holding a one position at a time throughout one year, and this would equal one FYE job, according to Labor Department statistics.

[7] IMPLAN 2011 data, Calaveras and Amador counties. IMPLAN provides input-output modeling of economic sectors and their interdependencies to estimate additional jobs and income generated by direct demands.

Amador counties, the output multiplier is 1.85. In other words, for every million dollars the logging industry spends, another $850,000 is spent elsewhere in the economy. The secondary impacts total $12–$23 million in output in the local economy, resulting in a total output of between $26 and $50 million.

Other studies have found higher employment numbers per board feet of timber, and per dollar of treatment expenditures (UMass 2009).[8] Such studies suggest that with intentional efforts to generate local labor demand with treatment and biomass activities, particularly among unemployed groups, the total impact on job creation could likely be significantly higher.

7.6.4 Biomass Chips

Collecting and supplying chips to biomass facilities for energy production supports additional employment. As with timber harvest-related jobs, the literature provides a range of direct job estimates for biomass collection efforts: about 300–400 direct jobs per million BDTs (the treatments would yield approximately 464,000 BDTs) (OFRI 2006). Based on the stated objective of biomass activities in the region to rely upon local labor, we assume all of these jobs could be sourced from local county labor forces.[9] Applying our range of direct jobs estimate (300–400 direct jobs per million BDTs of chips) to an approximated 0.5 million BDTs collected during treatment yields a total of 150–200 direct jobs. Furthermore, after applying a secondary jobs multiplier of 2.0, these direct jobs would help support an additional 150–200 secondary jobs within the two counties.

The direct output of biomass collection during treatment represents the total estimated revenue from the activities ($12–$23 million) as described earlier in this section. According to the 2011 IMPLAN data, the output multiplier for collection and gathering of forest products is 1.4, which leads to a total secondary impact of $5–$9 million in output for other industries in the local economy. Similar to the secondary output for logging industries, these impacts represent supply-chain purchases needed to collect and supply chips to biomass facilities, as well as employee spending in the local region.

7.6.5 Prescribed Burns

The literature describing the economic impacts of prescribed burns offers a range of direct job estimates: 2–9 direct jobs per 1,000 acres of burn area (Crone 2001, Kim 2010). As with our analysis of biomass-related jobs, we assume that the Amador Calaveras Consensus Group stated objective to source these jobs from the local county labor force would be successful.[10] Applying our range of direct jobs estimate to the 4,000 acres receiving burn-related treatment, a total of 8–36 direct jobs within the two counties would be supported. Furthermore, after applying a secondary

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[8] E.g., for every $1 million invested in biomass, it can create a total of 17.36 jobs (direct, indirect, and induced jobs) and for every $1 million in forest treatment work, the total induced jobs is 39.7.

[9] If these efforts to fully utilize local labor are unsuccessful, an assumption similar to for timber harvest would be appropriate - that half the jobs would be locally sourced.

[10] As with biomass-related jobs, if these efforts to fully utilize local labor are unsuccessful, an assumption similar to for timber harvest would be appropriate, that half the jobs can be locally sourced.

jobs multiplier of 2.0, these direct jobs would help support an additional 8–36 secondary jobs within the two counties.

The direct output of prescribed burns during treatment represents the total cost of the activities ($7–$20 million) as described earlier in this section. According to IMPLAN, the output multiplier for support activities for agriculture and forestry is 1.45, which leads to a total secondary impact of $0.6 - $0.7 million.

7.6.6 Costs of Fuel Treatments

Overall, there are two schools of thought with regards to forest management related to wildfires: (1) preventative fuel treatments and (2) reactive wildfire suppression. Because fuel treatments do not prevent fires, but reduce the risk and intensity of fires, both the preventative and reactive approaches will require some degree of postfire restoration, although the costs associated with restoration post fire in previously treated areas can be significantly less than the costs associated with fires that burn untreated areas (Chapter 4). Focusing on fuel treatments, there are three methods that are predominately used to reduce the risk of forest fires: (1) biological methods (e.g., prescribed fires and grazing), (2) chemical methods (e.g., herbicides), and (3) mechanical methods (e.g., forest thinning).

There are several challenges in estimating average fuel treatment costs. As described by Reinhardt, et al., there is a "paucity of consistent reporting data maintained by federal wildland agencies and the unique physical and managerial characteristics of fuel treatments have limited thorough assessments of the cost of individual fuel treatment. Additionally, data issues are complicated by the fact that agencies may conduct fuel treatments through timber sales, stewardship contracts, or traditional hazardous fuels funding" (Reinhardt 2008). The literature shows that several variables contribute to average treatment costs. Some of the most influential variables include:

- Size of treatment area
- Proximity to WUI
- Proximity to threatened/endangered species habitat
- Slope
- Biomass-related activity
- Treatment type (prescribed burn vs. harvest)
- Ability to offset costs with revenue from harvested materials

In the following sections, we will describe at greater detail two of treatment methods that are primarily employed in the modeled treatment scenario used in this analysis: prescribed burning and mechanical treatments.

7.7 Prescribed Burns

While there are several different types of biological methods for conducting fuel treatments, the most common are prescribed fires and grazing. According to the USFS's fuel treatment actions of 1998 and 1999 (describing actions that mostly occurred in the South), the average cost of implementing prescribed fire was $55 and $70 per acre (respectively, in 2012 dollars). Costs varied

across regions from a low of $20 per acre in Region 8 (Southern) to $578 per acre in Region 10 (Alaska). Per acre costs ranged from $71 to $108 in Region 2 (Rocky Mountain), Region 4 (Intermountain), Region 6 (Pacific Northwest), and Region 9 (Eastern) (in 2012 dollars). Per acre costs were $129 in Region 1 (Northern) and $197 in Region 5 (Pacific Southwest) (in 2012 dollars) (Kline 2004).

From 1985 to 1994, average costs per acre for different methods of prescribed burning in national forests were: $261 for slash reduction burning, $121 for management-ignited prescribed fire, $162 for managing natural fires, and $90 for brush, range, and grassland prescribed fires (2012 dollars). Treatment scale (area of treatment) and labor costs tend to be the most influential cost factors (Kline 2004). Hartsough et al. (2008) compiled per acre costs (based on expert estimates) for small, medium, and large prescribed fires in five locations in the western U.S. (see Table 7.7). For this analysis, we use the site-specific cost of $324–$390 per acre from the Central Sierra Nevada Range in California.

Table 7.7: Expert estimates of costs (per acre) for prescribed burns (2012$)

Location	*Burn treatment*	*Large burn*	*Medium burn*	*Small burn*
Northeastern Cascades, WA	Spring under burn using a strip head fire	$288	$1,055	$1,151
Northern Rocky Mts., MT	Fall under burn	$144	$475	$2,254
Blue Mountains, OR	Fall under burn	$34	$72	$158
Central Sierra Nevada, CA	Fall under burn using a combination of backing and strip head fires	$324	$355	$390
Southern Sierra Nevada, CA	Fall and spring under burn (3 times each)	$168	$249	$422

Source: Hartsough, R., S. Abrams, R. Barbour, et al. 2008. "The Economics of Alternative Fuel Reduction Treatments in Western United States Dry Forests: Financial and Policy Implications from the National Fire and Fire Surrogate Study." *Forest Policy and Economics*. 10:344-354.

7.8 Mechanical Treatments

Mechanical fuel treatments often include the harvesting of materials from the forest. These materials can be burned on site (e.g., pile burned) or removed from the forest and sold. This section focuses on the costs and benefits of past efforts to use mechanical treatments to reduce future fire risk.

One benefit that distinguishes mechanical treatments from other treatment types is the revenue generated from timber harvests. Skog points out the importance of separating and marketing large-diameter logs for higher value products (Skog 2006). Table 7.8 shows the average per acre treatment costs for mechanical fuel treatments under a number of different treatment scenarios based on the slope of the site. In general, treatment costs increase as the slope of the treated area increases beyond a certain threshold. All the options in the table have the representative costs associated with forest thinning efforts that remove 25%-50% of the biomass from the forested area.

For this analysis, we identified the most relevant option from this study and augmented the costs with evidence from other studies that show specific characteristics on cost that relate to facets of our analysis. For example, Calkin found that treatment near the wildland-urban interface (WUI) increases the cost of that treatment by approximately 62%. For all treatment efforts in the WUI, or near other forms of development, we inflated the average cost per acre by 62% to reflect this potential cost difference. Calkin also found that biomass removal associated with harvest-related treatment strategies can more than double the costs of fuel treatments (Calkin 2006). For this analysis, we assume that the cost estimates from Skog have already incorporated the costs of biomass collection efforts (Skog 2006).

Table 7.8: Estimated treatment cost (2012$/acre)

Treatment	*Average treatment cost*	
	Slope <40%	*Slope >40%*
1A	$1,036	$2,035
2A	$968	$2,101
3A	$980	$2,256
4A	$794	$2,078
1B	$1,131	$2,110
2B	$1,012	$2,139
3B	$1,035	$2,266
4B	$1,092	$2,091

Source: Skog, K. and R. Barbour. 2006. Estimating Woody Biomass Supply from Thinning Treatments to Reduce Fire Hazard in the U.S. West. U.S. Forest Service Proceedings RMRS-P-41.

7.9 Treatment Cost Literature Review

In the previous two sections, we outlined some of the literature that describes costs associated with various forms of fuel treatments. In order to most accurately estimate costs associated with our specific treatment scenario, we aligned the different types of treatment in our scenario with different components of treatment costs as they are listed in the literature. Table 7.9 shows all the treatment codes for the treatment scenario, our estimated range of per acre treatment costs, a short description of our assumptions, and the relevant sources.

As previously stated, these costs depend on a number of factors, including the cost of labor and transportation, as well as the physical characteristics of the forests and the topography of the area. Additionally, if the scenario we describe extends into longer implementation periods, costs can significantly increase as administrative efforts span over more and more years.

Table 7.9: Treatment cost literature review summary

Land type	*Treatment code*	*Treatment cost ($/acre)*	*Description of assumptions*	*Sources*
CSOPACs	111	$324–$390	(1) Central Sierra (Under burn using backing and strip head fires). (2) Blodgett Experimental Forest (Eldorado/Stanislaus/Tahoe National Forests) Sierra Mixed Conifer. (3) Based on expert opinion.	Hartsough, B. et al. 2008. "The Economics of Alternative Fuel Reduction Treatment in Western United States Dry Forests: Financial and Policy Implications from the National Fire and Fire Surrogate Study." *Forest Policy and Economics*. 10:344-354.
General forest	322	$749–$1,123	(1) Range depends on specific treatment scenario. (2) Treatment scenarios assume 25%-50% removal. (3) Treatment scenarios both even-aged and uneven-aged forests. (4) Assumes <40% slope	Skog, K., and R. Barbour. 2006. "Estimating Woody Biomass Supply from Thinning Treatments to Reduce Fire Hazard in the US West." USFS Proceedings RMRS-P-41.
Key roads	323	$1,213–$1,819	(1) Same as General Forest 322, but inflated by 62% to reflect added cost of treatment in WUI.	Skog, K., and R. Barbour. 2006. "Estimating Woody Biomass Supply from Thinning Treatments to Reduce Fire Hazard in the US West." USFS Proceedings RMRS-P-41. Calkin, D. and K. Gebert. 2006. "Modeling Fuel Treatment Costs on Forest Service Lands in the Western United States." *Western Journal of Applied Forestry*. 21(4):217-221.
Parcels with structures	323	$1,213–$1,819	(1) Same as General Forest 322, but inflated by 62% to reflect added cost of treatment in WUI.	Skog, K., and R. Barbour. 2006. "Estimating Woody Biomass Supply from Thinning Treatments to Reduce Fire Hazard in the US West." USFS Proceedings RMRS-P-41. Calkin, D. and K. Gebert. 2006. "Modeling Fuel Treatment Costs on Forest Service Lands in the Western United States." *Western Journal of Applied Forestry*. 21(4):217-221.
Riparian	311	$749–$936	(1) Same as General Forest 322, but including only the lower half of the range due to decreased volume removed.	Skog, K., and R. Barbour. 2006. "Estimating Woody Biomass Supply from Thinning Treatments to Reduce Fire Hazard in the US West." USFS Proceedings RMRS-P-41.
Steeply sloped	322	$2,020–$2,249	(1) Range depends on specific treatment scenario. (2) Treatment scenarios assume 25%-50% removal. (3) Treatment scenarios both even-aged and uneven-aged forests. (4) Assumes >40% slope.	Skog, K., and R. Barbour. 2006. "Estimating Woody Biomass Supply from Thinning Treatments to Reduce Fire Hazard in the US West." USFS Proceedings RMRS-P-41.
Transmission lines	323	$1,213–$1,819	(1) Same as General Forest 322, but inflated by 62% to reflect added cost of treatment in WUI.	Skog, K., and R. Barbour. 2006. "Estimating Woody Biomass Supply from Thinning Treatments to Reduce Fire Hazard in the US West." USFS Proceedings RMRS-P-41. Calkin, D. and K. Gebert. 2006. "Modeling Fuel Treatment Costs on Forest Service Lands in the Western United States." *Western Journal of Applied Forestry*. 21(4):217-221.
Wilderness-roadless	111	$324–$390	(1) Central Sierra (Under burn using backing and strip head fires). (2) Blodgett Experimental Forest (Eldorado/Stanislaus/Tahoe National Forests) Sierra Mixed Conifer. (3) Based on expert opinion.	Hartsough, B. et al. 2008. "The Economics of Alternative Fuel Reduction Treatment in Western United States Dry Forests: Financial and Policy Implications from the National Fire and Fire Surrogate Study." *Forest Policy and Economics*.10:344-54.

Notes: CSOPAC = California spotted owl protected activity centers.
These numbers are based on our initial literature review but the treatment costs used in the chapter are based on local estimates, located in Table 7.3.

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Mokelumne Watershed Avoided Cost Analysis: Why Sierra Fuel Treatments Make Economic Sense

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Disclaimer

This report is rich in data and analyses and may help support planning processes in the watershed. The data and analyses were primarily funded with public resources and are therefore available for others to use with appropriate referencing of the sources. This analysis is not intended to be a planning document.

The report includes a section on cultural heritage to acknowledge the inherent value of these resources, while also recognizing the difficulty of placing a monetary value on them. This work honors the value of Native American cultural or sacred sites, or disassociated collected or archived artifacts. This work does not intend to cause direct or indirect disturbance to any cultural resources.

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