Arnold Schwarzenegger
Governor

BIOMASS TO ENERGY:

FOREST MANAGEMENT FOR WILDFIRE REDUCTION, ENERGY PRODUCTION, AND OTHER BENEFITS

APPENDIX 8

PIER FINAL PROJECT REPORT

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APPENDIX 8:

B2E Project Economic Analysis

1. Principal Author:

Thomas Wegge, TCW Economics

Notice of Change in Scenario Naming Conventions

Key assumptions, modeling structures and terminology were altered and refined to accommodate new thinking during the course of this study. The reader will observe in the appendices that the scenarios are referred to as "Scenarios 1, 2 and 3" or "S1, S2 and S3."

In both the main text of the Final Report and in the Life Cycle Assessment appendix (Appendix 4), the former Scenario 1 (S1) was renamed to the "Reference Case." Scenario 3 (S3) has been renamed the "Test Scenario." Scenario 2 (S2), focused on the relative contributions and impact of Industrial Private Forestry (IPF) has been eliminated from most of the analyses that make up the entire study. These changes better reflect the focus of the study, which is fundamentally about the landscape level changes in wildfire, habitat, and other dynamics. The modification of terminology do not substantively affect the findings or recommendations of the study.

1. INTRODUCTION

1.1 Domain Description

The study area for the Biomass to Energy (B2E) Project is a 2.7 million-acre landscape that encompasses public lands (portions of the Plumas, Lassen, and Tahoe National Forests and Lassen National Park) and private lands surrounding the Mt. Lassen power plant in Westwood, California. The landscape's southwestern node includes major water conveyances and other assets (rail line) in the North Fork of the Feather River Canyon as well as areas of high fire hazard along the western slope of the Sierra Nevada. The landscape's southeastern node includes the Highway 89 corridor, with its associated urban development. Portions of five counties are included in the study area, including Plumas, Butte, Sierra, Lassen, and Tehama counties. Because study area lands within Tehama County are minor, effects on resources in Tehama County were not considered in the economic analysis.

The B2E Project developed a series of analytical models to evaluate the economic and environmental costs and benefits of using forest biomass to generate electrical power while changing fire behavior at the landscape level. The B2E Project operates in two key domains: the wildland landscape and the biomass power production plant. These domains are linked by the transport of biomass material from the wildlands to power plant. The landscape domain provides the surface for exploring how forest remediation treatments (which generate biomass material for electricity production) affect vegetation and fire behavior. Landscape-scale changes in vegetation and fire behavior ultimately determine many of the project benefits, including reductions in wildfire impacts on communities, forests, wildlife habitats, and watersheds; improvements in air quality and water quality; protection of human health and welfare; and

renewable energy production. The power production plant domain describes power plant-related costs and revenues that affect the economic analysis.

The economic analysis focuses on determining economic values of changes in resource conditions within both domains. As such, the analysis is necessarily dependent on modeling results from most other B2E technical disciplines, as well as on financial data for constructing and operating power plants and on the valuation of assets (structures, infrastructure, recreation resources, and agricultural production) at risk to wildfire in the study area. The analysis, however, is not a comprehensive economic assessment, which would require estimating monetary values for the ecological public goods and services, such as water quality, air quality and biological diversity, supported by the B2E landscape. As discussed by Boyd (2007), prices and quantities are not readily observable for most public goods and services affected by changes in the B2E landscape. (Recreation resources are an exception.) The analysis instead focuses on valuation of private goods and services (e.g., marketable assets such as timber, structures and power from biomass plants) affected by changes in resource conditions within the two domains. For the most part, data on prices and quantities consumed are available from market transactions to place economic value on these goods.

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2. RESEARCH OBJECTIVES

This section describes the economic analysis objectives. A review of important economic concepts and analytical frameworks is presented first.

2.1 Concepts and Analytical Frameworks

Economic analysis is the study of the processes by which scarce resources are (or might be) allocated to achieve competing objectives. Because, from an economic perspective, all resources are scarce with price an indicator of their relative scarcity, choosing to use a resource one way means choosing not to use it another way. Potential benefits foregone by the choice to use a resource in one way rather than another are referred to as opportunity costs. Consequently, every choice that is made “costs” something, even if the best choice is made. Choices are typically made from among the policy alternatives and, at a minimum, the cost of the choice made will be the foregone benefits of other uses of the resource that are not complimentary to the selected management approach. (Budgetary costs, such as government expenditures to implement an action, represent a portion of the opportunity costs because they reflect the costs of resources used directly in a project.)

As described in U.S. EPA’s guidance document for preparing economic analysis of proposed regulations (U.S. EPA 2000), the conceptually appropriate framework for assessing the economic effects of public policy decisions is an economic model of general equilibrium. The starting point for this type of model is to define the allocation of resources and interrelationships among the diverse components of the economy (households, firms, and government). Changes to this equilibrium condition, as characterized by effects to the various components of the economy, are then “modeled” as the economy moves to a new state of equilibrium. The differences between the old and new states – measured as changes in prices, quantities produced and consumed, income, and other economic variables – can be used to characterize the net welfare changes for each affected group in the model.

Different outputs from the general equilibrium framework can be extracted to assess both economic efficiency and distributional effects. Economic efficiency is concerned with the expected net gain or loss to society resulting from a policy choice. Measures of economic efficiency include changes in net wealth or income, and the value placed on a change in the quality of a product or service. Distributional effects focus on who is burdened and who benefits from a policy change, and include effects on jobs, income, and levels of economic activity (output) within different regions or areas.

Different analytical frameworks (Table 2-1) can be used to present the outputs from economic analyses. Deciding on the appropriate framework often largely depends on the policy questions that need to be answered and the availability of data to conduct the analysis. For example, cost-effectiveness analysis is typically used when a specific project outcome is predetermined and the analytical objective is to determine the least cost way to achieve the objective. Economic costs are derived in terms of the opportunity costs of foregone uses of resources, including any direct costs incurred by implementing agencies. Benefit-cost analysis is a more comprehensive approach to economic analysis, involving equal consideration of economic costs and benefits. Benefits reflect the increased value of market and non-market goods and services (e.g., recreational, aesthetic, and cultural values).

Table 2-1. Analytical Frameworks for Economics Analyses

ANALYTICAL FRAMEWORK	PRIMARY OBJECTIVE
Private Investment/Financial Analysis	*Identify rate of return on investment*
Cost-effectiveness Analysis	*Identify least cost program or project*
Fiscal Analysis	*Identify effect on local government budgets*
Local/Regional Economic Impact Analysis	*Identify effects on the local economy (jobs, income)*
Social/Community Analysis	**Identify effects on community well-being**
Benefit-Cost Analysis	*Identify the net economic value to society*

The successful application of either cost-effectiveness or benefit-cost analysis depends on the scientific understanding of the underlying physical and biological processes. The physical changes in environmental and resource conditions are often described by response functions that relate changes in the physical and biological environment to policy actions. A key function of the economic analysis is to attempt to characterize these physical and biological changes in monetary terms. However, if key relationships among the physical and biological processes are not well understood, the economic analysis will mirror (and often compound) the level of uncertainty.

Analytical frameworks that display non-monetary measures also are frequently used to evaluate policy decisions. Changes in energy consumption, health conditions, employment, or social effects related to the B2E Project could be accounted for. The Life Cycle Assessment (LCA) described in Chapter XX tallies energy produced and consumed from the cradle-to-grave production process involved in converting forest biomass to electricity. .

2.2 Analytical Objectives

The B2E Project involves the modeling of changes in vegetation conditions and fire behavior across the 2.7 million acre study area under alternative vegetation management scenarios. The overarching research question for the economic analysis is:

> *"Do the benefits of removing biomass (both timber and other biomass) from the forest and using it as a fuel source to generate electricity exceed the costs associated with the vegetation management activities?"*

The economic analysis considers three vegetation management treatment scenarios:

- ***Scenario 1 – No treatment*:** This scenario assumes no treatments on private or public lands, thereby providing a reference (baseline) for the interaction of the environment and fire. (Treatment includes thinning, selective harvest, and clearcut harvesting activities.) Vegetation is grown across the landscape over a 40-year period, and the resulting fire effects are modeled. This scenario assumes no salvage harvest or reforestation after wildfires.

- ***Scenario 2 – Industrial Private Forests (IPF) only*:** This scenario assumes treatments on private lands only; no treatments are assumed for public lands. Treatments on IPF lands, including pre-commercial thinning, underburning, and commercial thinning, improve the fire resistance of stands, thereby contributing to the primary land management focus on profit sustainability. On public lands, vegetation is "grown" from the current date and only fire effects are tracked, similar to Scenario 1.

- ***Scenario 3 – IPF and Public Multiple Use (PMU) Combined*:** This scenario assumes the overriding goal is to achieve fire behavior modification at a landscape scale. Private lands are treated as under the same prescriptions as Scenario 2 (IPF only), and public multiple use lands are treated using a variety of strategic approaches (defensible fuels

profile zones and SPLATS). Treatment on both private and public lands is consistent with current management restrictions. This scenario is fundamentally fire-oriented.

The economic analysis focuses on estimating the net present value (NPV) of changes in resource conditions associated with the vegetation management treatment scenarios (s1…s3) over a 40-year analysis period (t1…t40. Notationally, the analysis can be expressed as follows:

$$\mathbf{NPV_{s1...sn} = \sum Revenues_{t1..t40} - Costs_{t1..t40} + Environmental\ Benefits_{t1..t40} - Environmental\ Costs_{t1..t40} + Change\ in\ Market\ Asset\ Values_{t1..t40}}$$

where:

Revenues = discounted annual revenues for power generation, biomass co-products (sawlogs), and salvage logs
Costs = discounted annual O&M and capital costs for forest fuels management, power plant operations, fire suppression, and forest rehabilitation
Environmental Benefits = discounted annual positive changes in the provision of ecosystem services
Environmental Costs = discounted annual negative changes in the provision of ecosystem services
Change in Market Asset Values = discounted change in market asset values attributable to wildfires, including structures, infrastructure, agricultural lands production, and recreation resources.

Although the analytical notation includes consideration of environmental benefits and costs as part of a comprehensive economic analysis, research limitations did not allow for monetizing the environmental effects of the treatment scenarios evaluated for the B2E Project. These limitations and ways to address them are furthered detailed by Boyd (2007).

3. METHODS AND DATA

Consistent with requirements for economic efficiency analysis, a benefit-cost analytical framework was used to evaluate changes in resource costs and benefits associated with the treatment scenarios. Resource costs were measured in terms of opportunity costs, and benefits were evaluated in terms of willingness-to-pay (WTP).

A spreadsheet model was developed to calculate the annual costs and benefits of the no-treatment reference condition and the two treatment scenarios over the 40-year analysis period. The 40-year analysis period corresponds with the approximate life of biomass power plants and the modeling capabilities for reasonably projecting changes in future forest conditions. As a practical matter, costs and benefits that occur beyond 40 years in the future have little or no present value. Costs and benefits are discounted to present value using a 3 percent real discount rate.

As noted above, modeling results from other domains (e.g., vegetation, forest operations and equipment configurations, and fire behavior) are key sources of information for the economic analysis. In addition, data were compiled from outside sources to estimate the value of assets at risk to wildlife and to derive damage functions and recovery rates for assessing wildfire

damage to these assets. Research conducted by the California Department of Forestry and Fire Protection for the California Fire Plan was a key source of data for evaluating assets at risk to wildfire.

The methods and data used for the valuation of assets at risk to fire, saw log revenues, fuels treatment costs, power plant costs and revenues, and fire suppression and rehabilitation costs are described in the following sections.

3.1 Valuation of Assets at Risk to Fire

A primary focus of the economic analysis was on evaluating changes in the economic value of assets at risk to wildland fire. Based on previous research (California Department of Forestry and Fire Protection 2005 and Barenklau 2006), key assets with established market values that are at risk to fire include agricultural land resources, timberland resources, recreation resources, structures, infrastructure, and mineral resources.

A geographic information system (GIS)-supported approach that allows for considering spatially-explicit relationships was used to conduct the analysis of assets. GIS was used to develop baseline values of assets at risk and to assess how fire affects these values over time. The geographic mapping levels, units of valuation, and basis of valuation for the assets evaluated in the analysis are shown in Table 3-1.

Table 3-1. Geographic Specification and Valuation Parameters for the GIS-Supported Analysis of Assets at Risk to Fire

Applicable Assets	Geographic Mapping/Level of Disaggregation	Units for Valuation	Basis of Valuation
Agricultural resources	Regionwide, based on designated rangelands (CDF) and irrigated croplands (ag covertype)	Acres	Average rangeland and irrigated cropland values per acre; crop composite values used for specific areas (e.g., Sierra Valley)
Timberland resources	100 meter square grids used for SFA output, by county	Green and salvage volume (thousand board feet) classifications defined by CA BOE	Average stumpage values from CA BOE for harvest, treatment (co-products) and salvage
Recreation resources	Regionwide, based on CDF designated recreation areas and other important recreation areas	Visitor days	Average net economic value per visitor day
Structures	Parcels, by county	Improvements to real and personal property, by parcel	Assessment value of improvements and other personal property
Infrastructure	Regionwide, based on updated CDF data on powerline and facility	Improvements to real property and easements	Replacement value

	siting		
Mining	Regionwide, based on designated mining areas	Not valued	Not valued

GIS layers were created for each of the assets considered in this analysis. Baseline values for each asset were calculated by assigning a known or estimated dollar amount to each cell containing an asset. For example, one mile of transmission line was determined to have an average replacement value of $300,000. This value was converted to cost per meter giving each 100-meter cell containing a transmission line a baseline value for that asset. Layers for recreation, agriculture, structures, and infrastructure (power transmission lines) were then compared to modeled fire location and intensity for each 10-year time period in each scenario. Fire intensity (flame length) was translated into a damage function appropriate for each asset type. Burned cells containing assets were assigned a percent loss based on the fire intensity in that cell. Asset damages were aggregated within each asset type to determine total asset loss per scenario.

The methods and data used to determine economic values and to calculate damage functions for each asset category are described below.

Agricultural Resources

Crop Values

Agricultural crops produced in the study area primarily include irrigated hay, irrigated and naturally-irrigated pasture, and dry range. Net values (i.e., gross value of production net of operating costs) per acre were estimated for these crops, differentiating between areas that are identified as “agriculture” on the GIS Covertype overlay map and areas depicted as “range” on the CDF Land Management overlay map.

For agricultural areas, values were developed for the primary cropland areas in the study area based on the mix of crops in each area, which primarily includes hay and pasture, with some private dry range mixed in. The crop mix in each area was determined based on information provided by the Plumas-Sierra County Agricultural Commissioner (Bishop pers. comm.). Net values for alfalfa hay production ($328/acre) and pasture/grass hay ($67) were derived based on crop budgets for California’s Intermountain Region prepared by the University of California Cooperative Extension (2001, 2002). Values for private rangeland ($30) were estimated based on estimated forage yield for good rangeland [2.0 AUMs per acre (Integrated Hardwood Range Management Program 2000)] and the 2006 average private grazing land lease rate in California [$15 per AUM (Fritz 2006)].

For all other rangelands throughout the study area, a value was derived based on the forage yield for average range conditions [1.1 AUM per acre (derived based on yields for poor and good rangelands in Integrated Hardwood Range Management Program 2000)] and the average cost per AUM for leasing private grazing land in California [$15 per AUM (Fritz 2006)]. This methodology resulted in an average value of $17 per acre for rangeland in the study area.

Conceptually, rangeland values also could be estimated based on the cost of replacement feed for livestock if the rangeland asset was destroyed in a fire. This was the method employed by the California Department of Forestry and Fire Protection (CDF) (2005) in its draft analysis of assets at risk for its fire plan. Assuming that ranchers would replace lost forage produced by

rangelands by feeding livestock a mixture of oat and alfalfa hay, CDF estimated a per acre forage replacement value of over $35 for high-yield rangeland, $17.50 to $35 for medium-yield rangeland, and less than $17.50 for low-yield rangeland.

The low-range value estimated by CDF (less than $17.50 per acre) is similar to the $17 per acre derived above, based on the lease rate for private rangeland. This latter rate was determined to be appropriate for the analysis because of the fallowing factors: 1) much of the rangeland in the study area is located on public lands in rugged areas, indicating that forage yields would be in the lower range, reflecting a value similar to CDF's low-yield rangeland replacement cost; 2) not all rangelands are grazed each year, indicating that the forage value for all rangelands in the study area would be lower than yields on private rangelands; and 3) private lease rates reflect market-based values for rangelands, even if these rangelands are included in federal grazing allotments.

Net value parameters by area are shown in Table 3-2 below.

Table 3-2. Net Value Parameters for Agricultural Resources, by Crop Type

Area	Crop Distribution	Net Value per Acre	Weighted Value per Acre
Sierra Valley (Plumas/Sierra counties)	50% hay 50% private range	Hay = $328 Range = $30	Hay = $328*0.5 = $164 Range = $30*0.5 = $15 Combined total = $179
American Valley (Quincy area - Plumas County)	35% hay 30% pasture 35% private range	Hay = $328 Pasture = $67 Range = $30	Hay = $328*0.35 = $115 Pasture = $67*0.3 = $20 Range = $30*0.5 = $10 Combined total = $145
Indian Valley (Greenville area - Plumas County)	100% pasture/grass hay	Pasture/grass hay = $67	Total = $67
Lassen County (all areas)	33% hay 33% pasture 33% private range	Hay = $328 Pasture = $67 Range = $30	Hay = $328*0.33 = $109 Pasture = $67*0.33 = $22 Range = $30*0.33 = $9 Combined total = $140
Rangeland (throughout the study area exclusive of range located in areas mapped as "Agriculture"	100% range	Range = $17	Total = $17

Damage Functions

Damage functions were developed for two categories: agricultural lands, which include a mixture of irrigated hay and pasture and dry range; and rangelands, which are entirely non-irrigated. These damage functions were assumed to apply the same to all three fire intensities

(lethal, mixed lethal/non-lethal, non-lethal) because fires presumably would have the same effect on crop and rangelands regardless of intensity.

For agricultural lands, it was assumed that a fire would produce relatively minor damage to irrigated hay and pasture crops because the fire probably would burn out after reaching the edges of green crop fields. Based on the assumption that damage only would occur along the edges of fields, an assumed damage factor of 10% was assumed for the year of the fire, with 5% residual damage remaining in the year following the fire. Crop production was assumed to completely recover following the second year.

For rangelands, it was assumed that fire would affect forage productivity for the year of the fire plus two additional seasons (California Department of Forestry and Fire Protection 2005). For the year of the fire, 75% of forage production was estimated to be lost assuming that 25% of the forage would be grazed prior to the fire. The second year after the fire, forage production was assumed to be 50% of normal; for the third year, forage production was assumed to be 80% of normal. Forage production was assumed to return to normal after three years. Based on the damage functions assumed for combined irrigated cropland/rangeland areas, a weighted damage function was derived, as follows: Year 1, 30% damage; Year 2, 20% damage; Year 3, 5% damage; following years, no damage. For rangelands outside of "agricultural" areas, the damage function discussed above for rangelands was assumed to apply throughout the study area (i.e., Year 1, 75% damage; Year 2, 50% damage; Year 3, 20% damage; following years, no damage).

Timberland Resources

The economic assessment of timberland resources includes estimating changes over time in the value of standing timber in the study area, and also the value of treatment and salvage saw logs that are harvested. The valuation of treatment and salvage saw logs harvested in the B2E study area is described in Section 3.2

<u>Valuation of Standing Timber Asset</u>

The value of the standing timber asset in the study area was estimated using stumpage values developed by the California Board of Equalization (refer to Section 3.2, *Saw Log Valuation* for a detailed description of the methods and data). For each year, a post-fire value was estimated for the No-Treatment Scenario and for each of the two treatment scenarios. The analysis was designed to measure the anticipated beneficial change on timber asset value between the post-fire conditions under the treatment scenarios relative to the No Treatment Scenario (baseline conditions).

Output for pre-fire conditions on the volume of standing timber for four tree species in three separate diameter categories was provided by the Stewardship and Fireshed Assessment (SFA) team for each scenario and each of five time periods (2006, 2016, 2026, 2036, and 2046). SFA output also included the same volume information for three other categories of affected timber resources: 1) timber killed/consumed by a fire, 2) timber removed through treatment, and 3) timber removed through salvage harvesting. Volumes were expressed in both cunits and million board feet.

To calculate changes in the value of the standing timber asset, a baseline value was first established by multiplying the pre-fire standing timber volumes provided by the SFA team for each time period by unit stumpage values to arrive at a total value of the standing timber asset.

The value over the 40-year study period was then converted to present value. The value of timber lost due to fire under the no treatment and with-treatment scenarios was then calculated by multiplying the volume of timber killed/consumed by fires over each time period (provided by the SFA team) multiplied by unit stumpage values. The calculated losses over the 40-year period were then converted to present value and subtracted from the pre-fire baseline value to arrive at the post-fire value of the standing timber asset for each scenario. As a result, the difference in the pre-fire and post-fire values represents the change in the value of the standing timber asset for each scenario.

Because the SFA process explicitly accounts for the value of timberland resources lost as a result of fire, there was no need to develop a separate damage function for assessing these effects.

Recreation Resources

A wide variety of recreation resources are available to recreationists within the 2.7 million-acre B2E study area. Recreation assets range from intensively developed recreation sites in national parks and state recreation areas, to undeveloped dispersed use areas near and along hiking trails and stream corridors. Management of recreation areas and facilities involve several state and federal agencies. Private companies, such as Pacific Gas & Electric Company, also manage recreation sites within the study area. Additionally, some private landowners allow hunting and fishing on properties throughout the study area.

Recreation Asset Value

The first step to characterizing the value of recreation assets in the study area was to identify specific recreation areas to be included in the valuation. Because the universe of recreation facilities and sites in the study area is large, and use information is lacking for many sites, it was decided to limit recreation assets to significant recreation areas. Thus, recreation areas primarily with dispersed uses, such as trails, off-highway vehicle routs, and remote campgrounds, were not included. Exceptions included the Pacific Crest National Scenic Trail and the Feather Falls Scenic Area and National Recreation Trail because of the unique recreation opportunities that these areas provide.

Recreation areas included in the evaluation are identified in Table 3-3. As shown, these areas include major recreation areas such as Lassen Volcanic National Park, the Lake Oroville State Recreation Area, and the Lake Almanor Recreation Areas, smaller recreation areas adjacent to several lakes, two federal wilderness areas, several state wildlife areas, and areas along the Feather River.

For the recreation areas in Table 3-3, recreation use information, in the form of recreation days, was compiled from various sources. Baseline economic values that approximate the use value of each area were then estimated by applying an average (median) value per visitor day. This value was derived from a literature review of 287 existing outdoor recreation studies conducted by Walsh et al. (1992). The average per-day value of $27.02 (1987 dollars) was adjusted to 2006 dollars using the consumer price index for all consumers, resulting in an average value of $48.14 per visitor day.

Once baseline economic values were developed, a GIS mapping layer was created with the locations of each area using GIS-based information previously developed by CDF, augmented

with recreation site information for sites not mapped by CDF. Values were then assigned to each mapped recreation area.

Damage Function

The amount of damage that a fire could do to recreation areas depends on several factors, including the intensity and type of fire and the attributes of each recreation area. For example, a fire that burns into a recreation area with developed facilities could result in damage to camping sites, picnic tables, and restrooms, reducing the usability of the site until facilities are reconstructed. On the other hand, a fire in the vicinity of a hiking trail and fishing access area may only cause damage to visual resources, allowing some use of the area to occur once the fire has been suppressed.

Few past research efforts have been conducted to assess the effects of fire on recreation (Englin et al. 1996 in Hesseln et al. 2003). Furthermore, little quantitative information is available to evaluate the effects that wildfires have had on recreation visitation and values. Several studies, however, have been done that indicate fire effects cause decreases in aesthetic value, and a few studies have indicated that higher intensity fires negatively affected recreation values. (Hasseln et al. 2003)

Estimating the effects of future wildland fires on recreation assets in the study area is a complicated task, with the location, timing, and severity of fires playing major roles in the amount of damage to recreation areas and facilities and the time required for recovery of assets. For example, according to Kline (2004):

> Wildfire might decrease recreation benefits associated with large trees if they are killed by heat or fire, but might increase recreation benefits in a shrub-dominated setting by clearing underbrush and creating a more open forest. Wildfire effects on forest benefits also can change over time. For example, recreation might be significantly curtailed

Table 3-3. Significant Recreation Areas in the B2E Study Area

Recreation Area	Manager of Recreation Facilities	Recreation Days
Antelope Lake Recreation Area	USFS, Plumas National Forest	27,000 (campgrounds)[16]
Antelope Valley Wildlife Area	California Department of Fish & Game	2,000 (mostly big game and upland game hunting)[1]
Bass Hill Wildlife Area	California Department of Fish & Game	700[2]
Bucks Lake Recreation Area	PG&E/USFS	89,000 (day and overnight)[15]
Bucks Lake Wilderness	USFS, Plumas National Forest	9,600[8]
Butt Valley Reservoir	PG&E	18,970 (campgrounds)[3] 17,544 (day use)[3] Total = 35,514[3]
Caribou Wilderness	USFS, Lassen National Forest	5,347 (day and overnight)[12]
Chilcoot Wildlife Area	California Department of Fish and Game	No use.[1]
Coon Hollow Wildlife Area	California Department of Fish & Game	150 (mostly hiking)[4]
Crocker Meadows Wildlife Area	California Department of Fish & Game	1,200 (mostly big game and upland game hunting)[1]
Eagle Lake Recreation Area	USFS, Lassen National Forest	40,578 (campgrounds)[11]
Feather Falls Scenic Area and National Recreation Trail	USFS, Plumas National Forest	30,000[13]
Frenchman Lake Recreation Area	USFS, Plumas National Forest	50,043 (campgrounds) 14,302 (day use) [10]
Little Grass Valley Recreation Area	USFS, Plumas National Forest	25,481[14]
Lake Almanor	PG&E/USFS, Lassen National Forest	53,471 (campgrounds)[3] 224,960 (day use)[3] Total = 278,431[3] 150,000[5]
Lake Davis Recreation Area	USFS, Plumas National Forest	22,628 (campgrounds)[10] 69,664 (day use)[15]
Lake Oroville State Recreation Area	California Department of Parks and Recreation	1,137,200[6]
Lakes Basin Recreation Area	USFS, Plumas National Forest	5,166 (campgrounds) 12,500 (lodges and stables) no trail or day use data[10]
Lassen Volcanic National Park	NPS	365,535[9]
Middle Fork Feather River (Wild and Scenic River)	USFS, Plumas National Forest	Use data not available
Mountain Meadows Reservoir (Walker Lake)	PG&E	Use data not available. Receives low level of use, primarily by local

		residents. No developed recreation facilities other than launch ramp. Shore and lake day use. Most land nearby is privately owned.[3]
North Fork Feather River	PG&E/USFS	14,020 (Belden Reach area campgrounds)[3] 175,644 (Belden Rest Stop)[3] Total = 189,664[3]
Plumas Eureka Sate Park	California Department of Parks and Recreation	15,927 (camping)[7] 16,883 (day use)[7] Total = 32,810[7]
Pacific Crest National Scenic Trail	USFS	300 (through-hikers)[17]
Smithneck Creek Wildlife Area	California Department of Fish & Game	2,000 (mostly hiking and wildlife viewing)[1]
Warner Valley Wildlife Area	California Department of Fish & Game	500 (mostly hiking and wildlife viewing)[1]

Sources:

[1] Lidberg, Jim. Associate Wildlife Biologist. Plumas-Sierra Wildlife Unit, California Department of Fish and Game. Meadow Valley, CA. August 21, 2006 – telephone conversation.

[2] Clark, Beverly. Scientific Aid. Lassen Wildlife Unit, California Department of Fish and Game. Wendel, CA. September 11, 2006 – telephone conversation.

[3] Pacific Gas & Electric Company. April 2002. Report E5: Recreation resources (preliminary draft. Prepared for the draft license application, Upper North Fork River Project, FERC Project No. 2105. San Francisco, CA.

[Recreation day = visit by a person to an area for recreation purposes for any portion of a 24-hour period.]

[4] Lomeli, Henry. Wildlife Biologist. Butte County Wildlife Unit, California Department of Fish and Game. Chico, CA. August 21, 2006 – telephone conversation.

[5] California Department of Water Resources. December 2001. Comparative inventory of recreation facilities at California's largest reservoirs, 2000. Sacramento, CA.

[6] California Department of Water Resources. 2004. Relicensing study R-9 – existing recreation use. Prepared for the Oroville Facilities relicensing application, FERC Project No. 2100. Sacramento, CA.

[7] California Department of Parks and Recreation. 2006. California State Park System statistical report – FY 2004/05. Sacramento, CA.

[Recreation days = number of individual visits (not the number of individual visitors) to the state park during the fiscal year.]

[8]USDA Forest Service. 2006. National Visitor Use Monitoring Results for Plumas National Forest.

[Site visit = visit by one person for an unspecified period of time. Average wilderness visit length 22.6hrs]

[9] National Park Service. 2006. National Visitation Database. Accessed online at http://www2.nature.nps.gov/npstats/npstats.cfm. Accessed August 21, 2006.

[Recreation visits = number of individual visits]

[10]Valle, Pandora C. Recreation Manager. Beckwourth Ranger District, Plumas National Forest. Blairsden, CA. November 14, 2006. Personal Communication.
[11]USDA Forest Service. 2005. Lassen National Forest fee collection report for Eagle Lake Recreation Area.
[based on 13,526 occupied campsites and an assumed party size of three]
[12]Scott, Amber V. Recreation Technician. Almanor Ranger District. Lassen National Forest. Chester, CA. December 3, 2006. Personal Communication.
[Based on mechanical trail counters at three trailheads July-Oct, 2005]
[13]Morehouse-Braxton, Linda L. Assistant Resource Officer. Feather River Ranger District, Plumas National Forest. Oroville, CA. December 6, 2006. Personal Communication.
[Estimated combined hiking and camping use 30,000-35,000]
[14]USDA Forest Service. 2006. Plumas National Forest Little Grass Valley campsite occupancy report.
[15]California Department of Fish and Game. 2006. Lake Davis Pike Eradication Project Draft EIR/EIS. Sacramento, CA.
[16]Northwest Park Management. Oct 16, 2006. 2006 Seasonal Summary: Antelope Recreation Area.
[Campsite occupancy for 2005. During 2006, Antelope Lake RA experienced a 33% decline in campground use due to wildland fire damage and partial closure.]
[17]Dawson, Mike. Trail Operations Director. Pacific Crest Trail Association. Sacramento, CA. September 26, 2006. Personal Communication.
[Approximate number of people getting a permit to hike the entire PCT in 2005]

immediately following wildfire by damage to access and facility infrastructure. However, over time, opportunities to view the aftermath of wildfire, and resulting processes of forest recovery such as wildflowers, may attract numbers of recreationists exceeding prefire visitation rates (Englin and others 2001, Loomis and others 2001).

The authors of the updated California Fire Plan also contemplated the complex issues involved with estimating recreation values lost as a result of a wildland fire. As the authors noted, wildfire does not totally destroy the recreation values of lands that are burned; however, statewide recreation use is significantly degraded by wildfires, particularly due to the direct costs of replacing recreation facilities and due to lost private sector and public revenues during periods of facilities closures.

For purposes of estimating potential damages to recreation values, the authors of the California Fire Plan assumed that 15 percent of the recreation value associated with an acre of land is lost during the first year after a fire, with the percent of value lost decreasing to zero in a straight line over the 9-year period following the fire. For purposes of the B2E Project, this assumption was adopted for application to "moderate-intensity" fires. Furthermore, it was assumed that damage during the year of the fire would be twice as high based on the assumption that the fire would occur during the height of the outdoor recreation season, indicating 30 percent loss of value. For "high-intensity" fires, damage was assumed to be 60 percent during the year of the fire and 30 percent during the year following the fire. For "low-intensity" fires, damage was assumed to be 10 percent during the year of the fire and 5 percent for the following year. These assumptions are summarized in Table 3-4.

Table 3-4. Fire Damage and Recovery Assumptions for Recreation Assets

	Damage to Recreation Assets in Each Year									
Fire Intensity	**1 (fire year)**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Low	10%	5%	4%	4%	3%	3%	2%	1%	1%	0%
Medium	30%	15%	13	11%	9%	7%	6%	4%	2%	0%
High	60%	30%	26%	22%	19%	15%	11%	7%	4%	0%

Structures

Residential, commercial, and industrial buildings in forested areas are potentially at risk to destruction from wildfires. The B2E study area includes a diversity of land ownership, including private property. Several small towns dot the landscape with private parcels loosely clustered in the northwest, central, and northeast portions. Because data were readily available only for private property values, the structure asset layer does not include structures in National Forests, Lassen Volcanic National Park, or other public lands.

2. Structure Asset Values

Structure values were derived from county assessor parcel data. Data were purchased from a private vendor who provided parcel data in tabular format and parcel boundary shapefiles. Data were obtained for Plumas, Lassen, Sierra, and Butte counties. Structure value was assumed to be the sum of the "improvement value" and "other value" fields. Thus, the sum does not include

the assessed value of the land itself. The resulting structure value was joined to the parcel boundary using the APN in the project GIS.

Because the exact location of a structure on a parcel was unknown in many cases, parcels were assigned a value per acre calculated by dividing the improvement value by the number of acres in the parcel. This approach presents a limitation in the case of large parcels containing few structures since the acres burned may not include the structures that represent a substantial portion of the property value.

3. Damage Function

There are many factors that determine whether or not a structure burns in a wildfire. Fuel type, wind speed, terrain, relative humidity, defensible space, building materials, and suppression resources can all play a role. While wildfire risk models have been developed for individual homes, the scale of the B2E project precluded consideration of so many factors. Instead, flame length was chosen as a proxy for fire behavior, which is the result of fuel, weather, and terrain conditions. Data were not available for other factors affecting structure loss.

The structure damage function was based on three assumptions: (1) ground fires will not result in structure damage; (2) moderate intensity fires will cause partial structure damage; and (3) fires generating high flame lengths will result in complete loss (Table 3-5). These assumptions are based on the professional judgment of fire managers and modelers (Ager 2006; USDA Forest Service 2006).

Table 3-5: Structure Damage Determined by Flame Length

Fire Class	Flame Length (feet)	Structure Value Lost
0	No Fire	No Damage
1 (Surface Fire)	0-3.99	No Damage
2 (Passive Crowning)	4.00-7.99	50%
3 (Active Crowning)	8.00+	100%

4. Calculating Value Loss

To calculate structure value lost to wildfire, GIS was used to overlay wildfire perimeters, flame length, and private property improvement values for each time period in each scenario. As noted above, the improvement value was averaged across the entire parcel. A routine was written that identified the flame length in each pixel of each parcel within a fire perimeter and applied the damage function to the structure value assigned to the pixels. Losses were summed for each time period and divided by ten years to provide an average annual loss. The sum of losses over four time periods (40 years) provided the total loss per scenario.

Infrastructure

Following procedures developed by CDF for its Fire Plan, the assessment of infrastructure asset value focused on electrical transmission lines. Electrical transmission lines are located in several areas of the study area, with transmission line corridors tending to parallel roadway corridors. According to the California Energy Commission (2005), 60-92 kilovolt (kV) lines are located along Highways 36, 70, 89, and Highway 395 through the study area. Lines also are located in several other locations, including northwest of Westwood and north and south of the Portola area. These transmission lines could be subject to damage in the event of a fire.

Infrastructure Asset Value

No data are available concerning the value of electrical transmission lines in the study area. Information, however, is available concerning typical construction costs for transmission lines, which was used to approximate the cost to replace transmission lines should they be damaged by a fire. Typical costs for various voltages of transmission lines are shown in Table 3-6.

Table 3-6. Typical Electricity Transmission Line Construction Costs

Voltage	Type of Supporting Tower	Cost per Mile (2006$)
Unspecified[a]	Unspecified	$280,300-$470,700
Unspecified[b]	Steel pole	$267,300
60-kV[c]	Wood pole	$163,500-$177,200
115-kV[c]	Wood pole	$177,200-$190,800
115-kV[b]	Steel pole	$430,000
115-kV[c]	Steel pole	$340,800-$545,200
230-kV[c]	Steel pole	$490,700-$1,144,900

Note: Costs represent complete replacement of transmission lines and towers.
Sources:
[a] Geothermal Energy Association 2005.
[b] U.S. Department of Energy, Bonneville Power Administration, 2004.
[c] CSA Energy Consultants 1995.

As shown, costs vary but tend to increase with higher voltages and with stronger supporting structures. As mentioned previously, transmission lines in the study area fall into the 60-92 kV range, suggesting that full replacement costs could range from about $163,000 per mile for 60-kV wood pole lines to the low range of costs for 115-kV steel pole lines, at $340,800 per mile.

Given the rugged conditions in the study area, and the isolated locations of transmission lines, both indicating that repair and replacement costs could be higher than average, replacement costs in the upper range were considered to better approximate replacement costs for lines in the study area. For purposes of valuing transmission line infrastructure assets, a value of $300,000 per mile was used.

Damage Function

The amount of damage that a fire could do to electrical transmission lines depends on several factors, including the intensity and type of a fire. For example, a crown fire that leaps across a transmission line corridor could do substantial damage to lines, whereas a low-intensity range or grass fire may do little damage other than to singe poles. The type of structure supporting lines may also play a role in the level of damage to transmission corridors. Wooden support poles

could burn in a moderate- or high-intensity fire. In contrast, steel poles may sustain little damage, even during high-intensity fires.

The existing literature, however, indicates that even relatively low-intensity fires can cause at least short-term damage to transmission lines. For example, smoke from a fire can damage transmission lines or cause them to short out. Fires burning near transmission lines can also cause outages when flames ionize the air around lines, breaking down the normal isolating properties of air, causing power arcs. System insulators may also be damaged by the air pollution caused by a nearby fire. And, as mentioned previously, fire can damage wooden poles and can directly destroy the lines themselves.

For purposes of developing a damage function for the electric transmission line infrastructure, it was assumed that a low-intensity fire would result in 25% damage to lines and poles ($75,000 per mile), that a moderate-intensity fire would cause 50% damage to lines and poles ($150,000 per mile), and that a high-intensity fire would cause 100% damage to lines and poles ($300,000 per mile). Transmission lines presumably would be repaired in the year of the fire, resulting in no residual damage for the years following a fire.

Mineral Resources

The location of mineral resource assets within the study area was identified using county assessors' land use codes for Butte, Lassen, Plumas, and Sierra counties. These codes, which are employed by county assessors to designate the primary and secondary land uses of individual parcels, provide indications of active or potential mining activities on properties within each county. Using the relevant land use code for mining and mining-related uses, a GIS asset layer was created, identifying the location of potential mining uses throughout the study area.

Values, however, were not assigned to mineral resources for purposes of estimating fire-related damages. This decision was made based on two factors. First, little or no data are available on the value of mines or mining outputs. Within the mining industry, information concerning the value of output is closely guarded by individual mining companies, greatly limiting access to the data needed to assign values to mineral resource assets in the study area. Second, a wildland fire is not anticipated to result in significant damage to mineral resources beyond temporarily disrupting production or potentially damaging equipment near mine sites. Based on these factors, valuation of mineral resources at risk to fire was not conducted.

3.2 Saw Log Valuation

The economic analysis estimated the net revenues from harvesting of conifer sawtimber by species. A review of potential sources for objective and consistent valuation data found that the best available source was the California Board of Equalization (BOE). The BOE sets timber harvest values as the basis for property taxes paid by California forest landowners and purchasers of public timber, per the California Timber Yield Tax Law of 1976. These values reflect revenues to operators net of production costs.

The California Timber Yield Tax Law established a state property tax levied on commercial sawlog harvests in California. This yield tax is paid by forest landowners and purchasers of public timber on a quarterly basis to the BOE, which returns these tax receipts to the counties where the timber was harvested. The yield tax is levied as the timber owner (or timber purchaser, in the case of public lands) harvests trees for

commercial use (i.e. lumber, paper, composite panels). The amount of tax owed is calculated based on the volume of timber harvested, value for the timber by tree species, size, and location as set by the BOE. The tax rate, also set by the BOE, is currently 2.9% of the timber value.

The values for the species harvested are provided by the BOE as a result of market analysis conducted by BOE foresters using actual sawtimber transaction data for each of the 11 timber value areas in California. The market analysis attempts to provide approximate stumpage[1] values for the timber before it is harvested, processed and transported to the market (i.e. sawmill, paper mill, composite panel facility). Valuation is expressed in dollars per thousand board feet ($/MBF)[2]. BOE provides timber harvest values for miscellaneous, green and salvage timber respectively. Timber values as reported by BOE assume that harvest of the timber is accomplished using tractor logging systems. A discount of $50/MBF is applied to the timber value if the logging system of choice is yarder or skyline (harvest systems utilized on slopes greater than 50%), which are typically more costly logging systems than tractor.

BOE timber valuation assumes that value for some conifer species, such as ponderosa pine and Douglas fir, is also a function of size. For these tree species, the BOE assumes that the larger the diameter of the sawlog, the more value it has in the marketplace. For example, size code 1 represents timber measured at 300+ board feet per sawlog (BOE assumes sawlog segments of 16 feet in length) and for ponderosa pine is valued at least $100/MBF more than ponderosa pine sawlogs in size code 3, representing smaller sawlogs with between 65 and 150 board feet per sawlog segment.

Converting the values in the BOE timber harvest value tables from sawlog value to standing timber value is a matter of comparing the equivalent size classes. Table 3-7 provides a comparison of BOE size code with board foot measure, sawlog diameter and approximate diameter at breast height (DBH)[3] for an equivalent standing tree.

Table 3-7. BOE Timber Harvest Size Code Classification Comparison

BOE SIZE CODE	VOLUME PER SAWLOG (BF)	SAWLOG DIAMETER[4]	STANDING TIMBER DIAMETER (STEM MEASURED AT BREAST HEIGHT)[5]
1	>300	22+	32
2	150-300	16-21	24
3	65 - 150	13-15	18
SSM	<65	6-12	<15

[1] Stumpage values represent the value of timber as it stands prior to harvesting.
[2] Thousand board feet represents the volume of a log based upon board foot measure. One board foot represents the amount of wood contained in an unfinished board measured one inch thick, one foot long, and one foot wide.
[3] Diameter of the bole of a tree measured at 4.5 feet above ground level.
[4] Data sourced from Scribner log volume tables as authorized by the Northern California Log Scaling & Grading Bureau, Revised July 1, 1972.
[5] Estimates of DBH were made based on field experience and using a composite table – Table 41. Composite Table page 308, Forestry Handbook, comparing gross board foot volume by DBH.

Note that the standing timber diameter as estimated in the final column in Table 3-7, will vary based on tree vigor and form class, which is influenced by such variables as soil conditions and tree species.

Using information provided in Table 3-7 and BOE timber harvest value schedules, timber harvest valuation tables by species and DBH for green and salvage timber were generated for Timber Value Areas 6 and 7 (see Tables 3-8, 3-9, 3-10, and 3-11 below). Note that the values in Tables 3-8 and 3-9 utilize the timber harvest values assigned to Timber Value Area 6, which represents an estimated 23 percent of the industrial private forest (IPF) acreage in the B2E study area, including eastern Shasta County and Lassen County. Tables 3-10 and 3-11 provide values for Timber Value Area 7 (Plumas, Butte, Shasta and Sierra Counties), which includes 77 percent of the IPF acreage in the study area. [Note that timber harvest values calculated in Tables 3-8 through 3-11 for DBH measured at 15"+ utilized linear interpolation to estimate values ($/MBF) based on harvest values as stated in the BOE timber harvest value schedules.]

For the B2E Project, harvest volumes were reported by the Stewardship and Fireshed Assessment Team using diameter size classes including 10-14.9", 15-24.9" and 25" plus. In order to set a value for timber volume reported by diameter class, it was assumed that the median diameter figure (20" DBH) for the 15 – 24.9" diameter class provides a reasonable metric for valuation. For the 25" DBH plus diameter class, a mid range diameter of 30" DBH was chosen to reflect valuation and the fact that few stems over 36" DBH will likely be harvested during the four decade analysis period. Note that in Table 3-8 the median and mid-range diameter figure for the two larger diameter classes is highlighted in yellow. A graphic representation of valuation using information presented in Table 3-8 is provided in Figure 3-1.

For purposes of the benefit-cost model developed for the B2E Project, which was used to generate valuations of the total harvest of saw logs and salvage logs under the treatment scenarios, weighted averages of the unit values for Timber Value Areas 6 and 7 were created. These weighted values were generated based on the amount of IPF acreage in the B2E study area in each Timber Value Area (i.e., 23 percent in Timber Value Area 6, 77 percent in Timber Value Area 7). Weighted values were created separately for green timber and salvage timber for all the size and timber specie classifications shown in Tables 3-8 through 3-11.

Figure 3-1. Valuation of Standing Timber by DBH and Tree Species for the B2E Landscape

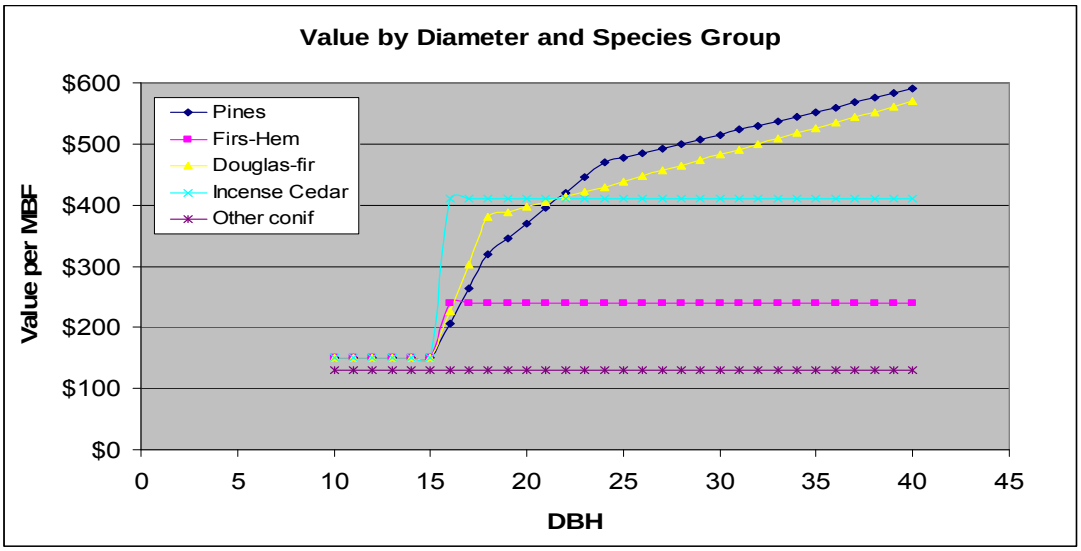
Value by Diameter and Species Group
$600
$500
$400
$300
$200
$100
$0
Value per MBF
Pines
Firs-Hem
Douglas-fir
Incense Cedar
Other conif
0
5
10
15
20
25
30
35
40
45
DBH

Table 3-8. Timber Harvest Value by Species and Diameter at Breast Height (DBH) for Green Timber (Value Area 6) in $/MBF Stumpage Value

	10” – 14.9” DBH						15” – 24.9” DBH								
Specie	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Pines	150	150	150	150	150	150	213	277	340	350	360	370	380	390	400
Firs-Hem	150	150	150	150	150	150	290	290	290	290	290	290	290	290	290
Doug fir	150	150	150	150	150	150	247	343	440	442	443	445	447	448	450
Incense Cedar	150	150	150	150	150	150	450	450	450	450	450	450	450	450	450
Other Conifer	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130

	25+” DBH															
Specie	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Pines	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560
Firs-Hem	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290
Doug fir	451	453	454	455	456	458	459	460	461	463	464	465	466	468	469	470
Incense Cedar	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450
Other Conifer	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130

Table 3-9. Timber Harvest Value by Species and Diameter at Breast Height (DBH) for Salvage Timber (Value Area 6) in $/MBF Stumpage Value

	10” – 14.9” DBH						15” – 24.9” DBH								
Specie	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Pines	150	150	150	150	150	150	153	157	160	173	187	200	213	227	240
Firs-Hem	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Doug fir	150	150	150	150	150	150	210	270	330	332	333	335	337	338	340
Incense Cedar	150	150	150	150	150	150	340	340	340	340	340	340	340	340	340
Other Conifer	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130

	25+” DBH															
Specie	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Pines	245	250	255	260	265	270	275	280	285	290	295	300	305	310	315	320
Firs-Hem	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Doug fir	341	343	344	345	346	348	349	350	351	353	354	355	356	358	359	360
Incense Cedar	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340
Other Conifer	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130

Table 3-10. Timber Harvest Value by Species and Diameter at Breast Height (DBH) for Green Timber (Value Area 7) in $/MBF Stumpage Value

	10” – 14.9” DBH						15” – 24.9” DBH								
Specie	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Pines	150	150	150	150	150	150	207	263	320	345	370	395	420	445	470
Firs-Hem	150	150	150	150	150	150	240	240	240	240	240	240	240	240	240
Doug fir	150	150	150	150	150	150	227	303	380	388	397	405	413	422	430
Incense Cedar	150	150	150	150	150	150	410	410	410	410	410	410	410	410	410
Other Conifer	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130

	25+” DBH															
Specie	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Pines	478	485	493	500	508	515	523	530	538	545	553	560	568	575	583	590
Firs-Hem	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240
Doug fir	439	448	456	465	474	483	491	500	509	518	526	535	544	553	561	570
Incense Cedar	410	410	410	410	410	410	410	410	410	410	410	410	410	410	410	410
Other Conifer	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130

Table 3-11. Timber Harvest Value by Species and Diameter at Breast Height (DBH) for Salvage Timber (Value Area 7) in $/MBF Stumpage Value

	10” – 14.9” DBH						15” – 24.9” DBH								
Specie	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Pines	150	150	150	150	150	150	173	197	220	242	263	285	307	328	350
Firs-Hem	150	150	150	150	150	150	140	140	140	140	140	140	140	140	140
Doug fir	150	150	150	150	150	150	193	237	280	287	293	300	307	313	320
Incense Cedar	150	150	150	150	150	150	310	310	310	310	310	310	310	310	310
Other Conifer	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130

	25+” DBH															
Specie	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Pines	356	363	369	375	381	388	394	400	406	413	419	425	431	438	444	450
Firs-Hem	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
Doug fir	328	335	343	350	358	365	373	380	388	395	403	410	418	425	433	440
Incense Cedar	310	310	310	310	310	310	310	310	310	310	310	310	310	310	310	310
Other Conifer	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130

3.3 Fuels Treatment Costs

Forest fuels treatment costs for Scenarios 2 and 3 were estimated using a spreadsheet model developed by the Forest Operations and Equipment Configuration Domain team. Costs were estimated by characterizing the type and blend of forest harvest and removal equipment used to perform forest remediation activities in the B2E study area. Equipment readily available and currently in use in Northern California, and that is specific to the forest remediation treatment prescriptions and topography as defined by the Stewardship and Fireshed Assessment team, was selected for modeling.

Cost estimation was based on information provided by experts (harvesting contractors and supervisors) currently conducting forest remediation activities in Northern California. Representative harvest operations, or “sides”, consisting of specific types and quantities of equipment for each harvest treatment prescription and range of slope conditions were developed. (“Side” is a common term used by harvest contractors to denote a separate and distinct blend of harvest equipment conducting harvest activities as a separate operation.) The spreadsheet model also incorporated estimates provided by experts of average production rates for each harvest operation (side). Purchase prices, fuel consumption rates and other parameters also were collected and used in the model.

For a specific equipment configuration, the machine-rate costs for each machine were combined with the expert opinion-derived numbers of machines of each type to calculate the annual cost for each type of machine used for the side. Total annual fuel and oil consumption were also calculated by type of machine with fuel usage estimates provided by the equipment vendors.

Total costs and fuel and oil consumption were then allocated to the two different products, chips and sawlogs, using the following logic: because a primary intent of the operations is to remove fuel and remediate forest stands, the biomass and sawlogs should share equally, on a per-ton basis, the costs of all activities that handle or process both products. Thus, costs were partitioned by weight over the biomass and sawlogs for activities directly associated with a side. The costs of ancillary activities were also shared on the same basis. Costs allocated solely to biomass included chipping (and costs of the loader used to feed the chipper if biomass was cold-decked for later processing) and hauling of chips.

The analysis did not consider loading and hauling activities associated only with sawlogs; therefore, the total reported costs for sawlogs were stump-to-landing, i.e., logs were brought to a deck on the landing. For the biomass, the costs covered the full span of harvest, skid, process and transport activities from the stump to delivery of chip to the biomass power generation facility.

Capital and operations and maintenance (O&M) costs were calculated separately on a per-ton unit basis for each product. These unit costs, which are reported in Table 3-12, were then multiplied by the amounts of biomass and sawlogs projected to be removed each decade, and divided by 10 (the number of years) to generate an average annual capital and O&M costs ($/year) for each of the two products, sawlogs and chips.

Table 3-12. Unit Costs Employed in the Assessment of Forest Fuels Treatment Costs

Equipment Configuration	Chips Stump to Plant		Sawlogs Stump to Landing	
	O&M Costs ($/BDT)	Capital Costs ($/BDT)	O&M Costs ($/BDT)	Capital Costs ($/BDT)
Clearcut <35% slope	$40.65	$11.71	$19.20	$6.51
Clearcut 35%-50% slope	$43.27	$12.88	$22.85	$7.91
Pre-commercial thinning <35% slope	$67.84	$21.23	NA	NA
Pre-commercial thinning 35%-50% slope	$79.25	$26.56	NA	NA
Commercial thinning <35% slope	$53.85	$17.33	$31.95	$11.90
Commercial thinning 35%-50% slope	$58.48	$19.72	$37.76	$14.55
Salvage <35% slope	NA	NA	$30.49	$7.35
Salvage <35% slope on public land	NA	NA	$34.33	$7.53
Salvage 35%-50% slope	NA	NA	$34.05	$9.21
Salvage 35%-50% slope on public land	NA	NA	$37.22	$9.21
Select harvest <35% slope	$42.48	$12.41	$22.37	$7.50
Select harvest 35%-50% slope	$48.53	$14.71	$27.28	$9.52
Select harvest 50%+ slope	$104.17	$17.45	$69.54	$7.60
Restrictive thinning <35% slope on public land	$57.29	$15.45	$31.34	$9.20
Restrictive thinning 35%-50% slope on public land	$59.74	$16.32	$32.07	$9.72

Note: BDT = bone-dry ton.
NA = not applicable.

3.4 Power Plant Costs and Revenues

Power plant cost estimates developed for the B2E Project are primarily comprised of the following three components:

- initial capital and development costs for the permitting and building of the project,
- the cost of financing these up-front costs during construction as well as the operating phases of the project, and
- the actual operating and maintenance of the project during its operating life.

Initial capital costs were estimated on the basis of similar-sized plants that are being built on the West Coast, with costs based on the assumption that a new facility would be constructed on land that is rural in nature, and that it is built where permitting for a biomass power plant is a reasonable financial undertaking. Installed cost was conservatively estimated at $2.5 million for each megawatt of capacity. Development cost estimates were based on experience of

permitting and financing such a project, and for securing a contract for the sale of plant output. These estimates included costs for legal and consulting work associated with project development activities.

Financing cost was based on the assumption that the project will be a stand-alone entity, and that the equity investors and debt lenders will have only recourse to the project itself. Equity investors are expected to be traditional industry investors who have use of the production tax credits that are available for owning biomass, a renewable energy source. Debt sources were assumed to be large commercial banks or institutional lenders such as insurance companies. The term of debt is typically 15 years, fully amortizing. It was assumed that there would be a large pool of experienced equity providers and lenders for projects of this type.

Operating and maintenance costs of the project were based strictly on the experience at Mount Lassen Biomass Project. Mount Lassen has had a long history of continuous operations, providing empirical data that should be very representative of the costs associated with the operations of a typical biomass power plant.

The resulting estimates of capital and O&M costs, per power plant, were used to estimate total costs for all plants that would be constructed under Scenarios 2 and 3. These per-plant estimates are shown in Table 3-13. Under Scenario 2, five power plants with capacity of about 10.6 MW each would be constructed. Under Scenario 3, seven power plants with capacity of about 9.8 MW would be constructed.

Table 3-13. Power Plant Cost and Revenue Estimates, by Decade (in millions of 2006 dollars, per plant)

Scenario	2006	2016	2026	2036
Scenario 1				
Capital costs				
Construction	$36.6	NA	NA	NA
Annual capital debt interest	$3.9	$3.9	$4.4	$5.1
Annual O&M costs	$8.3	$8.3	$8.6	$8.6
Annual power revenues	$7.1	$7.1	$7.9	$8.6
Scenario 2				
Capital costs				
Construction	$33.9	NA	NA	NA
Annual capital debt interest	$3.6	$3.6	$4.0	$4.7
Annual O&M costs	$2.5	$2.5	$2.5	$2.5
Annual power revenues	$6.6	$6.6	$7.2	$7.9

Note: NA = not applicable.

Power plant revenue estimates were developed by multiplying the electricity output of the power plants constructed under each scenario by a price per kWh. The prices incorporated into the revenue estimates were based on information provided by the California Renewable Portfolio Standard (RPS) Program. This program calls for the California Public Utilities Commission (CPUC) to establish a methodology to determine the market price of electricity for terms corresponding to the length of contracts with renewable generators. The "market price" must reflect the long-term market price of electricity a utility would need to purchase to meet its capacity and energy needs from conventional fossil fuel resources instead of the renewable resources proposed under the RPS bidding process.

The market price referent (MPR) developed by the RPS Program represents a proxy for the cost of a comparable, long-term contract with a combined cycle gas turbine facility, levelized into a cent-per-kWh value. Table 3-14 shows the MPR values for a baseload proxy plant adopted by the CPUC on April 13, 2006, in Resolution E-3980 Adopting 2005 MPR. As the table indicates, a 10-year contract for energy produced by a renewable plant coming on line in 2006 has an MPR of $0.08317 per kWh. For a 20-year contract, the MPR would be $0.08330 per kWh.

Table 3-14 Adopted 2005 Market Price Referents
(Nominal - dollars/kWh)

Resource Type*	10-Year	15-Year	20-Year
2006 Baseload MPR	0.08317	0.08178	0.08330
2007 Baseload MPR	0.07894	0.07926	0.08098
2008 Baseload MPR	0.07681	0.07817	0.08040
2009 Baseload MPR	0.07594	0.07811	0.08074

3.5 Fire Suppression and Rehabilitation Costs

Fire suppression and rehabilitation costs can vary considerably because of fire-specific differences in location, terrain, fuel type, proximity to populated areas, weather, fire intensity, etc. A review of literature and data concerning fire costs revealed little fire suppression and rehabilitation information specific to the B2E study area. Therefore, cost data developed for modeling purposes was based on national data and information available for fires in others areas, implicitly acknowledging that costs may differ for fires in the B2E study area. The following sections discuss the data used to develop the per acre costs estimates for fire suppression and rehabilitation.

Fire Suppression

For purposes of estimating suppression costs, cost data from the U.S. Forest Service (Strategic Issues Panel on Fire Suppression 2004) and from a study of Colorado fires (Lynch 2004) were used to develop per acre estimates.

According to annual U.S. Forest Service fire suppression cost data for the 1980-2002 period (Strategic Issues Panel on Fire Suppression 2004), annual fire suppression costs nationally ranged from $156 to $863 per acre (in adjusted 2002 dollars). For these fires, which affected more than 20 million acres over this period, suppression costs averaged $403 per acre.

Within the B2E study area, much of the area at risk is in rugged and isolated areas of national forests. Although national cost data may not be representative for the B2E study area, a comparison of the national cost data with suppression cost data for fires in Colorado, which may share some topography and fuel attributes with the B2E study area, indicates that national data may represent a reasonable approximation of suppression costs in the B2E study area. As Table 3-15 shows, per acre suppressions costs for all wildland fires in Colorado averaged $525 during the 1991-96 period but fell to $303 per acre in 2002. For individual fires that were the subject of cost case studies, suppression costs for all fires other than 1994's Hourglass fire, ranged from $223-$303 per acre.

Table 3-15. National U.S. Forest Service Fire Suppression Costs: 1980-2002 (2002$)

Year	Acres Burned	Total Fire Suppression Costs	Suppression Cost Per Acre
1980	243,221	$125,403,147	$516
1981	456,841	$176,504,811	$386
1982	74,372	$45,788,428	$616
1983	103,831	$51,371,132	$495
1984	186,825	$96,581,805	$517
1985	693,552	$241,957,455	$349
1986	451,218	$162,330,242	$360
1987	1,206,178	$361,736,313	$300
1988	3,675,507	$573,898,479	$156
1989	588,280	$424,595,066	$722
1990	500,822	$282,994,251	$565
1991	221,679	$136,279,418	$614
1992	765,391	$307,768,768	$402
1993	267,696	$128,022,767	$478
1994	1,706,085	$770,820,162	$452
1995	358,698	$189,484,322	$528
1996	1,353,388	$546,749,614	$404
1997	353,776	$164,467,686	$464
1998	267,445	$230,874,461	$863
1999	985,458	$364,190,968	$370
2000	2,730,210	$1,015,644,688	$372
2001	765,778	$655,021,724	$855
2002	2,128,599	$1,146,024,767	$538
Total	**20,084,850**	**$8,102,025,250**	**$403**

Source: Strategic Issues Panel on Fire Suppression 2004.

The Colorado suppression cost data are generally consistent with the national U.S. Forest Service cost data, indicating that the national suppression cost of $403 per acre is reasonable for use in estimating future suppression costs in the B2E study area. This cost was adjusted to 2006 dollars using the Employment Cost Index for state and local government workers, resulting in an average fire suppression cost of $465 per acre.

Rehabilitation

Expenditures on post-fire rehabilitation vary considerably because this spending is more discretionary than is spending on fire suppression. Additionally, variations in locations of fires can play a larger role in costs. For example, a fire that results in erosion that threatens urban water supplies or that increases the chances for major flooding in urban areas may spur significant emergency and long-term rehabilitation spending, whereas a fire in a remote area that does little damage to major watersheds may generate little or no rehabilitation spending. Activities funded by rehabilitation spending can vary from emergency erosion control to multi-year programs that include watershed seeding and tree plantings.

According to one study that collected rehabilitation cost information from government and industry forestry professionals in Oregon and Washington, rehabilitation costs generally range

from no expenditures up to $400 per acre (Mason et al. 2006). Rehabilitation costs for three large fires in Colorado fall into this range, with costs ranging from $78-$348 per acre (Table 3-16.) Higher rehabilitation spending following Colorado's Buffalo Creek and Hayman fires was largely driven by impacts on the City of Denver's water supply, efforts to reduce downstream flooding, and repairs to recreational facilities during the years following the fires.

Table 3-16. Summary of Colorado Fire Suppression and Rehabilitation Costs

Fire (Year)	Acres Burned	Fire Suppression Cost		Rehabilitation Cost[a]	
		Total (1,000)	Per Acre	Total	Per Acre
All (1991-96)	40,882	$21,472,607	$525	NA	NA
All (2002)	502,000	$152,000,000	$303	NA	NA
Individual fires:					
Black Tiger (1989)	2,100	$830,300	$395	NA	NA
Hourglass (1994)	1,275	$1,500,000	$1,176	NA	NA
Buffalo Creek (1996)	11,900	$2,650,000	$223	$1,600,000	$134
Bobcat Gulch (2000)	10,599	$3,840,319	$362	$823,854	$78
Hayman (2002)	137,759	$42,279,000	$307	$47,927,972	$348

Notes:
NA = not available.
[a] Average cost per acre reflects rehabilitation costs spread across all burned acreage, although rehabilitation does not necessarily occur on all burned acreage.
Source: Lynch 2004.

More typical of rehabilitation spending following fires in national forests is emergency short-term efforts to control erosion in watersheds. A U.S. Forest Service study that evaluated emergency rehabilitation treatments following 480 fires, primarily on National Forest system lands, from 1973 through 1998 found that rehabilitation spending is generally lower than the spending following the Colorado fires. Of the 480 fires evaluated, emergency rehabilitation was conducted following 321 of the fires; no rehabilitation occurred following the remaining 148 fires (Robichaud 2000). Over the 1973-1998 period, emergency rehabilitation spending for all fires included in the study averaged about $15 per acre (in 1999 dollars) in Region 5, which includes California. Among the 10 costliest fires nationwide, in terms of rehabilitation spending, was the Clarks Incident fire, which occurred in Plumas County in 1988. Rehabilitation spending following this fire totaled about $1.3 million (in 1999 dollars), indicating a cost of $32 per acre.

Fires in the B2E study area may be largely in isolated areas of national forests where there are no immediate concerns about urban flooding or threats to urban water supplies. If rehabilitation occurs following a fire, it is likely to take the form of the emergency rehabilitation measures reflected in the U.S. Forest Service study. For purposes of the B2E Project, it was assumed that the average rehabilitation cost associated with the Clarks Incident fire would be reflective of future rehabilitation spending in the study area. Adjusted to 2006 dollars, this cost is $41 per acre.

4. RESULTS

Table 4-1 shows estimates of the initial value of assets in the study area at risk to fire damage and fire-related losses (in present value) to these assets over the 40-year analysis period. Of the $20.8 billion in initial value, timberland resources comprise more than $18.1 billion in asset value, followed by structures ($2.4 billion), recreation resources ($117.8 million), infrastructure ($102.3 million), and agricultural lands ($41.3 million).

Table 4-1. Study Area Market Asset Value Changes by Treatment Scenario (in millions of 2006 dollars)

Asset Type	Initial Value	Loss in Value Due to Fires		
		Scenario 1 (No Treatment)	Treatment Scenario 2	Treatment Scenario 3
Agricultural lands	$41.3	$3.6	$3.4	$2.8
Recreation resources	$117.8	$1.7	$1.5	$0.95
Infrastructure	$102.3	$3.0	$2.8	$1.9
Structures	$2,364.5	$43.0	$29.7	$27.2
Timber	$18,144.2	$612.7	$551.0	$385.6
Total	$20,770.2	$664.1	$588.4	$418.5

Note: The loss in value for the treatment scenarios represents the accrued present value of the losses from fires over the 40-year project period.

The present value of losses due to fire over the 40-year period is $664.1 million under Scenario 1, $588.4 million under Scenario 2, and $418.5 million under Scenario 3. The reduction in asset value loss in Scenarios 2 and 3, relative to Scenario 1, is attributable to timber harvest and fuels treatment activities associated with the vegetation management treatments under these scenarios.

Table 4-2 shows the annualized costs and revenues associated with the No Treatment and treatment scenarios. The costs include capital and operations and maintenance (O&M) costs for fuels treatment and power production, and the revenues are those generated from the sale of power and saw logs, both from timber harvest and salvage activities. (Note that the costs associated with timber harvesting are not identified but are accounted for in saw log revenues in Table 4-2, which are revenues net of production costs.) The volume of chips generated by thinning activities are sufficient to fuel five power plants with an average capacity of about 10.8 MW per plant under Scenario 2 and seven power plants at an average capacity of 9.8 MW per plant under Scenario 3.

Table 4-2. Annualized Costs and Revenues for No Treatment and With Treatment Scenarios (in millions of 2006 dollars)

Value Category	Scenario 1 (No Treatment)	Treatment Scenario 2	Treatment Scenario 3
Project costs:			
Fuels treatment			
-- Capital costs	N/A	$3.1	$4.2
-- Operations & maintenance costs	N/A	$10.9	$15.0
Power Plant Operations			
-- Capital costs	N/A	$12.1	$15.6

-- Operations & maintenance costs	N/A	$24.3	$31.9
Fire suppression	$2.05	$1.9	$1.6
Rehabilitation	N/A	$0.05	$0.03
Total costs	$2.05	$52.3	$68.3
Project revenues:			
Power generation	N/A	$21.7	$27.9
Saw logs from timber harvest	N/A	$53.4	$72.3
Saw logs from salvage	N/A	$0.09	$4.2
Total revenues	N/A	$76.0	$104.4

Note: Revenues and costs represent the annualized present value, in millions of 2006 dollars, of values accruing over the 40-year project period. Saw log revenues are net of costs.
N/A = not applicable.

Table 4-3 shows the annualized revenues, costs, and asset values of the No Treatment Scenario and Scenario 2. Because the No Treatment Scenario assumes no vegetation management treatment or post-fire salvage harvest, no costs are incurred for treatment or power generation activities and no revenues are produced from the sale of power or saw logs.

Table 4-3 also compares costs and revenues (in net present value) under Scenario 2 with the No Treatment Scenario. Because the primary treatment focus of Scenario 2 is on sustained timber harvesting, saw log revenues from Scenario 2 dominate the economic results and obscure insights to the economic benefit of fuels treatment from modifying fire behavior. The avoided asset damage for Scenario 2 (relative to the No Treatment Scenario) is about $1.9 million annually, but vegetation management treatment costs are $14 million annually. Clearly, some of the treatment benefits are embedded in the sizeable stream of saw log revenues. Overall, the net present value of Scenario 2 is about $27.6 million greater than the No Treatment Scenario, suggesting that Scenario 2 would be worth pursuing on economic efficiency grounds.

Table 4-3. Net Present Value of Treatment Scenario 2 Relative to the No Treatment Scenario (in millions of 2006 dollars)

Value Category	Scenario 1 (No Treatment)	Treatment Scenario 2	Comparison of TS2 to TS1
Average annual project revenues:			
Power generation	N/A	$21.7	$21.7
Treatment saw logs	N/A	$53.4	$53.4
Salvage saw logs	N/A	$0.9	$0.9
Total annualized revenues	N/A	$76.0	$76.0
Average annual project costs:			
Vegetation management treatment			
-- Capital costs	N/A	$3.1	$3.1
-- Operations & maintenance costs	N/A	$10.9	$10.9
Power Plant Operations			
-- Capital costs	N/A	$12.1	$12.1
-- Operations & maintenance costs	N/A	$24.3	$24.3
Fire suppression	$2.0	$1.9	($0.11)
Rehabilitation	N/A	$0.05	$0.05
Total annualized costs	N/A	$52.3	$50.3

Average annual asset values:			
Agricultural lands	$23.8	$23.8	$0.006
Recreation lands	$68.0	$68.0	$0.004
Infrastructure	$59.0	$59.0	$0.006
Structures	$1,365.3	$1,365.6	$0.33
Timber	$10,469.78	$10,471.22	$1.54
Change in asset values			$1.89
NET PRESENT VALUE	N/A	N/A	$27.61

Notes: Revenues, costs, and asset values represent the annualized present value, in millions of 2006 dollars, of values accruing over the 40-year project period. Net present value = revenues – costs + change in asset values (loss or avoided loss to assets). Saw log revenues are net of costs.
N/A = not applicable.

Table 4-4 compares the annualized revenues, costs and asset values associated with the two treatment scenarios. Because the only difference between these treatment scenarios is that Scenario 3 also includes vegetation management treatment on public lands, comparing the two scenarios provides insights to the economic benefit of fuels treatment on public lands.

Vegetation management treatment costs for Scenario 3 are estimated at about $5.3 million annually. A direct benefit from treating public lands in Scenario 3, which is focused on modifying fire behavior, is an estimated $4.6 million annually in avoided asset damage (primarily timberland losses) and reduced fire suppression and rehabilitation costs. In addition, fuels treatment on public lands would generate more than $22 million in saw log revenues. Overall, Scenario 3 contributes more than $16 million in net present value, which is in addition to the $27.6 million from Scenario 2.

Table 4-4. Net Present Value of Treatment Scenario 3 Relative to Treatment Scenario 2 (in millions of 2006 dollars)

Value Category	Treatment Scenario 2	Treatment Scenario 3	Comparison of TS 3 to TS 2
Average annual project revenues:			
Power generation	$21.7	$27.9	$6.3
Treatment saw logs	$53.4	$72.3	$18.9
Salvage saw logs	$0.9	$4.2	$3.3
Total annualized revenues	$76.0	$104.4	$28.4
Average annual project costs:			
Vegetation management treatment			
-- Capital costs	$3.1	$4.2	$1.1
-- Operations & maintenance costs	$10.9	$15.0	$4.1
Power Plant Operations			
-- Capital costs	$12.1	$15.6	$3.5
-- Operations & maintenance costs	$24.3	$31.9	$7.6
Fire suppression	$1.9	$1.6	($0.32)
Rehabilitation	$0.05	$0.03	($0.02)
Total annualized costs	$52.3	$68.3	$16.0
Average annual asset values:			

Agricultural lands	$23.8	$23.8	$0.01
Recreation lands	$68.0	$68.1	$0.02
Infrastructure	$59.0	$59.1	$0.02
Structures	$1,365.7	$1,365.7	$0.06
Timber	$10,471.2	$10,475.4	$4.14
Change in asset values			$4.25
NET PRESENT VALUE	NA	NA	$16.65

Notes: Revenues, costs, and asset values represent the annualized present value, in millions of 2006 dollars, of values accruing over the 40-year project period. Net present value = revenues – costs + change in asset values (loss or avoided loss to assets). Saw log revenues are net of costs.
N/A = not applicable.

Fuels treatments under Scenario 3 also produce biomass that would be available for power plant operations. Based on treatment and transportation requirements under this treatment scenario, biomass fuel delivered to power plants would cost an estimated $68 per bone-dried ton (BDT). Based on the modeling of power plant financials, however, power plant operators could afford to pay no more than $8.20 per BDT to achieve an acceptable rate of return on investment under Scenario 3. (The financial model assumed that power plant project investors would require a long-term after-tax return to equity of 14.5 percent to attract investment in a project.) Barring some other source of revenue, such as revenue from steam sales or government grants, constructing and operating biomass power plants would not be feasible at a fuel cost of $68 per BDT.

From a broader societal perspective, subsidies based on the value of avoided asset losses and avoided fire suppression and rehabilitation costs could be offered to power plant operators to offset the relatively high cost of biomass fuel. Under Scenario 3, the avoided fire damage to assets and reduced fire suppression and rehabilitation costs in the B2E landscape would total about $4.6 million annually (relative to Scenario 2). When this asset benefit is incorporated into the power plant financials (by lowering annual O&M costs by $4.6 million), the analysis indicates that a power plant operator could pay up to $54.80 per BDT for biomass fuel, while still achieving the targeted return on investment. This suggests that fuel subsidies for biomass power plant operations of up to $46.60 per BDT ($54.80 minus $8.20) should be considered from a public policy perspective.

Although environmental costs and benefits are not monetized and included in the economic analysis, results from evaluating effects of the treatment scenarios on habitat indicate that implementation of the treatment scenarios would likely have an overall beneficial effect that would positively contribute to the net present value of these scenarios. On the other hand, the evaluation of carbon sequestration effects of the treatment scenarios indicate that, in the short term, carbon sequestration of the treated forest would be reduced and greenhouse gases would increase. In the long term, however, the increased productivity and fire resiliency of the treated forest would result in a substantial and prolonged net decrease in the level of atmospheric greenhouse gases. Effects on air quality would vary under the treatment scenarios, with CO and NOx emissions increasing and particulate matter, VOC, and SOx emissions decreasing over the four-decade study period. Overall, it appears that consideration of habitat, carbon, and air quality effects would likely contribute positively to the net economic value of the treatment scenarios.

5. CONCLUSIONS

5.1 Key Findings

Key finding of the analysis include:

- Scenario 2, which involves vegetation management treatments including timber harvest and fuels treatment on private lands, generates sufficient benefits (power and saw log revenues plus positive contributions to asset values from reduced fire risk) to exceed estimated costs, suggesting that implementing this scenario could be supported based on economic efficiency criteria. Annualized (discounted) benefits exceed annualized costs by about $27.6 million.

- Scenario 3, which includes treating public lands in addition to private lands, also generates annualized benefits that exceed estimated costs. Compared to Scenario 2, annualized (discounted) benefits exceed annualized costs by about $16.6 million, indicating that implementing Scenario 3 would incrementally contribute to net economic value.

- Comparing the two treatment scenarios reveals that vegetation management treatments on public lands in the B2E study area cost an estimated $5.3 million annually and generates about $4.6 million annually in benefits from avoided asset damage (due to fire) and reduced fire suppression and rehabilitation costs, in addition to $22 million in saw log net revenues.

- The benefits from vegetation management treatments (i.e., avoided asset damages and reduced fire suppression and rehabilitation costs) are relatively small in the context of total benefits of the treatment scenarios, which are generated primarily by revenues related to the sale of saw logs from fuels treatment activities. The relatively small effect on avoided fire-related damages to agricultural, recreation, structural, and infrastructure assets from vegetation management treatments reflects the undeveloped and generally rural characteristics of the study area. Only avoided fire-related damages to timberland assets are significant.

- The estimated net operating deficit of power plants that use chips produced from forest biomass in the study area as fuel reflects the relatively high cost of producing and delivering chips. Break-even analysis indicates that, under Scenario 3, the cost of chips for fuel would need to decrease from about $68 per BDT to about $8.20 per BDT for the power plants to be economically feasible. Subsidies based on avoided asset damage and reduced fire suppression and rehabilitation costs could contribute an estimated $46 per BDT.

- Although environmental costs and benefits were not monetized and included in the economic analysis, results from evaluating effects of the treatment scenarios on habitat, carbon sequestration, and air quality suggest that consideration of these effects would likely contribute positively to the net present value of the scenarios.

5.2 Limitations and Caveats

This section addresses key limitations and caveats to the research findings

Benefit-Cost Analytical Framework

Although benefit-cost analysis is widely used in the analysis of regulations and public policy, the approach is based on a number of underlying assumptions that have been challenged over the years. These assumptions include equating changes in income with social well-being, assuming that willingness-to-accept compensation and willingness-to-pay measures are essentially equal and substitutable, and using straight-line discount rates. According to Gowdy (2007), these and other basic assumptions underlying benefit-cost analysis are coming under increasing scrutiny because the assumptions are at odds with observed human behavior.

The successful application of benefit-cost analysis to natural resource policy issues depends on a scientific understanding of underlying physical and biological processes that shape the valuation of environmental costs and benefits. If these processes are not well understood, deriving valid estimates of monetary values is difficult. Boyd (2007) addresses the measurement challenges inherent to valuation of ecosystem services in the B2E study area. The lack of observable data from market transactions greatly increases the challenge to monetizing most of the environmental costs and benefits from the B2E Project.

Although sensitivity analysis was used to test the validity of certain conclusions drawn from the benefit-cost analysis, a more rigorous application is needed to thoroughly evaluate the sensitively of the results to the omission of monetized environmental costs and benefits and to data uncertainties. Conducting a comprehensive economic assessment at the B2E landscape would require a research effort that is an order-of-magnitude greater than this one.

Effects of Population Growth and Future Land Use Development

Although the economic analysis considered costs and benefits over a 40-year analysis period, changes in baseline conditions due to external forces such as population growth, recreation growth, and urban development were not considered. With the exception of tree growth in the supporting vegetation analysis, the economic analysis is considered static and does not account for important dynamic effects that would affect the value of assets at risk to wildfire.

GIS-Supported Analysis of Asset Values

A geographic information system (GIS)-supported approach that allowed for considering spatially-explicit relationships was used to assess the damages to assets at risk to wildfires. GIS was used to develop baseline values of assets at risk and to assess how fire affects these values over time. Some of the limitations and caveats from the GIS analysis include:

- The scale of the polygons and the difficulty of mapping assets within the polygons introduce substantial error in determining baseline values and expected damages to these values.

- The values used to develop the “structure” asset layer were based on assessed values rather than market values, likely resulting in underestimates of avoided damages to structures.

- Mining asset value data were not available; therefore, potential economic effects of avoiding damages to mining operations were not included in the analysis.

- The “infrastructure” asset value reflects only the value of electric transmission lines in the study area due to the difficulty of mapping and valuing other infrastructure assets.

Baseline Scenario Assumptions

The No Treatment Scenario assumes that no salvage occurs under the scenario. This assumption does not appear to be realistic and likely results in an overestimation of the comparative revenue generated by salvage activities under the treatment scenarios.

Other Data Limitations

- Rehabilitation costs associated with wildland fires are highly variable. The per acreage rehabilitation cost estimate incorporated into the benefit-cost model likely does not accurately capture probable rehabilitation costs within the study area. Similarly, assumptions built into the benefit-cost model concerning the number of acres that would be rehabilitated under each scenario may have considerable error.

- More research is needed to refine the damage functions and asset recovery rates that were incorporated into the benefit-cost model.

- The sensitivity of the economic results to fire ignition points is not known, but the results (relatively small avoided cost effects) suggest that these points are likely to be very important.

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