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Investments in Fuel Removals to Avoid Forest Fires Result in Substantial Benefits

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ABSTRACT

Forest fuel reduction treatments are needed, as shown by the increased number and cost of devastating crown fires in overly dense forests. Although large trees can be removed for valuable products, the market value for the smaller logs may be less than the harvest and hauling charges, resulting in a net cost for thinning operations. However, failure to remove these small logs results in the retention of ladder fuels that support crown fires with destructive impacts to the forest landscape. A cost/benefit analysis broadened to include market and nonmarket considerations indicates that the negative impacts of crown fires are underestimated and that the benefits of government investments in fuel reductions are substantial.

Keywords: forest fuels, nonmarket values, small-diameter logs, cost/benefit analysis, forest fires

If the negative impacts that result from crown fires were fully reflected in the market, there would be high motivation to avoid them, providing necessary incentive to remove excessive fuel loads in spite of the cost (Pfilf et al. 2002). For example, the cost of fighting fire could and should be considered a cost of not removing high fuel loads (see Figure 1). Similarly, there is the value of avoiding facility losses and fatalities. Communities value lower fire risk and reduced smoke. Forest fires destroy visual esthetics and limit recreational opportunities. Irreplaceable habitats for threatened and endangered species may be lost when forests burn. Valuable timber resources are destroyed. Forest fires consume forest biomass that otherwise could be used for products and clean energy conversion, and smoke increases atmospheric carbon associated with global warming.

Regeneration after fires is problematic and costly. Postfire invasion of exotic species may further threaten ecosystem recovery. Investments in postfire rehabilitation may be needed to avoid serious erosion, sedimentation, and water contamination. Conversely, if excess forest stems are removed to reduce hazardous fuel loads, then water otherwise consumed by overly dense forests could be available for other uses such as habitat, municipal reservoirs, and irrigation while also improving the health of remaining trees. Fuel reduction activities result in rural economic development benefits from the taxes and rural incomes generated by job creation. Because economic activity in these regions has been in decline as a consequence of lower federal timber harvests, any reduction in unemployment has higher than normal leverage on state and local finances by lowering assistance costs.

Forests thinned to remove fuel loads are unlikely to experience crown fires (Omi and Martinson 2002). Accounting for the full value of this reduced risk exposure, however, must take into consideration both the predicted costs of the activity as well as the approximated timing and cumulative values of avoided future fire events. Although it is impossible to predict exactly when a future fire might occur in a specific location, we do know that because of decades of fire suppression, the time since last burn in many forests is well beyond prior fire return cycles and that present fuel loads are well outside of historic levels (Agee 1993). Fire ecologists agree that the question is not whether these forests will burn but when.

Public Benefits of Fuel Reduction Investments

The challenge of developing long-term strategies to reduce wildfire risks across tens of millions of acres of Inland West forest is daunting. The body of information to be considered is huge and the planning process may be formidable. Infrastructure is limited, funding is scarce, costs are high, and politically charged conflicts are rampant. Strategies to help professionals, interested lay publics, and policymakers gain better understanding of the present circumstances and the future possibilities of hazardous fuel reductions are needed.

It is reasonable to assume that at some time there will be a forest fire in almost all high and moderate-risk forests and that such an inevitable event can be characterized as a

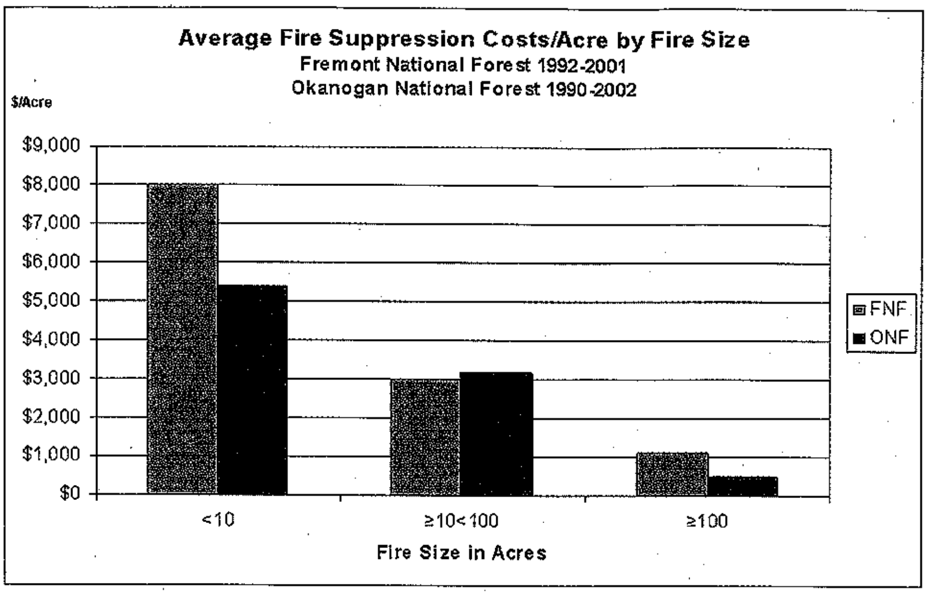

Figure 1. Average fire suppression costs—Fremont and Okanogan National Forests.

liability exposure. A simple present value calculation can be used to create a parametric output table of the estimated costs of future forest fires such that time, discount rate, type of public resource, and magnitude of event are definable variables readily customized for a spectrum of local expectations.

To illustrate how the risk of crown fires might be considered, a sample table has been constructed to display the present value of expected fire suppression costs for a variety of time-to-event intervals (see Figure 2). For this example, to add consideration of risk severity, assume that all acres of forests with a present high risk, if left untreated, will burn sometime in the next 30 years and all those forests considered at moderate risk will burn sometime in the next 60 years. If there is an equal probability of each acre burning in any year during the assigned interval, then a simplified average time for all acres to burn is equivalent to one-half the interval or 15 and 30 years, respectively.

Firefighting Costs

If we further assume that an inflation-adjusted interest rate of 5% is representative of the average anticipated cost of money throughout the risk interval, then we have what we need to begin a user-friendly approximation of the present valuation of fire risk. In the example in Figure 2, an average fire suppression cost of $1,000/ac, comparable with recent experience, has been used to calculate the present per acre value of a future liability. This example shows that every dollar that will be needed to fight forest fires during the 30-year period for high risk represents $0.48 of anticipated cost exposure today and during the 60-year period for moderate risk represents $0.23 today. Conversely, public expenditures in fuel removals today can be considered as investments toward a return that can be characterized in part as the sum of available present value estimates of costs avoided as fires do not occur.

Fatality and Facility Losses

Facility losses and fatalities are serious consequences of forest fire events. Fatalities from forest fires for 1990–1998 averaged 4.5 persons per million acres of wildland fires (Mangan 1999). Although it is difficult to place monetary value on lives lost to fire, an estimate by the Environmental Protection Agency, used to calculate the cost of regulations in comparison to expected health benefits, assigned the value of human life at $4.8 million per person (US Environmental Protection Agency 1999). Using these figures the present value of avoided fatalities would be $10/ac for high-risk areas and $5/ac for moderate-risk areas.

Facility losses are highly variable depending on the location and value of structures relative to the forest. Data from four large Colorado fires in 2002 (Rocky Mountain Insurance Information Association 2003) show insurance losses of $70 million from a total burned area of 225,000 ac. Estimated insurance losses from 2003 fires in California are greater than $2 billion with 750,000 ac burned (Insurance Information Network of California 2003, National Climate Data Center 2003). Using the more conservative Colorado numbers, a present value estimate of potential facility losses would be $150.24 per high-risk acre and $71.99 per moderate-risk acre.

Timber Resources

Destruction of marketable timber represents a lost public resource even if the forest plan does not include a provision for harvesting. The implicit value of ecological amenities in areas designated as no-harvest must be assumed to be greater than the foregone value of the marketable timber. Because these amenities are lost if the timber is destroyed by a crown fire, the market value of timber lost can be used as a probable lower bound of the true value. Simulations of the net yields of the 12-in. and larger-diameter trees from 1.3 million ac of high- and moderate-risk national forests in Washington and Oregon indicate average timber stumpage value at $1,605/ac (Mason et al. 2003). When discounted to create a present value estimate of timber resources at risk from fire, this figure becomes $772.01/ac for high-risk or $370.76/ac for moderate-risk stands.

Regeneration and Rehabilitation

Regeneration costs for commercially harvested forestland normally average $250/ac. Regeneration costs may be much higher and less successful after hot forest fires. Additional expenditures may be needed for rehabilitation activities to reduce erosion and protect water quality. Interviews with government and industry forestry professionals in Oregon and Washington indicate that rehabilitation costs have been in the $0–400/ac range. Increased regeneration costs and rehabilitation costs are likely to be site-specific so for this valuation an average regeneration cost ($250/ac) has been used to estimate present value of postfire restoration responsibilities at $120/ac for high-risk areas and $58/ac for moderate-risk areas.

Communities Value Risk Reduction

Experimental choice surveys, a specialized form of contingent valuation analysis (CVA), provide a promising method for estimating the willingness to pay (WTP) for fire risk reduction. In Washington State, rural and urban families were the subjects of an experimental choice survey, as they selected from different forest management alternatives that altered forest attributes. They selected from different mixes of (1) biodiversity and habitat; (2) esthetics; (3) rural jobs; (4) cost; and (5) a brand label for the treatments (Xu et al. 2003). The results showed a substantial WTP for biodiversity, habitat, and esthetics restoration, as well as a willingness to accept a level of cost and job losses to achieve these benefits. A WTP of more than $100/year per family for esthetics and habitat restoration was not uncommon, with city dwellers placing higher value on biodiversity than their rural counterparts.

Contingent values for protection from wildland fire have been estimated in other regions. Winter and Fried (2001) found a mean annual WTP for a hypothetical 50% reduction in fire risk of $57 per household per year for rural Michigan populations, with the amount sensitive to property value and family income. Presumably, the fire risks in the Inland West region are greater, supporting at least as high a WTP. Using the Michigan WTP of $57 per household per year, the number of households in counties surrounding the Fremont and Okanogan National Forests (US Census Bureau 2003) and the number of acres identified as at high and moderate risk in both forests, the authors calculated a present value per acre of annual WTP household contributions to assure reduced fire risk. Because the derived public benefit is the peace of mind that all acres and homes are safer as a result of annual investments in risk reduction, the value per acre can be considered to be the present value calculated as a perpetual annual series of payments and will be the same for both high- and moderate-risk acres. The mean present value for the two example forests was found to be $63.20/ac. Although rural families may be willing to pay more for fire protection than distant urban families, it is the collective WTP that determines the total benefit amount per acre. Adding the WTP benefit from more distant urban families would logically increase the value but has not been included here.

Non-market Valuations

$$V_0 = \frac{V_n}{(1+i)^n}$$

Where:

V_0 = present value at time 0

V_n = future value after n periods (years)

i = interest rate

n = number of periods (years)

Parametric Present Value Estimations of Fire Risk Costs with Assumptions of $1000/acre to Fight Fire and 5% as the Discount Rate.

For this Exercise Assume all High Risk acres burn in 30 years (15 year midpoint) and all Moderate Risk acres burn in 60 years (30 year midpoint).

Year	5	10	15	20	25	30	35	40	45	50	55	60
Method 1. Present cost/ac of a forest fire at specified future year	$784	$614	$481	$377	$295	$231	$181	$142	$111	$87	$68	$54

Figure 2. Parametric present valuation of estimated future fire fighting costs.

Regional Economic Benefits

Rural communities, which are most at risk from forest fires, often are economically depressed. Although fighting fires will induce some economic activity, much of that benefit goes to imported labor with little positive local impact. Fires also hinder some rural economic activities such as tourism and recreation. Fire risk reduction treatments, however, when scheduled over time, produce positive and sustainable contributions to the economies of local communities.

The Fremont National Forest estimates a harvest-to-annual jobs conversion ratio of 8 direct employees and 16 indirect employees per million board foot of harvest. To convert these employment figures into economic activity and tax receipts, our calculation uses similar estimates tied to a Washington State model (Conway 1994) that were further customized to thinning treatments in Lippke et al. (1996). Although the direct and indirect employment impacts are almost identical to the Fremont estimates, the Conway model shows nearly equal impacts broadly distributed to the nonrural parts of Washington State while also providing estimates of the benefits to the gross state product, which can be extended to tax receipts. A typical thinning treatment of 1 ac each year could generate dynamic direct and indirect impacts of 0.04 rural employees, $386 state and local tax receipts (at 11% of state product), and $664 federal receipts (at 19% of state product including some federal/state transfer duplication). Estimated state and local tax receipts of $386 per thinned acre can be used here as a conservative estimate of public economic value generated from hazardous fuel load reduction activities.

Wildlife Habitats

Given that habitat for threatened and endangered species may be lost when forests burn and that federal laws such as the *Endangered Species Act* suggest a very high value on species protection, an elusive question has been what is a threatened or endangered species or its habitat worth? Habitat for many sensitive species is lost when a crown fire consumes forest biomass. Although removal of hazardous fuels may have short-term negative impacts on habitat, these impacts generally are not as severe as those from a hot forest fire and may be avoided with due diligence. The protection of habitat in shortest supply should be an adjunct focus of fuel treatment plans linked to forest restoration. In some cases protection of habitat may mean fuel removals in other areas; where high- or moderate-risk forests comprise unique habitats, fuel reductions could occur in adjacent forests to create fuelbreaks. More work is needed to develop a consistent approach to public valuation of sensitive species; however, there are precedents for considerable public investments in species protection (Landry 2003, Lippke and Conway 1994).

Additional Values at Risk

By international agreement, countries are attempting to lower carbon emissions to reduce risk of global warming. Forests play several important roles in regards to global carbon balances. Carbon is removed from the air by trees as part of the photosynthesis process. Carbon is sequestered and stored in forests and wood products until released by combustion or decomposition. The use of wood building products offsets the use of more energy-intensive alternatives such as steel, aluminum, or concrete, resulting in less fossil fuel consumption and less atmospheric carbon. Markets, to promote tree farming to help reduce atmospheric carbon, are new and not well developed but may be expected to grow with the value of carbon credits increasing as more emitters of carbon (primarily utilities) bid for carbon offsets. As carbon credit markets are developed, they may generate revenues and that will offset treatment costs.

When forests burn, carbon dioxide, water vapor, carbon monoxide, particulate matter, hydrocarbons, and other organics; nitrogen oxides; and trace minerals are released into the atmosphere as smoke. Forest fires have been shown to contribute as much as 13–40% for some years of the annual atmospheric carbon generated by fossil fuel combustion (Page et al. 2002). Forest fires also produce fine particulate matter and other pollutants that can pose a significant health threat to people living in the "wildland-urban interface" (Government Accounting Office 1999).

Cogeneration in any number of forms adds value through the conversion of low-valued forest biomass to energy and can be considered a default use of material when higher-use markets are unavailable. When biomass is converted to energy it displaces energy created by fossil fuels. Because biomass-to-energy facilities produce less pollution per unit of energy than generation systems reliant on fossil fuels, net carbon emissions are reduced. Because forest biomass is a renewable domestic resource, reliance on foreign oil supplies is reduced with positive strategic result. The primary limitation to needed expansion of cogeneration infrastructure is assured access to sufficient biomass to warrant investments. Sustainable supplies of forest biomass represent an additional public value resulting from fuel removal activities.

Development of estimation methodologies for the value of available water quantities and protected water quality will be important for comprehensive assessments of the costs and benefits of fire risk reduction in overstocked forests. When significant precipitation occurs after a high severity forest fire, rapid surface runoff and peak flows may result in flash floods and erosion that can cause destruction to aquatic habitats and seriously affect water quality for human use (Ice 2003).

Other undesirable impacts (costs) associated with forest fire events include long-term degradation of visual esthetics with subsequent reduction in forest recreational activity, lost tourism revenues for rural communities, and reductions in real estate values within the wildland-urban interface.

Treatment Benefits	Value per acre	
	High Risk	Moderate Risk
Fire fighting costs avoided	$481	$231
Fatalities avoided	$ 10	$ 5
Facility losses avoided	$150	$ 72
Timber losses avoided	$772	$371
Regeneration and rehabilitation costs avoided	$120	$ 58
Community value of fire risk reduction	$ 63	$ 63
Regional economic benefits	$386	$386
Habitat	$?	$?
Smoke and Atmospheric Carbon	$?	$?
Energy	$?	$?
Water Quality & Quantity	$?	$?
Erosion	$?	$?
Other Values	$?	$?
Total Benefits	$1,982+	$1,186+
Treatment costs		
Operational costs	($374)	($374)
Forest Service contract preparation costs	($206)	($206)
Environmental Impacts of Fuels Removals	($?)	($?)
Total Costs	($580)	($580)
Positive Net Benefits from Fuel Removals	**$1,402+**	**$606+**

Figure 3. Summary table of present value costs and benefits associated with investments in fuel removals for fire risk reduction.

Summary of Costs and Benefits

Figure 3 shows present value approximations of some of the anticipated future losses and foregone benefits associated with failure to reduce hazardous fuel loads in at-risk forests. Habitat protection, air and water quality protection, carbon credits, and others, generally considered to be of high value, have been listed as credible additional public benefits from fuel reduction investments.

To develop an approximation of the net public benefit of hazardous fuel reductions, Forest Service contract preparation costs of $206/ac and operational costs of $374/ac are shown (Bosworth 2003, Mason et al. 2003). Fuel reduction treatments have been assumed to be forest thinnings that leave standing approximately 40–100 of the biggest trees per acre. A blank space is included as a placeholder for any potential environmental impacts that might result from fuel removal treatments such as soil compaction, damage to leave trees, and road sediments. However, the public value of such impacts is difficult to estimate and can be avoided with due diligence. Compromises to habitat quality for some species may decline while others increase, creating tradeoffs that are difficult to evaluate, but these changes are not likely to be as harmful as the impacts of catastrophic wildfires.

Although the values assigned from fuel reductions listed in Figure 3 can rightly be considered coarse estimates, they have been shown to be of sufficient magnitude to warrant aggressive public investment in fire risk reduction. The approximated net benefits from fuel removals are greater than $1,400/ac for high-risk forests and $600/ac for forests with moderate risk. Furthermore, it appears that substantial portions of fuel treatment costs are recoverable to the Treasury from tax collections. Conversely, failure to treat at-risk forests has resulted in a major national liability exposure.

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