Analysis of Costs and Benefits of Restoration-Based Hazardous Fuel Reduction

Treatments vs. No Treatment

NORTHERN ARIZONA UNIVERSITY FORESTRY

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Fact Sheet: Analysis of Costs and Benefits of Restoration-Based Hazardous Fuel Reduction Treatments vs. No Treatment

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- This study compares the cost of restoring forests to no taking action in ponderosa pine and dry mixed conifer forests in Arizona and New Mexico.

- The preliminary analysis shows that it is cost effective to spend up to $505/acre to restore forests to prevent catastrophic fire and avoid associated fire suppression costs. This value is a conservative estimate based on a comparison of the cost of restoration versus the cost of suppression, emergency rehabilitation and lost timber production.

- The analysis represents only a partial measure of the economic damage caused by catastrophic, unnatural fires. The above value ($505/acre) does not include the cost of: damage to water supplies, lost recreation revenue, lost wages, destroyed property, reduced property values and associated decreased tax revenues; loss of scenic value and wildlife habitat. If all the associated costs of damage caused by unnatural wildfire are considered it is rational to spend even more to restore forests.

- The analysis also assumes no return from the wood produced by the restoration treatment. In places where restoration by-products produce a return, the total amount that could be spent on restoration increase commensurately.

- Adding insured property loss, long-term rehabilitation and reforestation costs to direct suppression costs, conservatively places the cost of the Rodeo-Chedeski fire at approximately $300 million. Adding the additional costs of this one fire to the analysis raises the amount that could economically spent on restoration to $582/acre.

- Each year that no action is taken to restore acres that are at highest risk for unnatural fire (Condition Class 3) the problem becomes worse. Fuels resulting from beetle outbreaks are contributing to the hazardous fuels build up. In the nine western states with significant acres of ponderosa pine and dry mixed conifer forests there are 12,047,672 acres of Condition Class 3 lands. Based on this analysis we can invest $6 billion dollars to restore these acres or we could watch an equivalent amount go up in smoke as we attempt to suppress fires.

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Introduction

This progress report presents preliminary results of an economic analysis comparing restoration-based fuel treatments to no treatments for areas identified at high risk for fire. The with and without treatment comparison focuses on ponderosa pine and dry mixed conifer forest ecosystems in New Mexico and Arizona. The analysis provides a conservative estimate of the potential economic losses due to no action.

The results for New Mexico and Arizona indicate that restoration-based fuel treatments represent a rational economic choice even if one only considers direct avoided cost of current fires suppression activities. Society could pay up to $505 dollars per acre to treat the areas of high risk, and still break even in terms of investment. This investment cost is net of any value recovered from the restoration treatment; for example if the thinning part of a restoration treatment generated $200 per acre, the total break-even investment value rises to $700/acre. This investment break-even value does not include consideration of property damage and associated losses or lost ecosystem values, such as endangered species habitat and recreation amenity values.

Background

Historical practices starting with European settlers (e.g., overgrazing in the late 1800s, selective timber harvests, and fire suppression) have created vast areas of unhealthy forest ecosystems in the western United States. These practices have caused significant structural and functional changes in western ponderosa pine and dry mixed-conifer forests which are now at risk of ecosystem collapse (Cooper 1960, Covington and Moore 1994a, 1994b, Covington et al. 1997, Dahms and Geils 1997). Today, society faces the jeopardy of losing these forests to insect outbreaks, disease, and catastrophic crown fires. The overly dense stand conditions, exacerbated by drought, the increased bark beetle mortality, and larger and more frequent stand-replacing crown fire are interconnected symptoms of the forest health crisis caused by past practices and perpetuated by current inaction. Bark beetle outbreaks are associated with overly dense forests, and the bark beetle mortality increases the risk of crown fire in these dense forests. The ever-increasing severity and magnitude of wildfires, and the devastating outbreak of bark beetles in the southwest bear harsh witness to the hazardous conditions that exist over most of the forests in the Southwest.

Local, state and federal agencies, as well as industry and many environmental groups agree that restoration activities would begin healing degraded forests and reduce the threat of unnatural wildfire. However, the current pace and scale of implementation remains inadequate to significantly reduce the risk of collapse (e.g., as evidenced by the Rodeo-Chedeski, Biscuit, Cerro Grande, and Hayman fires). Inadequate federal funding for forest restoration and the reprogramming of treatment dollars to suppression activities perpetuates the problem. While society demands suppression of fires, it is extremely expensive and fails to solve the underlying problem leading to fires. When dollars are taken from restoration treatments and given to suppression activities, the diversion insures the continued need of suppression by undermining the logical approach to solving the wildfire problem.

Trends and Current Conditions

Figure 1 illustrates the trend that has occurred throughout ponderosa pine ecosystems. The top picture shows how the area appeared around the turn of the century and in terms of density, how it should look today. The middle picture shows the same location following the regeneration pulse of 1919 which resulted in the survival of many young trees in the absence of natural fire regime. The bottom picture shows the same area in 1985. The trees in the dog-hair thickets (dense areas of small diameter trees) are 65 years old, and have grown sufficient height to constitute ladder fuels which move ground fires into the canopy of older trees. Analogous trends have occurred in the dry mixed conifer areas.

Figures 2 and 3 present a graphical representation of the same historical trend. Figure 2 illustrates the dramatic increase in the number of small diameter trees in Arizona and New Mexico forests. Figure 3 shows the percentage distribution of Arizona's ponderosa pine forests by density class. The average condition in 1910 was around 30 square feet per acre. The average today is in the 100-150 square feet per acre range and indicates a dramatic increase in the density of ponderosa pine forest.

As described earlier, the disruption of the natural frequent fire regime and resulting increase in tree density has created unhealthy forest conditions. These forest systems are poised for collapse. Figure 4 illustrates the magnitude of this risk in terms of devastating crown fires in New Mexico. Approximately 60 percent of the ponderosa pine and dry mixed conifer forest types in New Mexico rate as high risk for crown fire hazard (Fiedler et al. 2002). As time passes these conditions are continuing to worsen. In addition to increasing acres burned and fire suppression costs, forests are experiencing unnatural irruptions of bark beetles. Figure 5 illustrates the irruption of bark beetle mortality in 2002, and the increase in acres burned for Arizona and New Mexico. These conditions are not without consequence. The sharp increase in 2002 could indicate that current conditions have passed an ecological threshold, and acres lost to bark beetles and fire will remain at a new higher level without treatment.

Figure 5 also illustrates that economic costs are on the rise. In 2002, Region 3 (Arizona and New Mexico) of the USDA Forest Service spent over $120 million for suppression and rehabilitation, and given the trend in forest conditions and a continuation of a policy of inaction, one would not expect any reduction in these expenditures in the future.

Figure 1 Example progression of ponderosa pine stand from pre-European tree density (1911), through influx of regeneration (1928), to unhealthy density (1985). Note that herbaceous understory had already been lost by 1911 due to excessive grazing. Photos are courtesy of H.B. "Doc" Smith, Ecological Restoration Institute, Northern Arizona University.

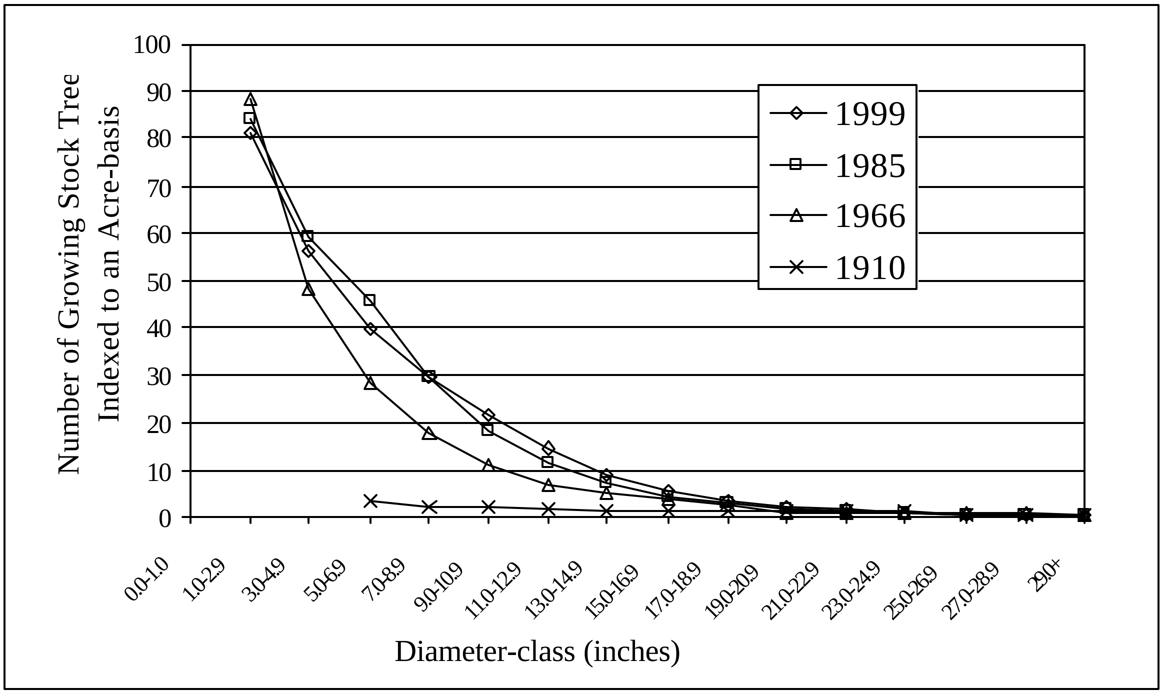

Figure 2. Number of trees per acre by diameter class for non-reserved forestland in Arizona and New Mexico for inventory years 1910, 1966, 1985, and 1999. Adapted from Cassidy 2003.

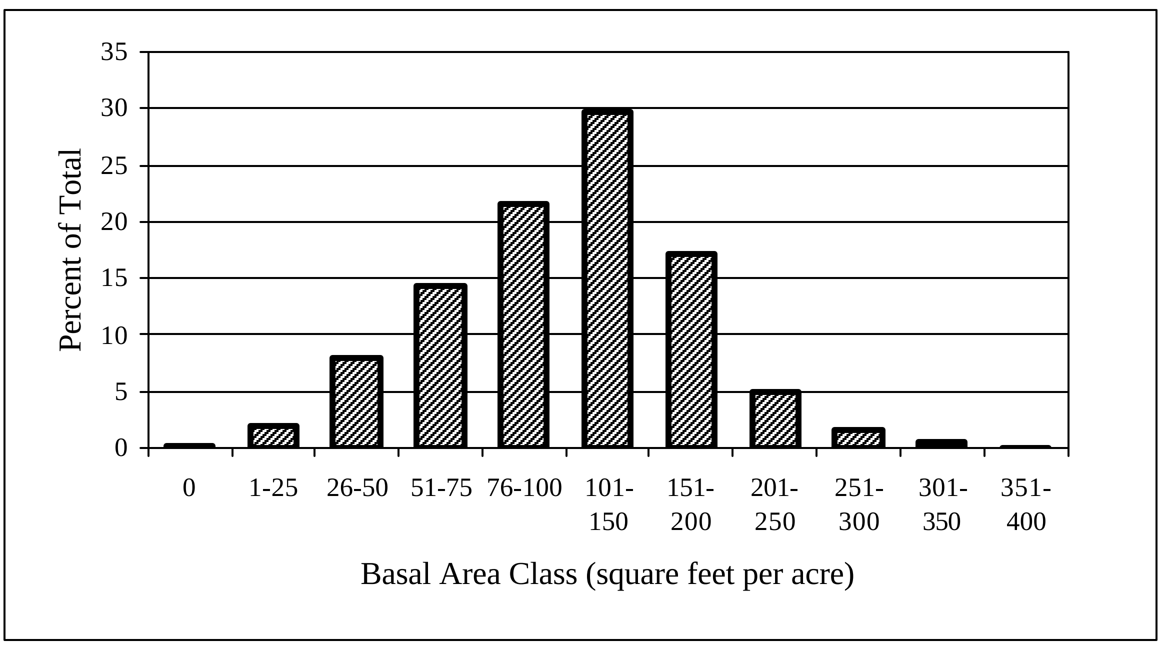

Figure 3. The percent of ponderosa pine forest in each basal area class (square feet per acre) based on 1999 Forest Inventory and Analysis (FIA) stand data for Arizona.1999. Data are from all inventory stands with a major ponderosa component. Adapted from Cassidy 2003.

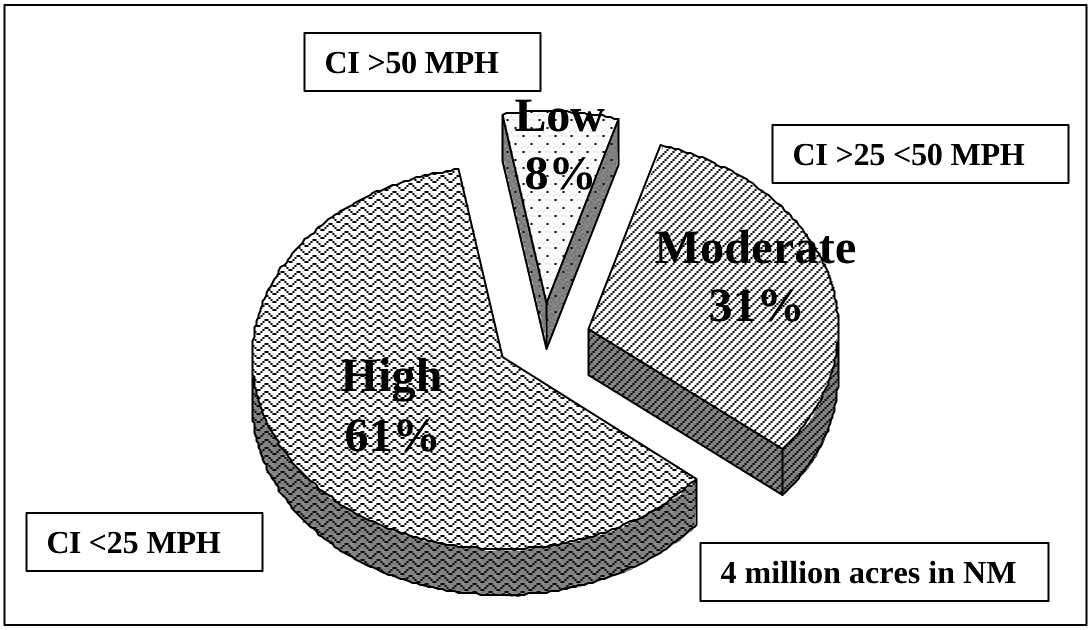

Figure 4. Percent of area by crown fire hazard for short-interval, fire-adapted forest types of New Mexico. Types are primarily transition ponderosa pine, ponderosa pine, and dry mixed conifer, and comprise approximately 4 million acres. CI refers to the crown index, a measure of crown fire hazard. The measure estimates the wind speed required to sustain a crown fire once it has reached the canopy. Adapted from Fiedler et al., 2002.

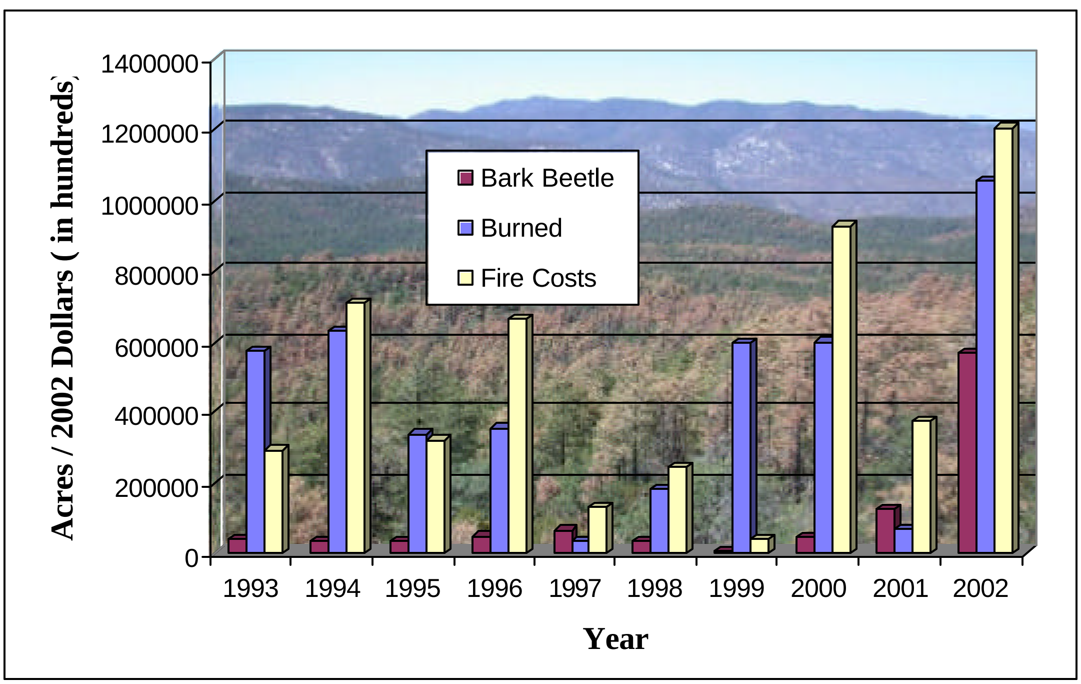

Figure 5. Trend in acres with bark beetle mortality, acres burned, and fire suppression and rehabilitation costs (in 100's of 2002 dollars) for Arizona and New Mexico. Graph based on USDA forest service data. Adapted from USDA Forest Service, 2002a.

Remedy for the Forest Health Crisis

The remedy for these unhealthy conditions requires large-scale (greater ecosystem) implementation of restoration-based hazardous fuel treatments that will simultaneously reduce the risk of crown fire and insect outbreaks, restore watershed function and condition, increase biological diversity, and improve socioeconomic well-being by promoting sustainable economic development within local communities.

A number of studies are asking the question, how much are these treatments going to cost and can society afford to pay for restoration. These recent studies examine the economics of implementing these types of treatments (Barbour et al. 2001, Fiedler et al. 2002, Lynch et al. 2000). In general, these studies found it difficult to justify treatment expenditures based on the value of the wood fiber removed by the treatments. This conclusion suggests that restoration must be considered an investment, and would need to be justified by the marginal benefits/value provided by a healthy ecosystem. However, it is possible we have been asking the wrong question. Perhaps the question we should be asking is: *Can we afford to not implement restoration-based hazardous fuel reduction/thinning treatment*?

Economic Analysis

Many question society's willingness or ability to pay for restoration-based fuel treatments on a scale sufficient to generate the ecosystem changes necessary for effective fuel reduction and hazard abatement. We argue that there is increasing evidence to suggest that the ever increasing ecological and economic costs resulting from high-intensity, ecosystem-scale fires in the ponderosa pine and dry mixed conifer forests of the West far exceed the cost to society of proactive restoration thinning treatments.

This economic analysis of ecological restoration answers the above question by comparing the costs of restoration to the costs and damages expected without restoration. The avoided cost analysis assumes that restoration of all high hazard areas in ponderosa pine and dry mixed-conifer forest, which comprise about 42 percent of these forest types in Arizona and New Mexico, would result in essentially eliminating large high intensity crown fires and the associated large expenditures and damages incurred in the recent past. The difference between projected fire costs and damages and the costs of restoration therefore represent a partial measure of the economic value of ecological restoration. Not considered in this analysis are: losses and damages to structures, private land value, and other infrastructure associated with the wildland–urban interface, and non-market values associated with improved ecological health. These non-market values include better wildlife habitat, improved water quality, increased forage production, and enhanced recreational quality. These are widely considered positive aspects of restoration and therefore the values estimated in this study underestimate the total economic value of restoration.

The Arizona and New Mexico situation

During the 10-year period from 1993-2002, an average of 443,307 acres burned each year in Arizona and New Mexico. Given that the number of acres in high fire hazard rating/fire Condition Class 3 is increasing every year, a conservative approach would assume that the average acres burned would continue in the future without treatment. During this same period, Region 3 (Arizona and New Mexico) of the USDA Forest Service spent an average of $377 per acre per year on fire suppression and an additional $22 per acre per year on emergency rehabilitation, which only covers emergency measures to control erosion/sedimentation and only occurs on a limited number of acres. Rehabilitation does not include reforestation activities.

Procedures for estimating and projecting future wildfire costs and damages

1. Expected-acres-burned per year was computed as the average annual fire acreage for fires greater than 100 aces on Arizona and New Mexico public lands during the period 1993-2002. Average annual fire acreage equals 443,307 acres (NIFC 2003).

   Assumptions:

   a. Future fire occurrence will be similar to that experienced in the last decade;
   b. The spike in fire acreage experienced in 2002 will be repeated periodically in future decades; and
   c. As a result of worsening hazard, including bark beetle mortality, estimates based on the last decade are likely conservative.

2. Average costs for suppression and rehabilitation were computed using costs and acreage provided by the Rocky Mountain Research Station for fires on public lands in which the Forest Service provided suppression. Totals were converted to cost per acre burned. Suppression cost equals $377 per acre; rehabilitation cost equals $22 per acre, in 2002 dollars (Gebert 2003).

   Assumptions:

   a. Average Forest Service costs are adequate estimators of costs on all public ownerships;
   b. Average costs include the wildlife urban interface (WUI) which comprise about 16% of Class 3 (high hazard) areas in the Region. Because suppression costs for fires occurring in the WUI would ordinarily be higher than for those more distant from civilization, region-wide averages may overstate costs for fires not threatening urban areas (USDA 2002b); and
   c. Given Assumption b, costs should be interpreted as applicable to the average fire situation – 16% of the acreage encompassed by an average fire would involve WUI acreage.

3. Timber losses were calculated by cumulatively reducing annual regional harvest values 5% each year. Average regional harvest values were provided by the USDA Pacific Northwest Research Station. Average annual harvest value = $11.5 million.

Assumptions:

a. Regional harvest value will decrease in proportion to decreases in the available timber base. This is consistent with forestry principles that equate allowable annual harvest with incremental growth and that reductions in growth caused by fire will therefore reduce harvest;

b. The above assumption is more conservative than basing timber-damage estimates on the volume and potential value of the timber actually destroyed by the fire. Destroyed trees may never have been utilized as timber or such utilization may have occurred in the future, reducing their value through discounting; and

c. The 5% annual decline in timber harvest value, while not empirically derived, was considered a reasonable and conservative assumption.

4. Structural and property losses and damages were not included in the economic analysis. Except for timber, expected changes in ecosystem values were also not included in the analysis.

Procedures for estimating and projecting future restoration costs

1. Restoration needs were estimated by determining the acreage of highly hazardous fuels (condition class 3 acreage) occurring within ponderosa and dry mixed conifer stands in Arizona and New Mexico (Schmidt et al. 2002). Class 3 acreage equals 4.4 million acres.

2. A range of restoration costs were estimated primarily through discussion with experienced Ecological Restoration Institute scientists because published data are scarce for the southwest. Net restoration costs may vary widely because they are dependent on the value of timber removed during the treatment. Such values are very site-specific and difficult to generalize. The analysis was therefore run for costs ranging from $200 per acre to $800 per acre in $200 increments.

3. The analysis was conducted as if all Class 3 acreage would be treated immediately. The per-acre results, however, may be applied to smaller units depending on budgets and capabilities presently existent. Delays, however, will result in losses as untreated areas continue to burn.

Economic analysis procedures

The economic analysis was conducted over a 20 year period and employed a 4% discount rate. Annual suppression and rehabilitation costs, and timber losses were discounted to present value for each year and summed to yield the present value without restoration. With restoration the present value was calculated as the initial net treatment cost plus the discounted value of maintenance treatments conducted in years 10 and 20. The analysis was repeated four times, once for each net treatment cost.

The present net value (PNV) was determined using a with minus without procedure. With this method the present value without restoration was subtracted from the present value with restoration. This difference in the with and without PNV's represents the net savings in costs and damages resulting from the with restoration scenario.

Results

The present value without restoration totaled -$2.5 billion for the 20-year analysis period (a loss or cost of -$2.5 billion). Restoration present value ranged from -$1.1 billion with net restoration costs of $200 per acre to -$3.8 billion for the $800 per acre cost. The break-even point occurred when net restoration treatment cost equal $505 per acre. With greater treatment costs PNV became negative; below $505 per acre the savings in fire costs and damages more than offset restoration costs. Table 1 shows these restoration treatment PNV's by differing treatment cost, converted to per acre basis.

Table 1. Present net value of with minus without treatment scenarios for four levels of treatment cost.

Treatment cost ($/acre)	Restoration PNV ($/acre)
200	306
400	106
600	-94
800	-294

Discussion

These results, which are based upon conservative assumptions, support the feasibility of spending up to $505 per acre for the ecological restoration of Class 3 forest lands in Arizona and New Mexico, given our assumption that crown fires over 100 acres would essentially be eliminated. The smaller fires (less than 100 acres) require no additional suppression and rehabilitation costs beyond those budgeted for pre-suppression and were assumed to be the same whether or not the forest was restored.

We believe these results to be very conservative for several reasons:

1. Per acre fire suppression cost did not include all charges for national contracts, such as many aviation or catering services. These costs averaged $96 per acre for the period of 1993-2002 (Gebert 2003);

2. Changes in ecological and social values associated with restoration, while not market-valued, are generally considered to be positive;

3. Losses and damages associated with structures, private land value, and other infrastructure associated with the wildland – urban interface were not included in the analysis; and

4. Pre-suppression costs are likely to decline as the risk of large fires declines or is eliminated.

Impacts Associated With Elimination Of Fire In The Wildland-Urban Interface

In 2002, the Rodeo-Chedeski fire caused about $250 million in damages over and above the suppression, emergency rehabilitation, and timber costs used in the previous analysis. If such a fire were to occur every decade, damages would average $25 million per year for a present value of $340 million over 20 years. This would add about $77 dollars per acre to the break-even cost for restoration, raising it from $505 to $582 per acre.

Rodeo-Chedeski: a manifestation of action delayed and a presage of tomorrow

During the period of June 18, 2002 until July 7, 2002 the Rodeo-Chedeski complex involved 467,066 acres in east central Arizona. Of those acres, 289,184 were on the White Mountain Apache reservation, 167,215 were on the Sitgreaves National Forest, and 10,667 acres are lands administered by the Tonto National Forest. The majority of Forest Service acres involved in this fire were categorized as being in Condition Class 3. Condition Class 3 lands are those where fire regimes have been significantly altered from their historical range and the risk of losing key ecosystem components is high. These areas require high levels of restoration treatments such as mechanical thinning before fire can be used to restore the historical fire regime.

Post-fire assessments clearly indicate that past management activities influenced the fire's rate of spread and intensity. Had it not been for past fuel treatments along the eastern flank of the fire, it could easily have continued out of control and we might not have the communities of Pinetop-Lakeside today.

<u>Costs</u>

- Suppression Costs: $43 - $50 million.
- BAER (Emergency Rehab Activities or lipstick on a corpse): As of 2 months ago the Apache-Sitgreaves National Forest had already spent $9 million.
- Long-term rehabilitation: the Apache-Sitgreaves will spend another $20 million over the next 3 years. The White Mountain Apache Tribe will also spend $20 million dollars over the next 3 years.
- Reforestation Costs: the White Mountain Apache Tribe expects to spend $90 million. The Apache-Sitgreaves only plans to replant about 500 "most critical" acres. The cost of this reforestation is included in the $20 million of long-term rehabilitation.
- Insured losses of homes and property $120 million.
- Emergency federal and state public assistance $2.5 million.
- Local levels of government are heavily dependent on sales tax collections. Sales tax revenue accounts for at least 20% and in some cases as much as 80% of a town's general fund revenue. The fire occurred at the height of tourist season. Local businesses were shut down for almost 30 days during June and July. These two months account for approximately 20% of total annual sales tax collections for this region. Loss in sales tax revenue during this period is estimated to be over $2million.

- Short-term job losses (Jul-Dec '02) estimated at 272 in Navajo Co. and 80 in Apache Co. Lost wages associated with the short-term unemployment in Navajo and Apache Counties are estimated to be $4.5 and $1.6 million, respectively (Thomas, Warren and Associates 2002).
- We have not even begun to calculate value of infrastructure (power lines, roads, bridges, etc.) losses nor have we yet calculated the costs associated with erosion, soil loss, wildlife habitat destroyed, sedimentation into reservoirs, and other changes in ecosystem services.
- 7,000 Mexican Spotted Owl PAC acres on Forest Service land alone suffered moderate to high severity burn. Half of this habitat area completely lost.
- Burned at least 5,000 acres of riparian habitat

When all is said and done, we could have simultaneously restored the ecosystem to a healthy condition and improved socioeconomic well-being by providing long-term employment and income. Instead we spent hundreds of millions of dollars in the creation of a landscape-scale ashen shroud. Some simple calculations indicate that we could have completed restoration-based fuel treatments on every acre for less than this fire will cost society.

Implications for the western United States

The current trends, conditions, and ecological and economic consequences previously described are certainly not unique to Arizona and New Mexico. The entire western United States has similar ecological conditions in ponderosa pine and dry mixed conifer forests, which are also at risk of collapse from insect outbreak and catastrophic crown fire. The analysis for the rest of the western states is ongoing but preliminary data suggest results will be similar to Arizona and New Mexico. Table 2 shows data on acres of ponderosa pine and dry mixed conifer in high and moderate risk classes by intermountain states. The majority of western states have significant forest at high or moderate risk of losing key ecosystem components.

Table 2. Acres of ponderosa pine (PIPO) and dry mixed-conifer (DMC) in Condition class 3 and 2 by intermountain states. Acres are based on USDA Forest Service data (Schmidt et al. 2002).

State	PIPO Class 3	PIPO Class 2	DMC Class 3	DMC Class 2
Idaho	1,570,943	3,799,634	655,943	740,622
Montana	115,920	4,273,502	161,591	41,078
Wyoming	120,553	769,022	59,016	73,388
Colorado	70,978	3,244,235	101,672	66,799
Arizona	1,646,143	2,663,137	117,441	1,027
New Mexico	2,086,119	2,973,421	453,441	6,867
Utah	4,081	334,737	4,681	25,021
Oregon	5,068,005	5,941,164	184,166	470,986
Washington	1,364,930	4,207,364	1,165,797	784,107

Condition Class 3 lands are those where fire regimes have been significantly altered from their historical range and the risk of losing key ecosystem components is high. Condition Class 2 lands are those where fire regimes have been moderately altered from their historical range and have moderate risk of losing key ecosystem components.

The fire suppression costs that could be avoided by restoration are also high for other western regions. Table 3 illustrates the fire cost for USDA Forest Service Regions in the western United States. The per acre cost for regions 1 and 3 are similar to the cost for Arizona and New Mexico. Southern Idaho, Utah, western Wyoming costs are significantly lower, and California, Oregon, and Washington have significantly higher costs. Note that these costs do not include all charges for national contracts, such as many aviation or catering services. These cost averaged $96 per acre for the period of 1993-2002. (Gebert 2003)

Table 3. Average per acre suppression and rehabilitation based on expenditures by USDA Forest Service Regions in the western United States

USDA-FS Region	States in Region	Avg. Cost/Acre (2002 $)
1	Northern Idaho, Montana	386
2	Eastern Wyoming, Colorado	384
3	Arizona, New Mexico	399
4	Southern Idaho, Utah, western Wyoming	202
5	California	561
6	Oregon, Washington	485

Conclusions

> *"Ironically, exclusion of low-intensity fires virtually assures eventual occurrence of large high-intensity fires that kill most trees. Roughly half of the more than 3 million acres that burned in wildfires in 1994 in the Western United States was in these ponderosa pine forests. In an active wildfire year, the expense of attempting to exclude fire from these forests can reach one billion dollars. Paradoxically, these costly attempts at suppression are often unsuccessful. In comparison, costs of restoration treatments are modest."* (Arno 1996)

We no longer face the question of whether society will spend the money or not. We are going to pay, one way or another, unless we make the unlikely choice to no longer spend money trying to fight and contain unnatural crown fires. We now face the choice of how we are going to spend the money, and what are we likely to obtain from that expenditure. If we invest in restoration-based hazardous fuel treatments, we invest in the future; we invest in healthy, sustainable ecosystems for our children and grandchildren. If we continue our current approach of suppression, we continue the depreciation of our forests, increasing the risk of radical shifts in their structure and function due to crown fire. Given these choices, it makes a great deal of economic sense to conduct forest restoration on a large scale today in order to retain future ecological and economic values. Our analysis demonstrates that the fire suppression costs that can be avoided in the future are sufficiently large by themselves to justify restoration expenditures today.

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