U.S. Wildfire Cost-Plus-Loss Economics Project: The "One-Pager" Checklist

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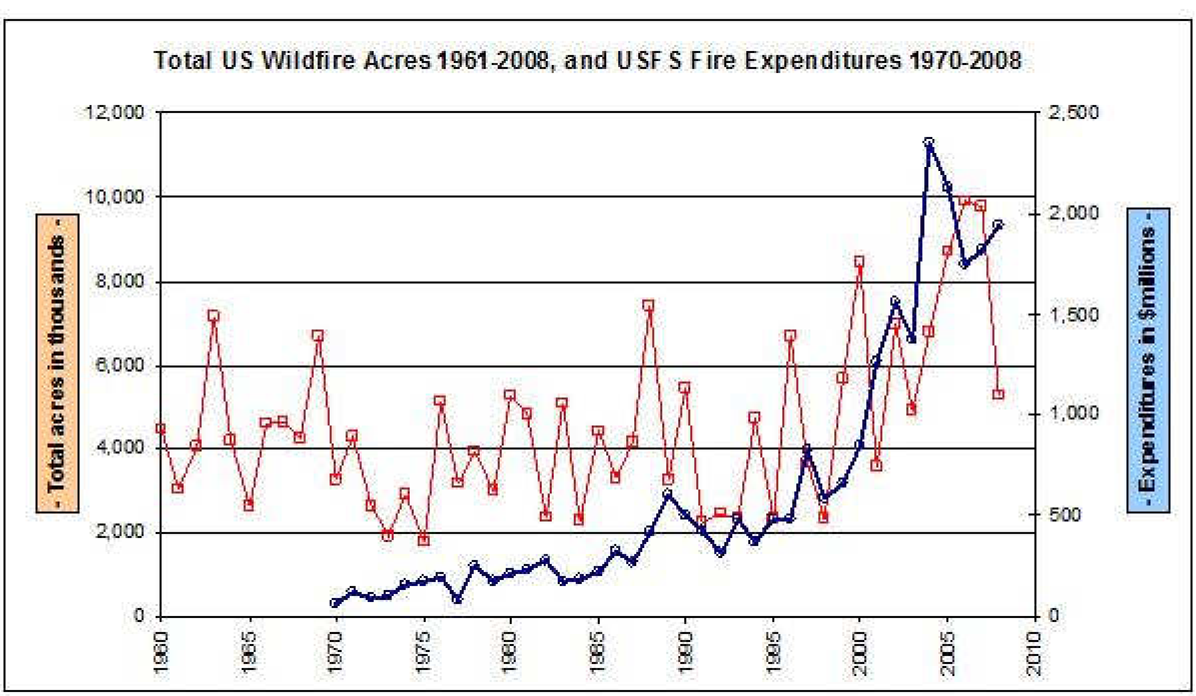
What are the actual costs of a wildfire?

Official Forest Service tallies usually include suppression expenses only. Media reports sometimes include estimates of damage to homes and infrastructure. But the economic impacts of wildfires are far-reaching and new (and old) research shows the need for improved cost estimates of wildfire.

Large wildfires consume more than just suppression expenses ("costs") – they also do measurable short- and long-term damages ("loss") to public and private equity and resources. Traditional fire appraisal uses the term "cost-plus-loss" to account for all the economic impacts of wildfire. This econometric analysis method is sometimes expressed as LCD (least cost plus damage) or C+NVC (costs plus net value change). The goal (economic utility) of fire suppression is to minimize cost-plus-loss.



Recently analysts, government officials, and the media have drawn increasing attention to the escalating frequency, severity, and costs over and above fire suppression associated with large-scale forest wildfires [1] – including losses of human lives, homes, pets, crops, livestock and environmental damage.

- The Western Forestry Leadership Coalition recently released a report entitled "The True Cost of Wildfire in the Western U.S." (Dale et al 2009). The authors examined six major US wildfires, and compared suppression costs and tactics with "total costs." Two examples of this process were the 2000 Cerro Grande fire in New Mexico (shown to have suppression costs that reflected only 3% of total damage estimates), and the 2003 Old, Grand Prix, and Padua fire complex in California, in which suppression costs were only 7% of total costs to date – with total losses expected to increase dramatically in years to come (Dunn et al, 2005).

- The 2003 fires in San Diego and Southern California were a disaster by any measure – 24 fatalities, over 3,700 homes destroyed. At the time, the costs of the suppression efforts were staggering, $43 million. However, Matt Rahn, a researcher from San Diego State University, recently presented findings that put this figure at less than 2% of the total long-term cost of the fire (Rahn, 2009).

- The Hayman Fire (2002) burned 138,000 acres and cost $42,279,000 ($307/acre) to suppress. But Professor Dennis Lynch of Colorado State University estimated that an additional $187,500,000 ($1,358/acre) in losses had accrued within a year. Suppression costs were only 18% of the total, and Dr. Lynch stated, "I recognized the need to follow costs into subsequent years to more completely identify a fire's true impact" (Lynch, 2004).

To date, our own findings paint a far different picture than that commonly reported by the media or understood by the public. We have found that total short-term and long-term cost-plus-loss attributed to wildfires typically attains amounts that are ten to 50 times (or more) reported suppression expenses.

The Pacific Crest Trail, Mount Jefferson Wilderness Area, 2004. In addition to being unsightly and dangerous due to the threat of falling limbs, trees and reburning, much of this trail segment has been closed or difficult to traverse since the 2003 B&B Fire Complex. (Photo: B. Zybach).

Losses in excess of suppression costs include economic damages to timber and forage values, wildlife habitat and populations (including endangered species and their critically protected habitat), air and water quality, recreational opportunities, public health, private businesses, and other resources and amenities important to all citizens. The National Association of Forest Service Retirees issued "Forest Health and Fire: An Overview and Evaluation" (Pfilf et al., 2002) that documented and analyzed the recent historic increases in US wildfire occurrences and severity. The report called for a detailed accounting of "total losses associated with fire and other forest health situations," specifically mentioning homes, evacuations, insurance claims, natural resources, recreation, water, forest health, timber, habitat, wildlife, management costs, subsequent increases of insects and disease.

Appraisal of resources damaged by wildfire is not always straightforward. Human lives and adverse health effects are usually not considered in terms of dollar losses at all, and tallies of wildlife fatalities are rarely done. Habitat, scenery, ecosystem services, and other non-commodities are difficult to value, although there has been considerable study and published efforts in that regard. Rarely has there been any attempt to quantify the long-term consequences of a damaged renewable resource base to provide for the needs of an ever increasing present and future human society (e.g. Bowman et al. 2009).

Consideration of an inclusive and comprehensive cost-plus-loss evaluation could be a helpful exercise when evaluating suppression/readiness need and effectiveness appropriation. We offer an operational methodology to better characterize the broader true costs to society of large-scale wildfires: typically, those fires involving loss of human life, thousands of acres in size, and/or millions of dollars of damage. This article focuses on practical uses of a "first step" tool we have developed – a one-page checklist – that can be employed by local citizens, media, fire managers, and elected officials to begin the process of better accounting for short-term and long-term effects of wildfires on US lives and economies. We use comprehensive "cost-plus-loss" accounting methods and consider direct, indirect, and post-fire costs and losses. We have developed eleven separate ledger categories of costs and losses that are reflected in the general ledger, and these same categories are listed in the "one-pager" checklist (see Table 1), as further described in the following. Within each ledger category, costs and losses are characterized as direct, indirect, and post-fire.

Direct costs. These are the amounts spent directly controlling a wildfire (suppression) and wildfire-related expenses, such as evacuations, commerce disruption, equipment damage, burnt homes, cars, and personal property, school and playground closures, additional air quality monitoring, public health alerts, or other costs directly related (and generally concurrent) to the fire.

Indirect costs. These have been typically over-looked in accounting for wildfire damages in earlier reports. Indirect costs include amortized wildfire preparedness expenditures such as crew training costs, equipment and supply outlays and depletion planning, and fire insurance premiums. Damage to capital investments such as recreational structures, devalued experiences, investments in forest management (reforestation, thinning) agriculture (crop establishment and treatments), past property taxes, reduced air and water quality, and changed landscape aesthetics are other indirect costs. This category considers indirect costs that are concurrent to a wildfire; i.e., accrued as the fire occurs. [2]

Post-fire costs. These are the long-term damages (losses), direct and indirect, to society and the environment. These include capital value losses to timber, agriculture, homes, and other public and private equity. Some post-fire losses can be difficult to quantify, and may only become apparent over time. Long-term human health effects, increased costs of medical care, reduced property values due to wildfire smoke damage, rehabilitation costs for publicly and privately damaged facilities, negative impacts on affected livelihoods, and sediment management costs in reservoirs subjected to increased soil erosion are examples of post-fire costs that may be attributed to specific wildfire events. Yet to be fully documented are wildfire smoke emission effects on possible climate change.

These are the eleven categories, with basic definitions, that are used in the checklist "one-pager," and in the comprehensive ledger:

1. Suppression costs. These costs are the ones most commonly reported by media (to the exclusion of other costs and losses) and are often under-reported at that. Typical costs include wages, transportation, equipment, services, supplies, etc. Special costs, such as equipment depreciation, communications interruptions, and emergency evacuations, need to be accounted for, as well. Indirect suppression costs include emergency preparedness measures, supply purchases, crew training, and equipment maintenance. Post-fire costs and losses include equipment repair, supplies replacement, formal reviews, and possible medical treatments and hospitalization of personnel.

2. Property Damage and destruction to federal, state, county, private, and municipal structures and facilities are major losses attributed to wildfires, particularly when transportation networks and communications systems are considered. Damage to timber and agricultural crops are other direct property losses. Some structural losses to private property may be insured; these can include business properties and homes, vehicles, and livestock. Capital goods and equipment damage and depreciation, evacuation expenses, and other losses are directly related to fire and smoke damage. Indirect losses include pre-fire insurance premium payments, building and landscape maintenance expenses, firefighting equipment purchases, and fire-related business closures. Post-fire losses include salvage, clean-up, rehabilitation, and repair expenses, equipment and capital goods replacement, drinking water pollution, smoke damage, deflated real estate values, lost sales tax revenues, and fire insurance premium increases.

3. Public health. These are some of the most overlooked and potentially costly areas associated with wildfire (and resultant smoke) damage. In addition to fatalities, wildfire smoke inhalation is known to cause and exacerbate a wide range of human health problems, including asthma, emphysema, and heart disease. Medical equipment, health-related evacuations, ambulance charges, and hospitalization are some of the direct health losses related to wildfire. Indirect losses include health insurance premiums, pre-fire medical equipment purchases, and medical personnel training. Post-fire losses include long-term health effects and increased health care expenses, insurance premium adjustments, health-related work absenteeism, survivor benefits, and even funeral and burial costs.

4. Vegetation. Standing timber losses have often been considered in wildfire damage estimates, but loss of future harvests from destruction of growing stock has been less frequently accounted for. On public lands losses include destruction of forage on grazing lands, secondary forest products destruction and/or degradation, and loss or degradation of wildlife habitat (including endangered species populations and protected habitats). On private land vegetation losses include timber and agricultural crops burned or impacted by wildfire smoke, such as wine grapes. Indirect losses include mortality of growing stock, the pre-fire investments used to establish or maintain such stock (such as nursery or planting costs and fencing), and irrigation systems. Post-fire losses include seeding, planting, and other revegetation costs, landscape rehabilitation, lost timber growth, and related product sales, business, job, and tax losses.

5. Wildlife. In addition to mortality of forest, range, and aquatic wildlife populations, direct losses include damage and destruction to a wide variety of common or protected habitats and to such amenities as viewing areas and feeding stations. Indirect losses include damage and destruction to pre-fire habitat improvement projects, population enhancement costs, and investments in wildlife research. Post-fire costs include reduced population productivity, foregone game management income, habitat restoration expenses, and related business, job, and tax losses. The loss of listed endangered animals and their habitat is included here.

6. Water. Direct losses include water usage for suppression action, local water system shutdowns, and reductions in drinking water, hydropower, and irrigation supplies and sales. Indirect losses are related to pre-fire planning, system investments, and wildfire-related pollution control devices. Post-fire losses include degradation of domestic water, irrigation, and hydropower supplies, system repairs, administrative costs, sediment and pollution controls and mitigation, and long-term changes in water yield and watershed ability to collect and store water.

Tillamook Fire smoke plume, August 24, 1933. In a single day the 1933 Tillamook Fire increased more than 200,000-acres in size, creating a mushroom cloud 40 miles wide and 8 miles high and producing hurricane-scale winds that furthered the spread of the fire. This cloud was formed largely by water vapor, ash, soil, carbon monoxide, and carbon dioxide in nearly immeasurable amounts and proportions (Photo: The Oregonian, courtesy of Oregon Department of Forestry).

7. Air and atmospheric effects. Direct losses are related to air pollution, including particulate, noxious gases, and CO2 emissions, and visibility impacts to road and air transportation, especially if delays and/or accidents result. Indirect losses are related to public health effects, property damage, and compromised recreational opportunities.

Post-fire losses include additional air pollution controls, carbon mitigation costs, added administrative overhead, and future reductions in business, job, and tax revenues.

8. Soil-related effects. Soil erosion can occur during a wildfire due to fire-induced wind, or from suppression actions. Soils can be baked, as well. Indirect losses include investments in fertilization, scientific research, and planning. Post-fire losses include decreased soil productivity, increased soil erosion, and post-fire soil rehabilitation, erosion and sediment mitigation, and project administration.

9. Recreation and aesthetics. Campground closures, evacuations, recreation-related business shutdowns, and structural assets damages and destruction are direct recreation losses attributable to wildfires. Indirect losses include pre-fire recreation-related investments by agencies, businesses, and individuals. Post-fire losses include recreational activity decline, degradation of scenic values, compromised hunting, fishing, hiking, camping, and wildlife viewing experiences, recreation-related structural repair or rehabilitation, and reduced business income, jobs, and tax revenues.

10. Energy. Direct losses include transmission line shutdowns and resultant loss of metered power sales, destruction and damage to energy production and transmission systems, and loss of biomass energy supplies. Indirect losses include pre-fire investments in energy production facilities and transmission systems and power planning costs. Post-fire losses include energy sales reductions, equipment repair, added sediment control, and future business, job, and tax revenue losses.

11. Heritage (cultural and historical resources). These losses include damage and destruction of historical resources and pre-Contact archaeological sites, loss or damage to historic cultural trail systems, ceremonial sites, and sacred sites, and heritage-related business shutdowns. Indirect losses include pre-fire public and private investments in heritage resources, including formal evaluations, research, and structural improvements. Post-fire losses include heritage site rehabilitation and repair costs, devaluation of cultural and spiritual assets, the loss of traditional uses and heritage, lost research opportunities to gather limited and fragile information, and heritage-related business, job, and tax revenue declines.

Conclusions

US wildfire events have become increasingly large, destructive, and costly during the past 20 years, and particularly since the turn of the century. During this time wildfire suppression costs have also increased dramatically. Suppression costs, however, represent only a small fraction of over-all wildfire cost-plus-loss. Other concurrent direct and indirect losses together with long-term post-fire losses can total 10 to 50 times (or more) the suppression costs. A more comprehensive economic and risk analysis and awareness on the part of decision-makers and the public of wildfire cost-plus-losses is needed, as are land and property management reforms, to help reverse these trends.

Our one-page checklist is intended to make initial estimates of total fire costs, and to ultimately be used in conjunction with a more comprehensive ledger for better tracking costs and losses over time. We believe that the use of these tools will better inform land

and resource managers in the management of fuels and wildfires by identifying true costs of decisions and allowing better judgment in the establishment of resource use priorities.

How to Use the Cost-Plus-Loss Checklist

The checklist is meant to help expand the discussion regarding the overall, long-term impacts of wildfire. Use the category descriptions to start the search for information regarding wider wildfire impacts on areas of concern in your community. Fully accounting for impacts under each of these categories is difficult, as data and information are often difficult to obtain, but some is available with a little digging.

1. Start by checking off all those items that don't apply.
2. Next, insert readily available numbers, particularly those quoting "experts" in the local media. Human fatalities, acres, and other data can also be acquired in this manner.
3. Insert "placeholder" estimates for precise numbers becoming known — such as final suppression costs, insurance payments, etc. This sub-total would be near the lowest end range of values for damage from a particular event.
4. Insert estimates for unknown or long-term costs, such as wildlife habitat loss, public health effects, air pollution, etc. Contact local experts for estimates, or even rough estimates in a range of values.
5. Continue to update list as better information becomes available — whether via existing sources, research, or a combination of the two utilizing the general ledger.

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[1]It is beyond the scope of this article to examine or discuss the possible causes of recent escalations in wildfire occurrences, suppression costs, or cumulative damages – only to acknowledge these facts, which are well documented in numerous publications and other media.

[2] Although we have standardized costs to dollar figures, values place on human lives, aesthetics, or pollution, as examples, are often highly subjective and difficult or impossible to quantify. Their inclusion in the checklist is simply to acknowledge their existence, and to allow for users to better consider such values in context with other wildfire impacts. A more specific example is provided by current concern with greenhouse gas emissions related to wildfire smoke. Thomas M. Bonnicksen has developed a mathematical model used for estimating the amount of greenhouse gases (CO_2, CH_4, N_2O) emitted by forest fires (Bonnicksen 2009). Using his model, he estimated that the 66,000-acre Moonlight Fire (2007) on the Plumas National Forest generated nearly 5 million tons of greenhouse gases. How can this amount be expressed in dollar terms? Will cap-and-trade legislation currently before the US Congress affect such an evaluation? The same model was used to calculate that 40 million tons of greenhouse gases were released or will be released as the dead wood decays that resulted from the 800,000 acre Idaho Batholith fires of 2007, and that the 1.34 million acres that burned in wildfires in California in 2008 generated CO_2 emissions equivalent to approximately 13 million cars driven all year. The checklist is not intended to answer these questions, but to account for them and put them in context.

Advances in Fire Practice is a sub-site of wildfirelessons.net and is focused on bringing efforts and ideas to the forefront that leaders in the fire management, practice, and research communities have identified as innovative and widely applicable. It provides access to critical and proven fire information and resources. Advances in Fire Practice section can be reached directly by going to http://www.wildfirelessons.net/AFP.aspx or through the main Wildland Fire Lessons Learned Center website at www.wildfirelessons.net.

Wildland Fire Lessons Learned Center

The Wildland Fire Lessons Learned Center actively promotes a learning culture for the purpose of enhancing safe and effective work practices in the entire U.S. wildland Fire community. It is located at the National Advanced Fire & Resource Institute in Tucson, Arizona.

Table 1. Wildfire 'Cost-Plus-Loss' Ledger Checklist Form

Fire Name ____________________ County _________ State _____ Country __________
Ignition Date ____________ Containment Date ____________ Total Acres __________
Cause: Human___, Lightning__, Operation__, Prescription__, Maintenance__, Other___
Major Landowner(s) __________________ Human Fatalities ____ Homes Lost _______

Cost-Plus-Loss Category	A. Direct	B. Indirect	C. Post Fire	Totals
1. Suppression Costs a. Public				
b. Tribal/Private				
2. Property Damage a. Public				
b. Tribal/Private				
3. Health Effects a. Public				
b. Tribal/Private				
4. Vegetation a. Public				
b. Tribal/Private				
5. Wildlife a. Public				
b. Tribal/Private				
6. Water a. Public				
b. Tribal/Private				
7. Air and Atmospheric a. Public				
b. Tribal/Private				
8. Soil-Related a. Public				
b. Tribal/Private				
9. Recreation a. Public				
b. Tribal/Private				
10. Energy a. Public				
b. Tribal/Private				
11. Heritage a. Public				
b. Tribal/Private				
Totals				

Name ___________________________ Title ___________________ Affiliation ________________

Date ___________________________