GISF Research Paper 001

Assessing the Environmental, Social, and Economic Impacts of Wildfire

Douglas C. Morton, Megan E. Roessing,
Ann E. Camp, and Mary L. Tyrrell

Forest Health Initiative

Yale University
School of Forestry & Environmental Studies
Global Institute of Sustainable Forestry

Assessing the Environmental, Social, and Economic Impacts of Wildfire

Douglas C. Morton, Megan E. Roessing,
Ann E. Camp, and Mary L. Tyrrell

May 2003
GISF Research Paper 001
Forest Health Initiative

Yale University
School of Forestry and Environmental Studies
Global Institute of Sustainable Forestry
360 Prospect Street, New Haven, Connecticut 06511 USA
www.yale.edu/gisf

This project was supported by a grant from the American Forest & Paper Association

Acknowledgements

This project was made possible through generous support from the American Forest and Paper Association and the Global Institute of Sustainable Forestry at the Yale School of Forestry and Environmental Studies. We would like to acknowledge the following students at the Yale School of Forestry and Environmental Studies for their major contribution to the research on specific fires: Kate Hammond on the Cerro Grande fire; Laura Ruiz on the Star fire; Andrew Niccolai on the Hayman fire; and Kimberlee Mortimer on the Carlton 01 fire.

We would like to thank Mary Coulombe for insighful advice on the project and report; Sheila Olmstead for reviewing and providing thoughtful comments on the draft report; and Page Bertelsen and Dave Hobson for logistical and technical support. In addition, we would especially like to thank our contacts at the numerous federal, state, tribal, and nonprofit agencies that provided information for this report; without their efforts and attention to detail, this research would not have been possible.

Table of Contents

Introduction iv
Executive Summary 1
National and State Data 7
Case Studies 14
Cerro Grande: New Mexico, 2000 17
Canyon Ferry Complex: Montana, 2000 20
Shenandoah: Virginia, 2000 23
Carlton: Florida, 2001 25
Star: California, 2001 27
Double Trouble: New Jersey, 2002 29
Hayman: Colorado, 2002 31
Rodeo-Chediski: Arizona, 2002 35
Battle Creek: South Dakota, 2002 39
Biscuit: Oregon and California, 2002 42
Case Study Summary 45
Conclusions and Recommendations 54

Introduction

Environmental, economic and social impacts from wildfires in the United States have been steadily increasing over the past decade, culminating with several large and costly fires in 2000, 2001 and 2002. These fires not only consumed forest and rangeland vegetation, but also adversely impacted wildlife habitat, recreation and tourism, water quality and supply, and property values, all of which depend on a forested landscape. Although federal and state agencies keep records of the total acres burned, structures destroyed, and fire suppression costs, data on indirect and continuing impacts of wildfire are rarely calculated. However, these impacts, such as restoration costs, alteration of wildlife habitat, lost tourism revenue, or human health effects, are important components of risk assessment and wildfire management.

In collaboration with the American Forest & Paper Association, the Global Institute of Sustainable Forestry at the Yale School of Forestry & Environmental Studies has collected and summarized available national and state-level data for a variety of wildfire impacts from the past three years. This report also contains summaries of 10 recent fires which provide data on the types of information collected for individual fires and the magnitude of wildfire impacts when they occur. We specifically selected large wildfires at the wildland/urban interface for case studies because we expected these fires to have a diverse range of substantial impacts. As a result, the case study fires are not representative of typical or "average" wildfires, since most fires occur away from the wildland/urban interface or are smaller than the fires in this report. Nevertheless, the nature and availability of wildfire impact information from these individual fires provides a foundation for understanding the nature and extent of impacts from wildland/urban interface fires and incorporation of this information into wildfire policies, risk assessments, and management practices.

Our objective in undertaking this study was to provide foundational information for a dialogue on what data are needed to inform policy makers and improve assessments of the risks and benefits of wildfire management. We are aware that other studies delve more deeply into specific aspects of forest management, fire management, and restoration of fire-damaged ecosystems. It is not within the scope of this report to include a summary of current studies, nor to review the extensive literature on the subject of wildfire impacts. Instead, this report provides the context for other work by documenting the current availability of information on wildfire impacts and providing examples of specific impacts for 10 large wildfires. Understanding the nature and extent of available data is the first step towards informed decision making regarding wildfire policy and risk assessment.

Executive Summary

Wildfires create a myriad of environmental, social, and economic impacts. Knowledge of both short and long-term impacts of wildfire is essential for effective risk assessment, policy formulation, and wildfire management. The goal of this report is to assess the availability of information on a range of wildfire impacts from federal, state, and local sources and to characterize the nature of these impacts when they occur. We have found that data are summarized at the national and state levels for only a few categories (number of fires, acres burned, structures burned, and suppression cost), providing policy makers with an incomplete picture of the total impacts from wildfires. For individual large wildfires, our research has shown that information is available for a broad range of environmental, social, and economic impacts, well beyond what is summarized at the national or state levels. These indirect and continuing wildfire impacts can be substantial, particularly for large wildfires at the wildland/urban interface. Therefore, we suggest that more thorough data collection on the broad array of wildfire impacts, summarized at state and national levels, would provide policy makers with a more comprehensive understanding of wildfire impacts and ultimately serve to enhance current state and national risk assessment methods and wildfire management.

In this report, we summarize the availability and nature of wildfire impact information from eight federal agencies involved in fire management, three states, and ten individual fires from the last three wildfire seasons (Figure 1). Research on data availability was conducted via a thorough review of information posted on the internet and detailed phone interviews with key personnel at federal, state, tribal, and local agencies. We focused on thirteen categories of environmental, social, and economic wildfire impacts (Table 1). Below, we highlight the findings from our research on wildfire impact data at federal, state, and case study levels.

Wildfire Impacts
Total acres burned
Cost of fire suppression
Damage to homes and structures
Alteration of wildlife habitat
Damage to watersheds and water supply
Damage to public recreation facilities
Evacuation of adjacent communities
Tourism impacts
Damage to timber resources
Destruction of cultural and archaeological sites
Costs of rehabilitation and restoration
Public health impacts
Transportation Impacts

Table 1. Wildfire impact categories considered in this report

Figure 1. Map of wildfire impact data collection priorities for this report. California, Colorado, and Florida (in gray) and 10 case study fires from 2000 to 2002 were researched in detail

National Wildfire Data

Overall, wildfire impact information is only summarized on a national basis for the total number of fires, area burned, number of structures burned, and cost of fire suppression. Data on the remaining ten wildfire impact categories considered in this report are either not collected by land management agencies or, if they are collected by individual agencies, they are not summarized at the national level. The principle sources for summary information at the national level are the National Interagency Fire Center (NIFC), the annual National Fire Plan budget, and federal land management agencies.

NIFC is the primary source for summary wildfire impact information at the national level. However, NIFC only collects and publishes summary data on three wildfire impacts relevant to this study (Table 2). In the future, NIFC's interagency focus may provide the appropriate structure for coordinating data collection on additional wildfire impacts among federal agencies.

Year	Suppression Costs	Acres Burned	Structures Burned
2000	$1.3 billion	8,422,237	861
2001	$0.5 billion	3,570,911	731
2002	$1.6 billion	6,937,584	815

Table 2. National wildfire statistics available from NIFC

The National Fire Plan is an important source of funding for a variety of fire-related activities, yet the nature of the budgeting process limits the use of this information for assessing wildfire impacts for four reasons. First, funding for several categories of wildfire impacts noted in Table 1 may be lumped into one budget line item in the National Fire Plan. As a result, it can be difficult to distinguish specific wildfire impacts using budget figures. Second, funding for emergency programs is appropriated on an as-need basis, such that initial budget figures for these programs do not reflect the total wildfire impacts during that fiscal year. Third, economic impacts from wildfire may continue for several budget cycles. For example, restoration costs for a 2000 wildfire may appear on National Fire Plan or federal agency budgets for fiscal years 2000 to 2003, such that total economic impacts from a given fire season may not be fully understood for several years. Finally, the National Fire Plan budget reflects the funds that are available for wildfire projects, not the total funds requested by various agencies. As a result, budget figures, even at year's end, may not reflect the true long-term costs of wildfires if various restoration efforts were not funded.

Each federal land management agency monitors the four basic categories of wildfire impact information summarized by NIFC, but data on most of the long-term environmental, social, and economic impacts from wildfires listed in Table 1 are not summarized by any agency at the national level. One of the complications of summarizing wildfire information from federal agencies stems from differences in accounting systems. For example, to accurately sum fire suppression costs for an individual fire, each federal agency that supplied personnel must be queried separately.

Federal agencies do collect detailed information for individual wildfires on federal land. These data are included in wildfire impact assessments, such as Burned Area Emergency Rehabilitation (BAER) reports. BAER reports provide detailed information on wildlife habitat loss, watershed damages, destruction of cultural and historical sites, and other impacts for specific fires, but these categories are not summarized for all wildfires or for each federal agency. Post-fire reports provide a detailed view of the impacts from wildfire immediately following the burn, but they do not address continuing impacts from wildfire, such as increased erosion, which are not assessed in a uniform fashion by any federal agency.

State Wildfire Data

States vary in their capacity to monitor wildfire impacts. We investigated three states in detail, California, Colorado, and Florida, although we contacted officials from seven additional states as part of our research for the case study fires. Most states provide summary data on the number of fires, total burned area, suppression costs, and structures destroyed on an annual basis. Beyond these basic data, however, wildfire impacts are rarely summarized at the state level.

Among the states we contacted, Colorado was the only one that has monitored smoke-related illnesses following wildfires, although this analysis is not ongoing. The Colorado Department of Public Health and Environment also had the most advanced emergency response for smoke monitoring and smoke forecasting during wildfires. Florida calculated the impact of 1998 fire season on statewide tourism, although this assessment is not done annually. California was the only state we contacted whose fire plan includes estimates for many of the wildfire impacts discussed in this report.

The California Fire Plan, through the use of a geographic information system (GIS), includes statewide estimates of the potential impacts from wildfire on grazing land, private property, wildlife habitat, flooding, water supply, air quality, timber, and cultural resources. Some of these variables are estimated on an annual basis, such as average private property damages, while others are calculated in a spatially explicit manner for every acre in the state. The California Fire Plan is a definite step forward toward incorporating wildfire impacts into risk assessments and wildfire management.

Case Studies

As data on many of the environmental, social, and economic impacts from wildfires are not summarized at national or state levels, we chose 10 large wildfires from 2000 to 2002 in order to investigate the availability of information from individual wildfires and to characterize the nature of these impacts when they occur. Each of the fires in this report occurred at the wildland/urban interface, and therefore had the potential for significant impacts. These case study fires are not representative of all wildfires, since most fires occur away from the wildland/urban interface or are smaller than the fires chosen for this study. In fact, the 10 case study fires are among the most costly and damaging fires in the recent years, nevertheless they provide illustrative examples of the magnitude of the indirect and continuing impacts from large wildfires.

Information on impacts from individual large wildfires is summarized in rapid assessment reports, such as Forest Service Burned Area Emergency Rehabilitation (BAER) reports, and raw data are available from the various federal, state, and local agencies that are involved with rehabilitation and restoration of burned areas. Based on the case study fires, we conclude that at least some information is available for each of the wildfire impact categories investigated in this study, although this information is rarely summarized specifically to examine wildfires (Table 3). For example, although both Shenandoah National Park and Mount Rushmore National Memorial monitor visitation, neither had analyzed the changes in tourism revenue during or following the Shenandoah Complex (2000) or Battle Creek (2002) fires, respectively. As a result, characterizing wildfire impacts often requires some interpretation and calculation, even when data are available for individual fires.

The magnitude of environmental, social, and economic impacts from wildfires is a function of the size, intensity, and location of the burn. Table 3 provides an example for each wildfire impact category from a case study in this report. For large fires at the wildland/urban interface, indirect and continuing impacts from wildfire can be substantial.

Impact	Availability of Information	Fire	Example
Alteration of wildlife habitat	• Negative impacts are reported in BAER report. • Positive impacts are not well documented.	Star (CA, 2001)	Loss of Protected Activity Centers for CA Spotted Owl and Goshawk and 7,600 acres of old forest types.
Watershed and water supply damages	• BAER report includes burn severity by watershed and estimated flood flow increases from watershed damages. • Water supply damages may be available from water authorities or state agencies.	Hayman (CO, 2002)	Damage to Denver Water reservoir; $4 million spent on restoration and water treatment to date.
Public recreation facilities damaged	• Federal and state agencies record physical damages. • Closure information is rarely summarized. • Impacts to viewshed or experience are not monitored.	Biscuit (OR, 2002)	Damage to trails, campgrounds, and signs; restoration expected to cost $2.4 million.
Evacuation of adjacent communities	• Data on the number of persons and length of displacement are often part of the BAER fire summary. • Impacts from displacement are rarely calculated (e.g., temporary housing costs).	Carlton (FL, 2001)	40 homes evacuated for 1 day.
Tourism impacts	• Park visitation information exists, but wildfire impacts are not specifically calculated. • State-level data, when available, are annual estimates.	Battle Creek (SD, 2002)	Mount Rushmore National Memorial within 1 mile of fire boundary, however tourism increased by 7% over 2001.
Timber damages	• Controversy exists over reporting "lost" volumes--what burned vs. what is recoverable through salvage operations. • Damaged volumes are in BAER report, salvage details are in Environmental Impact Statements for restoration projects.	Rodeo-Chediski (AZ, 2002)	1 billion board feet damaged on tribal and federal lands, valued at more than $300 million.
Cultural and archaeological sites	• Damage or destruction of ruins is documented in BAER report.	Cerro Grande (NM, 2000)	671 cultural and historical sites were within the fire boundary; 511 were in low burn severity areas.
Rehabilitation and restoration costs	• Total is a combination of BAER projects and separate restoration efforts. • Costs are generally available for each agency, but totals must be calculated and interpreted for each fire.	Canyon Ferry Complex (MT, 2000)	$8.1 million spent on restoration, reforestation, resurveying, invasive species, and soil stabilization.
Health impacts	• State Public Health departments monitor air quality, but rarely participate in active wildfire monitoring. • Follow-up studies on smoke-related illnesses are rarely completed.	Shenandoah Complex (VA, 2000)	Degraded air quality in eastern Virginia, smoke-related illnesses were not monitored.
Transportation	• Good information is available for road closures, but no estimates are made of lost toll revenue or social impacts of delays and closures.	Double Trouble (NJ, 2002)	Closure of the Garden State Parkway, a toll-road, for 12 hours.

Table 3. Summary of information availability and example of each wildfire impact category

Based on our survey of 10 fires, the most costly economic impacts from wildfires are damages to structures and timber and fire suppression. The Cerro Grande fire (2000) damaged structures on private, county, and Los Alamos National Laboratory property; to date, settlement of these damage claims has cost the federal government more than $800 million. The Rodeo-Chediski fire (2002) burned roughly 1 billion board feet of timber on tribal and federal lands, valued at more than $300 million. However, when fires occur at lower intensity or beyond the wildland/urban interface, the most costly economic impact is fire suppression.

The magnitude and duration of environmental impacts from wildfires depend on a variety of factors, such as weather and the availability of sufficient restoration funds. Post-fire flooding events or re-burns can dramatically increase the time needed for recovery of the burned landscape. The ability to conduct restoration work on burned areas affects the trajectory of landscape recovery and the duration of erosion, invasion by noxious weeds, and other continuing wildfire impacts. Due to the severity of the 2002 fire season, restoration funds from the Forest Service budget may not be available for many smaller fires. For example, the Battle Creek fire burned 12,420 acres of the Black Hills National Forest and private lands in South Dakota. The National Forest originally requested $4.3 million for restoration of the burned area in 2003-2004. However, budget cuts at the national level and the likelihood of other high-priority fires receiving the limited national funds resulted in the Black Hills National Forest ultimately requesting only $220,000 from the Forest Service Region 2 budget for 2003, leaving many restoration projects unfunded.

Information on the short-term social impacts from wildfire, such as road closures and evacuations, are included in BAER reports, but long-term social impacts are rarely calculated. However, on-going research efforts are beginning to include measures of social impacts, such as the emotional stress from property loss, reduction in property values, and damage to viewsheds.

Although we provide information on a number of important wildfire impacts, we did not consider the full range of positive and negative wildfire impacts. Consideration of carbon, tax revenues, and insurance costs, for example, were beyond the scope of this study. We also did not consider the magnitude of other natural and anthropogenic influences on the landscape, such as beetle infestations, hurricanes or other natural disasters, or other variations in park visitation, which could provide added context for the wildfire impacts discussed in this report. Negative impacts from wildfire restoration, such as smoke impacts from prescribed burns, are also not explicitly considered.

Overall, access to data on the broad array of wildfire impacts from individual fires is limited, but improving. Currently, federal agencies conduct an assessment of wildfire impacts and threats to watersheds, life, and property following most large wildfires on federal land, but the future damages to environmental or cultural resources from erosion, flooding, or re-burns are not systematically reassessed in subsequent years. Dissemination of wildfire information has also improved. We noted significant improvement in information availability between wildfires that burned in 2002 versus 2000. Much of this increase can be attributed to improved internet capacity at federal, state, and local agencies. This increase in internet capacity provides a useful platform for distributing more detailed information on wildfire impacts to policy makers and other interested parties in the future.

Conclusion

This report summarizes the current status of wildfire impact information from federal, state, and local sources in order to begin a dialogue on what data are needed to inform policy makers and improve our ability to assess the risks and benefits of wildfire. Based on our survey of 10 large wildfires, we provide examples of the magnitude of a variety of wildfire impacts, many of which are not directly calculated by federal agencies or summarized at state or national levels. These case study fires also provide an opportunity to assess the utility of data on a broad array of wildfire impacts for policy formulation and wildfire management.

Our conclusions on data availability and the magnitude of indirect and continuing wildfire impacts provide an opportunity to reassess wildfire policies and management practices. Two important questions will help guide this discussion. First, are data on these additional wildfire impacts at the state or national levels useful for policy makers and managers, and therefore worth the costs of data collection? And if so, then how can we effectively conduct data collection, disseminate information, and incorporate this knowledge into policies and practices at state and federal levels?

National and State Data

At the federal and state level, the environmental, social, and economic impacts of wildfires are difficult to quantify. Much of the information that exists is scattered across bureaucratic lines. Agencies collect information according to their priorities. Because the National Park Service has a strong mandate to provide public recreational opportunities, it may monitor visitation during a wildfire event. The Bureau of Land Management, lacking such a mandate, does not. The objective of this study was to determine what quantitative information is available at the various levels of federal and state government on the environmental, social, and economic impacts of wildfires, specifically focusing on the following categories: 1) wildlife habitat destroyed or substantially altered, 2) water quality and watersheds impacted (on both public and private land), 3) public recreation facilities damaged or destroyed, 4) tourism impacts, 5) private property affected (including homes and other structures lost), 6) communities evacuated, 7) volume of timber destroyed on public and private lands, 8) cultural or archaeological sites damaged, 9) soil erosion mitigation efforts required, 10) public health impacts, 11) transportation impacts, 12) acres burned, and 13) suppression costs. These thirteen categories of economic and social impacts are also addressed in each of the case studies that follow in this report.

This section focuses on whether summary information exists for each of these thirteen categories at the federal and state level. This report is not an exhaustive overview of where fire impacts information can be found throughout the country. There is great uncertainty in locating this information as no one entity coordinates a database of wildfire impacts. Therefore, the information that follows is based on Internet research and phone interviews with employees from federal and state agencies. Phone interviews were conducted with staff from the National Interagency Fire Center (NIFC), the five federal agencies involved in wildfire response (National Park Service, Bureau of Land Management, Forest Service, Bureau of Indian Affairs, and Fish and Wildlife Service), and the Natural Resources Conservation Service (NRCS). Research and phone interviews were also conducted to determine what information is collected and reported in three states: California, Florida, and Colorado.

National Fire Data

The National Interagency Fire Center (NIFC) was created to coordinate fire activities among the different land management agencies. NIFC is located in Boise, Idaho and maintains a website to provide fire information and education to the public; however, it appears that interagency coordination is primarily focused on fire suppression to the virtual exclusion of other facets of fire management. Examples include the differences between initial rehabilitation efforts across jurisdictions and the lack of coordinated collection of fire statistics across agencies.

The NIFC website contains a section on national fire statistics that includes total acres burned and the ten largest fires each year, the ten year average for acres burned, acres treated by prescribed fire, causes of fire and suppression costs for each federal agency, and a list of historical fires that had the greatest impacts on lives and resources. The website contains little information, however, about the effects of wildfires on landscapes and communities.

The NIFC website also contains the estimated cost of federal wildfire suppression in fiscal year (FY) 2000, 2001, and 2002 (Table 4). In FY 2000, a total of 8,422,237 acres burned, 861 structures were destroyed (including outbuildings and garages), and approximately $1.3 billion was spent on federal fire suppression. In contrast, FY 2001 was a less active fire year in which a total of 3,570,911 acres burned. This decrease in fire

activity was reflected in the cost of federal fire suppression, estimated at $542 million. However, 731 structures burned that year. In 2002, 815 structures and 6,937,584 acres burned and $1.6 billion was spent on federal fire suppression. These three categories, structures burned, acres burned, and suppression costs, are the only figures relevant to this study that NIFC compiles at the national level.

Year	Suppression Costs	Acres Burned	Structures Burned
2000	$1.3 billion	8,422,237	861
2001	$0.5 billion	3,570,911	731
2002	$1.6 billion	6,937,584	815

Table 4. Categories of national fire data recorded by NIFC

The difficulty with summarizing fire information at the national level is that each federal land management agency has slightly different reporting requirements. There has been some interest in creating a single database for fire information; however, certain reporting requirements would need to be changed so that the same budget categories were used by all agencies.

This study focuses on the economic and social impacts of wildfires in the last three years. Part of the difficulty in collecting this information and discerning trends at the national level is that the impacts associated with each fire are spread out over several budget cycles. It can take several years to plan the restoration projects for one wildfire and then another year or two to complete the work on the ground. Therefore, for many of the case study fires the complete economic impacts are not yet known.

The National Fire Plan

The National Fire Plan was created in 2000 as a vehicle for coordinating and defining the federal government's priorities for fire management. Funding through the National Fire Plan also began in 2000. Each fiscal year, funding levels are outlined in the President's budget and refined through the congressional appropriations process. For the past three budget years, much of the funding has focused on fire suppression and preparedness (Table 5).

National Fire Plan funding is split into two budgets, one budget for the Forest Service, which is located in the Department of Agriculture, and another for the Interior Department, which includes the Park Service, Fish and Wildlife Service, Bureau of Indian Affairs, and Bureau of Land Management. The Forest Service has traditionally taken the lead in firefighting among the federal agencies and has received more funding than the Interior Department under the National Fire Plan. Each budget includes line item funding for federal agencies for preparedness (including research under the joint fire sciences program), suppression, emergency suppression contingency (utilized when suppression funds are exhausted), hazardous fuel treatments, rehabilitation and restoration, and local fire assistance (including state, rural, community, and volunteer fire assistance programs).

Fiscal Year	Preparedness	Suppression	Rehabilitation and Restoration	Emergency Suppression Contingency
2000	574,617	197,256	20,000	590,000
2001	925,855	472,433	246,457	624,623
2002	903,425	382,745	102,668	300,000

Table 5. Calculated funding levels for the National Fire Plan, 2000 - 2002. Funding levels in thousands of dollars (source: National Fire Plan website)

The originally appropriated amounts in the National Fire Plan often change as the fiscal year unfolds. If large fires exhaust the emergency suppression funds there will be a supplemental appropriations bill adding additional funds to the National Fire Plan. Actual suppression costs frequently exceed the original suppression budget. Funding levels for the National Fire Plan also change in response to the previous fire season. Fiscal Year (FY) 2001 had the highest level of funding in all categories, reflecting the active fire season of 2000. During the fire season of 2001, while fires burned in Florida, Nevada, Washington, and Oregon, the total acres burned was less than the 10-year average. Therefore, the National Fire Plan budget decreased for FY 2002.

Several of the impacts of fire, including water quality, watershed systems, damage/destruction of public reaction sites, damage to archaeological sites, and soil erosion are mitigated by restoration projects funded through the Rehabilitation and Restoration line item of the National Fire Plan. Following a wildfire, National Fire Plan rehabilitation and restoration money is used to fund federal land management agency projects on burned land. In general, National Fire Plan funding levels are decreasing, especially for rehabilitation and restoration programs; there will be a corresponding decrease in projects involving watershed remediation and stabilization. The amount of funding for rehabilitation and restoration decreased by $143,789,000 between FY 2001 and FY 2002. Because of the sharp decrease in funds, dollars allocated to these projects may not reflect the actual need or impact of the fire on watershed values. It is unclear whether spending on rehabilitation projects can be used as a proxy for the true economic costs of a wildfire on watershed values. It should be noted that the emergency rehabilitation work that occurs immediately after suppression; for example, work accomplished by the Forest Service Burned Area Emergency Rehabilitation teams is included in the suppression line item of the National Fire Plan.

Utilizing 2001 National Fire Plan funding, agencies completed rehabilitation or restoration projects on 2.51 million acres, placing a priority on the wildland-urban interface. Funds were provided for projects involving reforestation and reseeding, fixing roads and trails, refencing, treating invasive plants, and habitat and watershed restoration. The economic benefit of restoration programs to communities should not be ignored. Restoration projects often bring funds to local communities impacted by a nearby wildfire. For example, in FY 2001 the Bureau of Land Management purchased $13 million dollars worth of seed for reseeding efforts from local suppliers. Much of the equipment used in rehabilitation efforts is also bought from local machine shops.

Federal Agencies Involved in Fire Response

Five federal agencies are involved in fire management and emergency response: the Forest Service, Bureau of Land Management, Bureau of Indian Affairs, National Park Service, and Fish and Wildlife Service. Federal land management agencies conduct fire impact analyses and rehabilitation projects at the individual fire or unit level. No personnel interviewed were aware of any attempts to calculate the impact categories described above at the regional or agency level for the Bureau of Land Management, National Park Service, or Forest Service. Each agency keeps track of suppression and total rehabilitation costs for budgeting purposes, but the summary information is not broken down into subcategories. Occasionally, specific categories of information will be sought out and summarized across the agency. For example, the Forest Service will try to compile specific information when requested by Congress. However, the Forest Service attempts to control paperwork by only requiring reporting of data that is actually going to be analyzed and applied; therefore, without direct plans to use these data, fire information is not widely summarized on a national level.

Most of the acreage managed by the Fish and Wildlife Service (FWS) is in Alaska, where fires are generally not suppressed or remediated. Therefore, FWS does a very small amount of fire analysis compared to other land management agencies, although FWS experts consult on endangered species matters for other

federal agencies. FWS has only spent approximately 10 million dollars on fire rehabilitation projects on their own lands since 1999. FWS also does not collect information on the amount of habitat impacted by wildfire. Such data would need to include information on habitat improved as well as habitat destroyed by wildfire. These impacts, however, are difficult to quantify and verify.

The Bureau of Indian Affairs (BIA) does not calculate any of the categories of wildfire impacts addressed in this report at the regional or national level. Since they work in partnership on Native American lands, much of this information, if collected, would be kept on a tribal basis, including tourism impacts, impacts to cultural and archaeological sites, private property values, and data on wildlife and watershed impacts. The Bureau of Indian Affairs does gather assistance requests that apply to timber impacts from various sources, but personnel were not aware of timber impacts from wildfire being compiled at either the national or regional level.

Emergency Rehabilitation Programs

Several emergency rehabilitation programs are funded and administered by the land management agencies. These programs are the first step in rehabilitating and restoring federal lands after a wildfire. The Forest Service has the Burned Area Emergency Rehabilitation (BAER) program, the most well known and active of the rehabilitation programs. The other land management agencies have similar programs, such as the BLM's Emergency Stabilization and Rehabilitation Program. However, the scope of the Department of the Interior's programs are often not as extensive as the Forest Service BAER program.

Though the BAER program is considered part of the suppression effort, funded under the suppression line item in the National Fire Plan budget, the program does not receive funds until they are requested for a specific fire. All fires over three hundred acres and defined as "Class C" can request a BAER team. The team is interagency in makeup and conducts a rapid assessment of the fire and suppression efforts to determine what is needed to protect soil and watershed resources. The BAER program is only authorized to implement projects that protect watershed values. Through the BAER program and the follow-up rehabilitation work done by the affected National Forest, the Forest Service spends more on rehabilitation and restoration projects than any of the other federal agencies. BAER projects may include reseeding of burned areas, contour felling of logs, and placement of straw bale check dams, all to prevent soil erosion and increased stream sedimentation. However, BAER projects cannot include non-watershed related activities such as fixing fences, rebuilding burned structures, or salvaging timber. Oftentimes, a national team does the assessment and then a local team implements the recommended projects. Since the BAER program's budget is based on the number of requests, it fluctuates from year to year. In FY 2002, the Forest Service authorized $44 million for the BAER program. Much of the information collected and analyzed in the following case studies is published in the BAER reports for each fire. However, this information is often not systematically collected after the initial rehabilitation efforts or summarized for each fire across agency boundaries.

Private property in the Rodeo-Chediski burned area (Arizona)

Natural Resources Conservation Service

The Natural Resources Conservation Service (NRCS) provides funding for rehabilitation projects on private land through the Emergency Watershed Protection (EWP) program. This program distributes funds to state, county, and local government agencies for disaster-related projects on private land that will reduce the risk to life and property. Although many large wildfires occur on public land, often they also involve state and private lands. Under this program, NCRS will pay up to 75% of the costs of the project. The remaining 25% is matched by local sources with cash or in-kind donations, including volunteer efforts.

The Emergency Watershed Protection program is not a budget line item; funding is provided by supplemental appropriations when natural disasters take place. Generally, Congress agrees to fund the EWP to a certain level, under which some of the funds are earmarked to specific projects (including wildfires), but most are allocated on a first come, first served basis (Table 6). If there is not enough money to fund all the projects, each project is prorated to provide some funding for all. All EWP projects must be sponsored by a county or state agency and the work must take place on private land. The Forest Service, since it is also under the USDA, can use small amounts of EWP funds to respond to natural disasters, excepting fires.

2001	2002	Average (last 5 or 6 years)
$94 million	$140 million	$110-111 million

Table 6. Funding Levels for EWP program (source: NRCS EWP program)

State Level

Three states (California, Colorado, and Florida) were selected to research collection of environmental, economic, and social impact information at the state level. California was selected because it is a large state with frequent fires and has a state fire plan that evaluates many of the impact categories considered in this report. Colorado has experienced several large fires in the past three years and was considered representative of western states. Florida experienced many fires in 2001 and has a considerable amount of burnable vegetation; however, Florida has very little federal land so the Florida Division of Forestry plays a greater role in fire management in the state.

California

California's fire plan includes a risk analysis of the economic impacts of wildfire to environmental resources including: air quality, water quality and watershed impacts, range habitat, public recreation, structures, timber, wildlife habitat, and historical and cultural resources. For some of these impacts, the costs are calculated as an annual average. For example, the average cost of homes lost to wildfire is $163 million per year. However, many of the impacts were calculated on a per-acre basis. These calculations are often based on modeling, and therefore may result in a wide range of possible cost. These calculations provide critical information on the magnitude of the economic impact of wildfires on various resources. For example, the state of California estimates that the costs of air quality impacts of wildfire range from $1- $15,000 per acre, the cost of burned rangeland is estimated at $8 per acre statewide, the loss of public recreation is valued at $5 - $107 per acre burned, and, for a moderate severity fire, timber loss is estimated at $2,538 – $8,823 per acre.

These calculations do not consider the beneficial effects that fire can have on some plant and wildlife species. Because of this uncertainty, California did not calculate costs for species habitat change as a result of fires. The difficulty of determining costs and benefits also complicated the calculations for watershed impacts. Fires can increase runoff in the short term with benefits of $3 - $12 per acre for increased water production and $17.50 per acre in increased hydroelectric energy production. However, these benefits must be balanced by the costs incurred through increased sedimentation and reforestation. The state of California estimated that increased sedimentation would cost $9 - $90 per acre, reseeding $30 - $200 per acre, and reforestation $200 per acre. Because of difficulties in valuation, the state did not place a value on historic and archaeological sites.

Streambed sedimentation after the Hayman (Colorado) fire

Calculations of economic loss were combined with location of fire protection services, location and impacts of past fires, and vegetation information, to create GIS layers showing "high risk/high value" areas throughout California where fire management activities can be targeted. This information on the environmental and economic impacts of wildfires was then used to inform fire management under the California Fire Plan. The goal of the plan is to reduce costs and increase efficiency by targeting fire suppression.

Colorado

The level of state aggregation of our target environmental, economic, and social impacts is similar for Colorado and Florida. The State of Colorado keeps track of the number of wildfires, acres burned, structures burned, and suppression costs for each year. At the county level, BLM and the Forest Service have helped create "community fire plans." These plans attempt to determine variations in fire risk through interviewing community members to discern the risk to private property and cultural resources. However, data on private property and cultural resource risks are not compiled at the state level. During the Hayman fire in 2002, the Colorado Department of Public Health and the Environment monitored smoke and studied public health impacts, although this study is not done annually. Additional information on the target economic and social categories is not collected or summarized by the state of Colorado.

Florida

Florida also tallies the number of fires and acres burned for each year. Prior to 2001, the state only kept records on structures burned and the value of those structures. In 2001 and 2002, the state recorded the numbers of homes threatened and lost, structures threatened and lost, and vehicles threatened and lost. Similar to Colorado, the other environmental and social impacts that are the focus of this report are not recorded at the state level. However, some of the impacts, such as impacts to timber and tourism, were summed for the unusually active 1998 fire season, which burned extensively in Northeastern Florida. The tourism impacts of

the 1998 season were estimated to be a loss of $138 million (due to a cancelled NASCAR race and beach and theme park closures); property loss was estimated at $10-$12 million; the loss of softwood timber resources was estimated at $354- $605 million; and over $100 million was spent on fire suppression.

Conclusion

The number of fires, acres burned, structures burned, and suppression costs are the only wildfire impacts summarized and reported at the federal level. The categories of wildlife habitat, water quality and watersheds, volume of timber on public lands, cultural or archaeological sites, and soil erosion, where the information exists, are most likely calculated by a specific federal or state agency field office. Information on tourism or transportation impacts is most likely found at the local or state level in response to an unusually active fire year. Health impacts from wildfire smoke are difficult to distinguish but what information exists is calculated at the state or local level. Information about impacts to private property, such as communities evacuated and rehabilitation on private lands, is usually coordinated at the county level with assistance from federal and state grants.

Sources

National Interagency Fire Center, website

National Interagency Fire Center, External Affairs Office

National Interagency Fire Center, Fish and Wildlife Office

Bureau of Indian Affairs, Washington, D.C. office

Forest Service, Burned Area Emergency Rehabilitation staff

Forest Service, Fire and Aviation Division

BAER program Authorities and Policy. http://www.fs.fed.us/r5/baer/1b/html

National Association of Public Administration. Wildfire Suppression: Strategies for Containing Costs. (2002) http://www.napawash.org/Pubs/FireSuppression_September_2002.pdf

Office of Management and Budget, Budget of United States Government, Fiscal Year 2004 - Appendix. http://www.whitehouse.gov.omb/budget/fy2004/pdf/appendix/AGR.pdf

FY 2001 Performance Report National Fire Plan U.S. Department of Agriculture U.S. Department of the Interior February 2002. http://www.fireplan.gov/2001_year_end_pdf/fy_2001_perf_rpt.pdf

National Resources Conservation Service. Emergency Watershed Protection Program Brief. http://www/nrcs.usda.gov/programs/ewp/questions.html

National Resources Conservation Service, Emergency Watershed Protection Program

California Fire Plan. http://www.fire.ca.gov/FireEmergencyResponse/FirePlan/fireplan.pdf

Southwest Colorado Fire Information Clearinghouse. http://www.southwestcoloradofires.org/prevention/fireplans.htm

Colorado Department of Forestry, Fire Division

Florida Forest Protection Board website. http://flame.fl-dof.com/General/firestat.html.

Staff at Florida Division of Forestry

David T. Butry, D. Evan Mercer, Jeffrey P. Prestemon, Thomas P. Holmes, and John M. Pye. "The Economic Effects of the 1998 Florida Wildfires." In Mercer, D. E., J.M. Pye, J.P. Prestemon, D.T. Butry, and T.P. Holmes. 2-7-2000. Economic Effects of Catastrophic Wildfires. Unpublished final report. Forestry Sciences Laboratory, Research Triangle Park, NC 27709. 64 pages. http://flame.fl-dof.com/joint_fire_sciences/economic.pdf

Case Study Fires

Introduction

State and national data sources only summarize the number of wildfires, acres burned, structures lost, and suppression costs; the remaining data categories considered in this report are not summarized annually by federal or state agencies. Therefore, we investigated individual wildfires to determine what additional information might be available from federal agency field offices, state and local governments, private landowners, tribes, and businesses. Detailed information from individual fires will provide context for the national and state data and begin to fill in data gaps regarding specific wildfire impacts. Due to the inherent variability in individual wildfires, we investigated 10 large wildfires from 2000, 2001, and 2002 with a diverse range of expected impacts.

During the combined 2000 and 2001 fire seasons, more than 49,000 fires burned on federal lands, however only 952 fires burned more than 1,000 acres. The number of wildfires on federal lands highlights two important components of tracking wildfire impacts. First, current protocols mandate that any fire on federal land must be documented, regardless of its size. Even basic bookkeeping for these 49,000 fires requires a large effort for the federal land management agencies. Second, fire size, which can vary considerably, is only one determinant of the magnitude of wildfire impacts. For example, many small fires and fires in remote wilderness areas may have little or no economic impact. Very large wildfires or fires at the wildland/urban interface may cause significant economic impacts. Environmental and social impacts from wildfire also vary with fire size, intensity, and location. Below, we describe the methodology for the case study fire selection and data collection process in detail.

Methodology for Case Study Fire Selection

We investigated ten large wildfires to examine the availability of data for a variety of potential impacts, with the following goals in mind:

- Capture the regional diversity of forest fires in the United States, including fires in the western, southern and eastern United States.
- Sample a range of fire sizes (1,000 to 500,000 acres) to understand how impacts vary with fire size.
- Include a variety of expected impacts, such as fires with known damages to wildlife habitat, high-value property or recreation areas at the wildland/urban interface, timber, watersheds or community water supply, public health, etc.
- Build on existing information, such as the National Academy of Public Administration Wildfire Suppression Report (2002), to understand recent changes in the availability of information on wildfire impacts.
- Provide an opportunity to assess differences in data availability by agency, region, and category of wildfire impact.

Using a geographic information system (GIS), we selected wildfires based on these five criteria. For 2000 and 2001 fires, we compared fire information from a GIS database of all fires on federal lands with maps of communities and vegetation types. After excluding fires that burned less than 1,000 acres or non-forested land, we selected large fires near communities by visual inspection of the GIS data. From this list of large fires near communities, we selected twenty fires from 2000-2001 for a preliminary Internet investigation. The results of the Internet search regarding information availability, fire characteristics, and potential wildfire impacts allowed us to narrow the list of possible case study fires.

A complete GIS database of fire locations was not available for 2002. Therefore, the selection process for the 2002 case study fires was slightly different than the selection of 2000 and 2001 fires. We chose three of the 2002 case study fires based on media coverage and size; the Hayman, Rodeo-Chediski, and Biscuit fires were high profile fires and among the most costly fires in recent history. Two additional fires, the Double Trouble and Battle Creek, added regional diversity and variety of fire size to the list. The final list includes fires ranging in size from 1,400 to 500,000 acres (Figure 2 and Table 7).

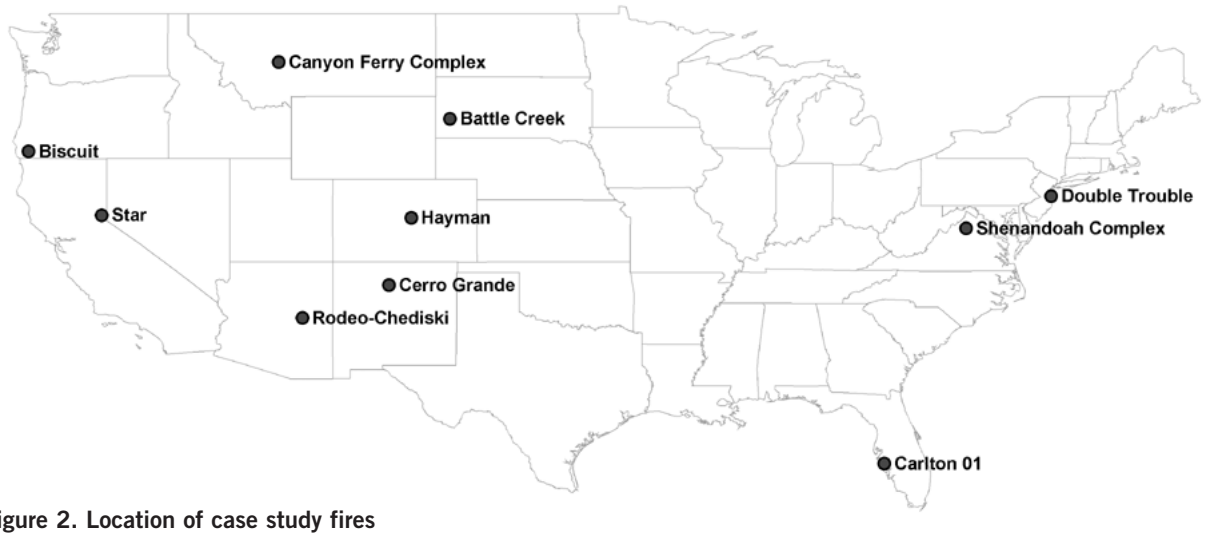


Figure 2. Location of case study fires

Fire Name	State	Size (acres)	Date
Cerro Grande	NM	42,875	May 2000
Canyon Ferry Complex	MT	43,994	July 2000
Shenandoah Complex	VA	24,223	Sep. 2000
Carlton '01	FL	6,000	April 2001
Star	CA	15,359	Aug. 2001
Double-Trouble	NJ	1,400	June 2002
Hayman	CO	137,760	June 2002
Rodeo-Chediski	AZ	462,614	June 2002
Battle Creek	SD	12,420	Aug. 2002
Biscuit	OR	~500,000	Aug. 2002

Table 7. Case study fires chosen for this study in chronological order

We specifically chose case study fires with substantial impacts to explore the availability of information on these damages. Each of the fires occurred at the wildland/urban interface. The case studies in this report are not representative of typical damages from wildfire, since most fires occur away from the wildland/urban interface or are smaller than the fires chosen for this study. In fact, the ten wildfires summarized in this study are among the most costly and damaging wildfires in recent years.

Data Collection

For each of the ten case study fires, we conducted a thorough search of Internet information, followed by targeted phone interviews with key personnel from the various federal, state, tribal, and local agencies involved with the fire. Phone interviews enabled us to obtain up-to-date information on the status of rehabilitation and restoration efforts, collect additional agency documentation of wildfire impacts, and to ask specific questions about the impacts being considered in this study.

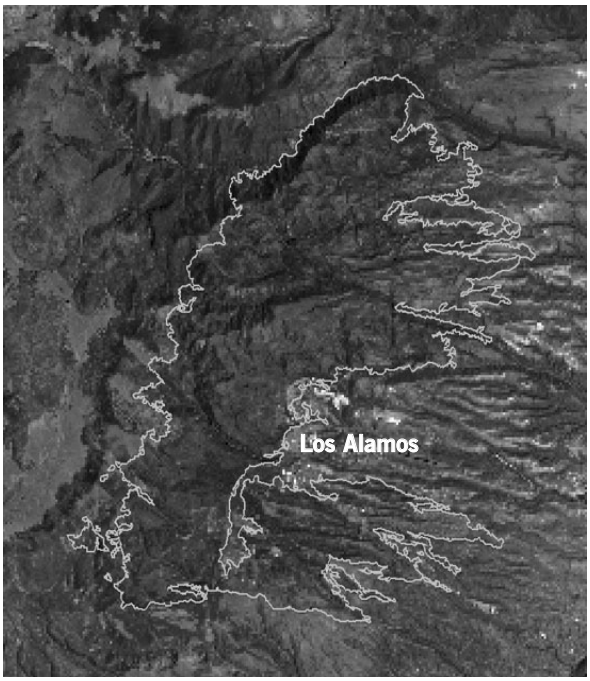
For each fire, we collected the three basic statistics that are kept by all federal agencies: fire size, broken down by land ownership; fire suppression costs; and the number of structures damaged or destroyed by the fire. These three statistics are readily available from federal agency web pages, and are always summarized in the Burned Area Emergency Rehabilitation (BAER) report. Where possible, we identified the available information on 10 additional wildfire impacts (Table 8). These impacts reflect the broad array of possible significant damages from wildfires, although the list is not exhaustive. Since the relative importance of these damages varies by fire, we chose to focus our data collection for each case study fire on the most important impacts from that fire. In the case study summaries that follow, we present the results of our data collection efforts and provide details on the availability of wildfire impact data. General conclusions about the data collection process, availability of information, and lessons on the magnitude of wildfire impacts from the ten case studies are presented following the individual fire summaries.

Impact	Example
Alteration of wildlife habitat	Loss of Protected Activity Centers for federally listed species
Watershed damages	Increased erosion and sedimentation in public water supply reservoirs
Public recreation facilities damaged	Trails, campsites, and structures
Evacuation of adjacent communities	Number of persons and length of displacement
Tourism impacts	Closure of parks or back-country areas
Timber damages	Timber volumes lost on public and private lands
Cultural/archaeological sites	Damage or destruction of ruins
Rehabilitation/restoration costs	BAER projects or flood mitigation efforts
Health impacts	Smoke-related illnesses
Transportation	Closure of roads and airports

Table 8. Possible impacts from wildfires considered during data collection for each of the 10 case study fires

Cerro Grande
New Mexico, 2000

Although it burned just 42,875 acres in north-central New Mexico, the Cerro Grande wildfire was the first fire in U.S. history to cause more than $1 billion in documented direct economic impacts (Table 9). Started as a prescribed burn in the National Park Service's (NPS) Bandelier National Monument on May 4, 2000, erratic winds and extremely dry conditions enabled the fire to escape established fire lines. The Cerro Grande was upgraded to wildfire status on May 5th. Within a few days, high winds drove the fire into the Department of Energy's Los Alamos National Laboratory (LANL), where considerable high-tech equipment and facilities were destroyed. In addition, a total of 18,000 people from the towns of Los Alamos and White Rock were evacuated on May 10th and 11th, respectively. The fire burned into the town of Los Alamos, ultimately destroying 260 residences and 120 other structures and damaging water facilities, electricity and gas lines, and other infrastructure. Between May 5th and July 20th, when the fire was finally controlled, fire suppression costs totaled $33.5 million. The principle impacts from the fire were damages to private property, LANL, cultural and historic sites, and rehabilitation of burned watersheds for flood mitigation.



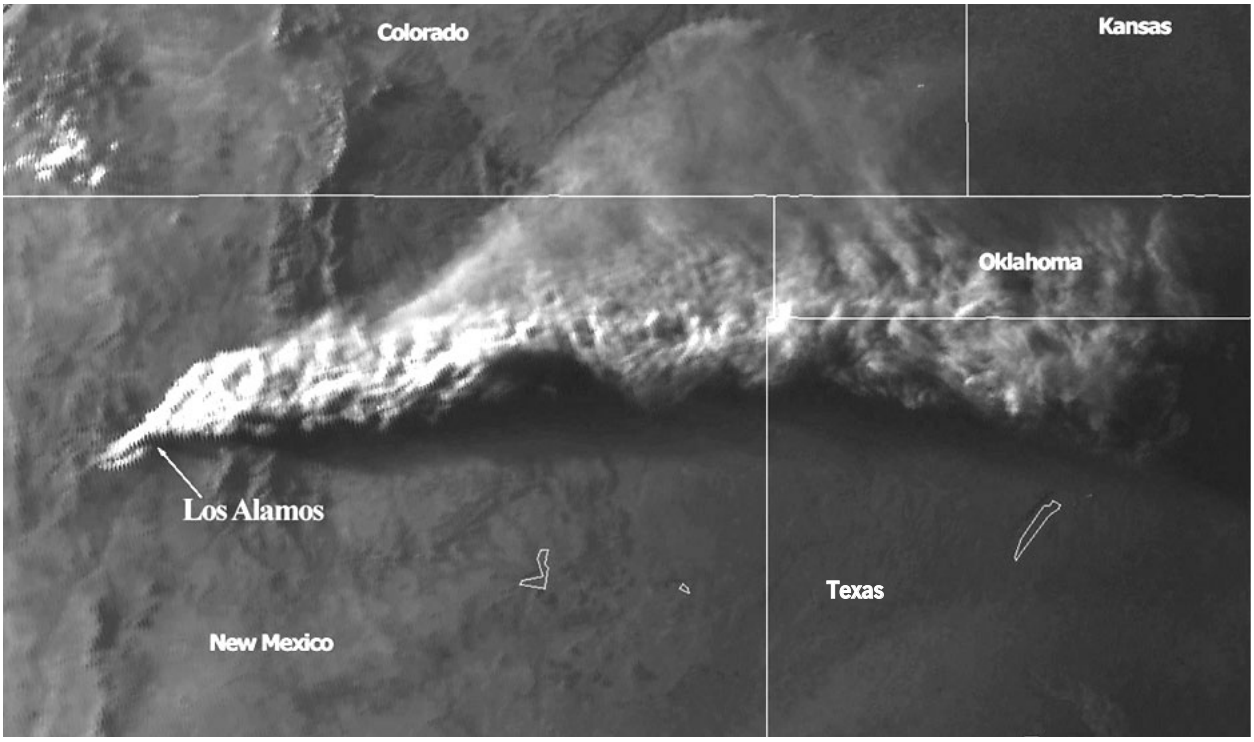
Cerro Grande fire boundary

National Park Service	824 acres
Los Alamos National Laboratory	7,403 acres
Santa Clara Pueblo	6,681 acres
San Ildefonso Pueblo	294 acres
Santa Fe National Forest	25,606 acres
Los Alamos County and City	1,359 acres
Other Private Lands	708 acres
Total	**42,875 acres**
Fire Perimeter	**47,646 acres**

Table 9. Cerro Grande fire burned area broken down by ownership

Since the Cerro Grande fire began as a prescribed fire on NPS land, there was enormous political pressure on the federal government to compensate LANL and residents of the town of Los Alamos whose properties had been damaged by the fire. The resulting law, the Cerro Grande Fire Assistance Act, the first of its kind, was signed on July 13, 2000. Without this act, federal reimbursement for the Cerro Grande fire would have been capped at $50 million under the Stafford Act.

The Cerro Grande Fire Assistance Act created a $450 million "Cerro Grande Fire Assistance Program" to compensate individuals, businesses, Pueblo tribes, non-profit organizations, and local governments for a variety of damages (Table 10). To date, nearly 17,000 claims have been filed, 1,000 of which have not yet been resolved. Compensation to Los Alamos County has totaled nearly $115 million, including $36.5 million for long-term recovery, restoration, and hazard mitigation. To date, FEMA has paid out more than $441 million on these claims, and has asked Congress for an additional $80 million appropriation.



May 11, 2000 smoke plume from the Cerro Grande fire (National Oceanic and Atmospheric Administration image)

The Cerro Grande Fire Assistance Act also included $138 million to restore LANL to full operation, $45 million in administrative costs for FEMA, and approximately $25 million for soil, watershed, and erosion control divided between the Bureau of Indian Affairs (BIA), Natural Resources Conservation Service (NRCS), and USDA Farm Service Emergency Conservation Program. Additional congressional and federal agency appropriations have paid for over $35 million in forest, soil and watershed rehabilitation, and an additional $203.5 million for LANL.

A total of 671 cultural resources are known to exist within the boundary of the fire. Although most of the structures were in low burn severity areas, 126 were within the high and 34 were within the moderate burn severity areas. The Puye Cliff Dwellings, located on the Santa Clara Indian Reservation and listed on the National Register of Historic Places, were among the most severely impacted sites. Restoration of cultural resource areas has focused on hazard tree removal and site stabilization.

To date, emergency rehabilitation, restoration, and flood mitigation measures under BAER have cost an estimated $72.4 million, divided between 8 federal agencies and the State of New Mexico (Table 11). Another $30 to $35 million has come from FEMA under the Cerro Grande Fire Assistance Act. The most costly projects have been aerial reseeding and mulching ($3.8 million), thinning and fuels reduction ($20.4 million), and flood mitigation efforts such as the US Army Corps of Engineers' Pajarito flood control project ($15 million). Much of the emergency rehabilitation work has been completed, although long-term mitigation measures and monitoring will continue for several years.

Economic impacts from the Cerro Grande fire have been easier to collect than information on the damages to soils, wildlife, and the Los Alamos viewshed. The total impacts from the fire are now approaching $1.1billion (Table 12), yet given the additional social and environmental impacts, the final cost of the Cerro Grande fire will not be known for many years to come.

Information on impacts from the Cerro Grande fire was easily accessible and very detailed. The Bandelier National Monument, FEMA, LANL, and Santa Fe National Forest webpages were frequenty updated as new documents became available. In addition, the oversight of the post-fire recovery process by the news media, US General Accounting Office, and these four agencies has ensured that accurate and detailed information was available on a timely basis

Loss of income
Loss of business
Replacement cost of a home
Debris removal
Landscaping
Land stabilization
Loss of land value
Household contents
Costs of mitigation measures
Personal property items
Interest paid on disaster loans
Subsistence resources normally used by tribal members

Table 10. List of damages paid by FEMA under the Cerro Grande Fire Assistance Act

LANL	$17,175,000
USDA - BAER	$12,770,000
USDA – Fire Plan (estimate for FY 2001/02)	$1,560,000
NRCS	$2,620,000
US Army Corps of Engineers	$20,500,000
Other Federal	$115,486
BLM	$613,820
BIA	$8,749,463
NPS	$1,636,172
NM State	$260,353
US Department of the Interior (estimated)	$6,388,700
Total	**$72,388,944**

Table 11. Estimated total costs for Cerro Grande BAER

Fire Suppression	$33.5 million
FEMA Cerro Grande Fire Assistance Program Funds	
Individual, Business, and Los Alamos County Claims	$455 million
LANL Restoration	$138 million
Administration	$45 million
BIA	$9 million
USDA Farm Service, Emergency Conservation Program	$10 million
NRCS Emergency Watershed Protection Program	$4 million
Additional FEMA Request	$80 million
FEMA support for Emergency Restoration	$30-35 million
Additional LANL Request	$203.5 million
BAER Costs, All Agencies	$72.3 million
Evacuation (~1 week)	18,000 people
Homes/Structures Destroyed	260/120
Cultural and Historic Sites Damaged	671

Table 12. Summary of Impacts from the Cerro Grande fire

Sources

National Park Service, Bandelier National Monument

Santa Fe National Forest

Los Alamos County

Federal Emergency Management Agency

Cerro Grande BAER Report

Cerro Grande Prescribed Fire Board of Inquiry Final Report

Canyon Ferry Complex
Montana, 2000

The Canyon Ferry Fire Complex began in July 2000 and was an administrative combination of two fires, the Cave Gulch fire and the Bucksnort fire, that burned on opposite sides of Canyon Ferry Lake (Figure 3). The Cave Gulch fire burned primarily on the Helena National Forest on the east side of Canyon Ferry Lake, although it also damaged some state, private, and Bureau of Land Management (BLM) land. The smaller Bucksnort fire occurred on the west side of the lake, burning mostly private and BLM land, along with some state-owned grazing allotments. The Bucksnort fire was much closer to Canyon Ferry Lake, a man-made lake created by the Bureau of Reclamation. The Bureau of Reclamation currently manages the recreation area for the BLM. The complex burned a total of 43,944 acres including 10,575 acres of private land. In general, the Cave Gulch fire burned with lower severity at lower elevations and with moderate to high severity at higher elevations. However, certain drainage basins burned with high severity at all elevations, leading to mudslides after the fire. Overall, burn severity of the fire complex was roughly one-third low severity, one-third moderate severity, and one-third high severity.

The diversity of landowners involved affected by the fire complex has spawned an extensive range of rehabilitation projects. Many remediation projects are still underway and work will continue into the future. The rehabilitation effort began with a Forest Service BAER report and a BLM Emergency Fire Rehabilitation Plan (EFR). The Bureau of Reclamation, Forest Service, Bureau of Land Management, and the Lewis and Clark Conservation District have also been involved in rehabilitation efforts to varying degrees. The federal agencies have focused their efforts on the land under their control while the Lewis and Clark Conservation District has obtained grants to assist private landowners with remediation efforts.

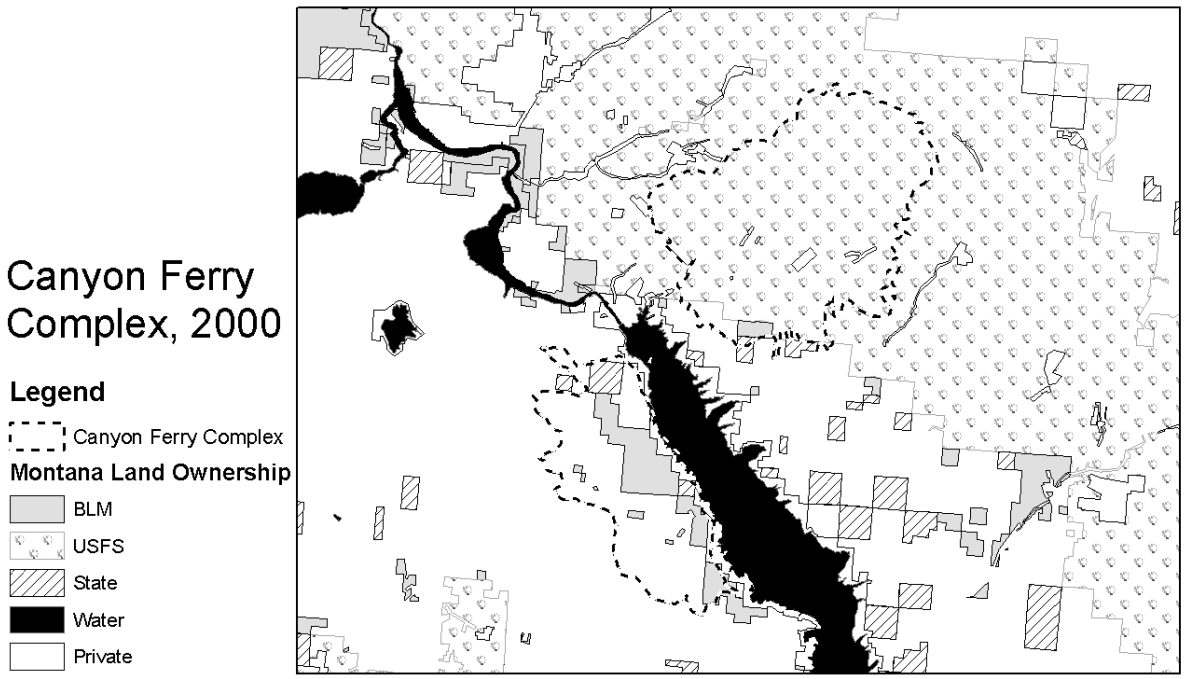


Figure 3. Boundary of Canyon Ferry Complex fires, showing mosaic of land ownership

The main impact from the fires has been increased flooding and mudslide events near Canyon Ferry Lake. In response, most of the federal rehabilitation projects have focused on watershed impacts and reforestation (Table 13). The Forest Service Fire Rehabilitation team spent $107,000 in the past two years on watershed remediation projects; and the Bureau of Reclamation is planning on spending a total of $600,000 on projects including replacing culverts. The BLM and Bureau of Reclamation spent $38,300 on watershed remediation projects through their EFR plan. In addition, the National Resources Conservation Service (NRCS) state office is planning additional remediation projects for next year.

Suppression Costs	$9,544,627
Watershed Remediation	$745,300
Reseeding and Erosion Barriers	$455,394
Reforestation	$155,757
Resurveying and Range Improvements	$4,338,900
Invasive Species Remediation	$2,380,570
Value of Houses Burned	$300,000- $450,000
Decline in Recreational Visits (Helena NF)	80%
Restoration of Archaeological Sites	$48,520
Supervision of Mushroom Collectors	$6,790

Table 13. Summary of major environmental, social, and economic impacts for the Canyon Ferry fire

Reforestation and reseeding projects also took place on federal land. The Forest Service has spent $133,757 on reforestation projects and $22,000 on exclosures to promote aspen regeneration. In addition, the BAER team reseeded 7,866 acres and put erosion barriers on 472 acres of the Helena National Forest, spending $359,794. The BLM and Bureau of Reclamation have set aside $95,600 for reseeding projects.

Following the burn, there have been extensive resurveying and range improvement projects on both federal and private land. To date, the Forest Service has spent $283,900 to repair cattle guards, restring fences, and resurvey boundaries. The Lewis and Clark Conservation District received a $4,000,000 grant from the Montana Department of Labor and a $45,000 grant from the National Fire Plan for resurveying and range projects on private land. The BLM and Bureau of Reclamation have spent $10,000 repairing fences.

Funds have also been allocated for projects to restrain the spread of noxious weeds in the wake of the fire. The Forest Service has spent $2,324,320 on noxious species projects, the BLM and Bureau of Reclamation spent $11,250, and the Lewis and Clark Conservation District received a $45,000 grant from the Noxious Weed Trust Fund, part of the National Fire Plan, to administer projects on private lands.

The Canyon Ferry fire also impacted homes and local communities. Six houses burned on land that was leased from the Bureau of Reclamation, and numerous garages and outbuildings were also lost in the fire. Flooding that occurred following the fire has impacted several additional buildings on land leased from the Bureau of Reclamation. Local roads were closed and the community of York was evacuated as a result of the Cave Gulch fire, although the fire stopped short of the community. Though smoke impacts were not specifically documented, one local resident commented that smoke lingered into the fall. However, smoke impacts from the Canyon Ferry Complex were compounded by smoke from other fires in the area.

Public recreational facilities and archeological resources were also damaged by the Canyon Ferry Complex. Within the Helena National Forest, 26 known historic or prehistoric sites were within the fire boundary and many burned with moderate intensity. Some sites were bulldozed in the process of fire control. To remediate these damages, the Forest Service has spent $48,520 to restore and to restrict access to exposed archaeological sites. Damage to developed recreational sites was mostly minor, affecting interpretive signs, picnic tables, and several old outhouses. However, recreational visits decreased 80% on the Helena National

Forest, probably due to fire-induced closures. Following the fire, there was an increase in use of the National Forest by mushroom collectors. As a result, the Forest Service spent $6,790 to issue permits and supervise mushroom collectors.

Rehabilitation and restoration work on the Canyon Ferry complex will continue through 2003. Due to the danger of post-fire flooding and mudslides, most rehabilitation funding has focused on watershed remediation, invasive weed projects, and resurveying and range projects. Less money was spent on remediation of archaeological, cultural, and developed recreation sites.

Sources

Lewis and Clark Conservation District, Lewis and Clark County, Montana
Forest Monitoring Report for Helena National Forest FY 2000
Fire Rehabilitation Team, Townsend Ranger District, Helena National Forest, Montana
Bureau of Reclamation, Billings, Montana
State Engineer, Natural Resources Conservation Service, Bozeman, Montana
Emergency Fire Rehabilitation Plan, BLM-Butte Field Office, MT and Bureau of Reclamation – Billing, MT

Shenandoah Complex

The Shenandoah Fire Complex included three fires: the Old Rag, Pinnacles, and Rapidan Road wildfires. Together, these fires burned 23,110 acres of Shenandoah National Park and 1,113 acres of private lands in Virginia between October 29th and November 12th, 2000. Although suppression costs totaled $4.8 million, ecological damages were minimal. The fires burned at low intensity, only partially consuming leaf litter and downed fuels, and caused minimal watershed impacts. The fires damaged seven historic ruins, mostly log cabins, because of years of leaf build-up within the structures. However, two historic cabins that are used by visitors were not damaged. The Department of Interior assembled a BAER team to assess damages to cultural and natural resources, but the team made few recommendations for restoration. Emergency rehabilitation costs through September 2003 will total $95,271. BAER projects mainly focused on hazard tree removal and rehabilitation of fire lines. Additional impacts include a reduction in tourism revenues and smoke-related impacts to air quality and public health.

Many visitors experience Shenandoah National Park via Skyline Drive, a scenic road that runs the length of the park. During the fires, 10 miles of the central portion of Skyline drive were closed, as were 26 hiking trails, including a stretch of the Appalachian Trail. Closures to Skyline Drive during the November 2000 fires decreased the number of visitors entering the park by car relative to other recent years, while the number of hiking visitors increased during that period (Figure 4). According to park employees, the low-intensity fire was such a novelty that it drew additional hiking visitors to the park. Entrance fees for a seven-day pass are $5 for hikers, or $10 per car. Assuming that all visitors pay these pass fees and spend only one day in the park, the economic impacts of the fire on revenue from park visitation are likely negative (Table 14). A more detailed economic analysis, such as a travel-cost recreational demand model, would be required to fully understand the fire's impact on park-related tourism.

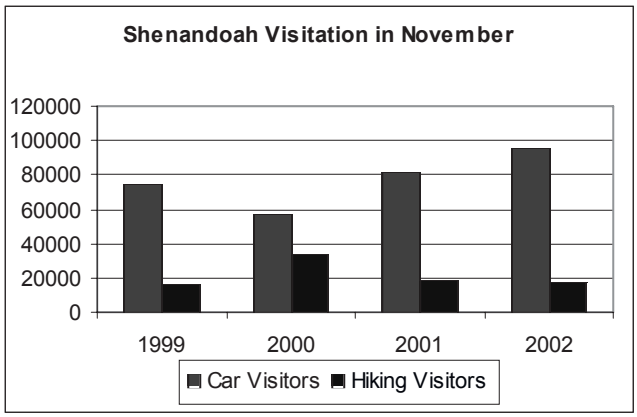


Figure 4. November car and hiking visits to Shenandoah National Park 1999 to 2000. Fires occurred in 2000.

Smoke from the Shenandoah fires severely degraded air quality in both the urban and rural areas surrounding the park (Figure 5). In general, wildfire smoke may cause road and airport closures, community evacuations, and increased incidence of smoke-related illnesses. Neither Shenandoah National Park nor the Virginia Departments of Environmental Quality or Health adequately monitored either air quality during the fires or smoke-related impacts from the Shenandoah complex, although post-fire analysis of air quality data suggested that the fire's impacts were widespread.

	1999 Visits	2000 Visits	2000-1999	Fee	Possible Impact
Car	74,726	57,287	-17,439	$10	-$174,390
Hiking	15,959	34,017	18,058	$5	$90,290
Total					**-$84,100**

Table 14. Possible economic impacts of changes in Park visitation during the 2000 Shenandoah Complex Fire

As mandated by the Clean Air Act, Shenandoah National Park collects air quality samples every three days. However, these air quality data are not publicly available for up to three months following sample collection because of lengthy laboratory analyses and assessments of data accuracy. As a result, these data are of little use for assessing the immediate air quality impacts from active wildfires.

The Virginia Department of Environmental Quality also monitors air quality and fine particulate matter (PM 2.5) at 20 stations across the state. The Luray PM 2.5 monitoring station, 10 miles west of Shenandoah National Park, had the highest PM 2.5 reading during the Shenandoah fires since monitoring began in 1998 . Luray was actually upwind from the fire, suggesting that communities south and east of the park may have experienced more smoke-related impacts (Figure 6). Statewide, 11 of the 20 PM 2.5 monitoring stations attributed their maximum readings in 2000 to the Shenandoah fires, including stations up to 275 miles away from the fires. Although the consequences of impaired air quality from the Shenandoah fires are inestimable, smoke from the fire impacted much of the state of Virginia.

Fire Suppression	$4,800,000
BAER Team and Projects	$95,271
Reseeding (25 acres)	$8,000
Tourism Losses (estimated)	$84,100
Smoke Impacts	Inestimable
Historic Structures Damaged	7

Table 15. Summary of the impacts from the Shenandoah Fire Complex

Figure 5. Smoke from the Shenandoah fires as seen from private lands bordering the park

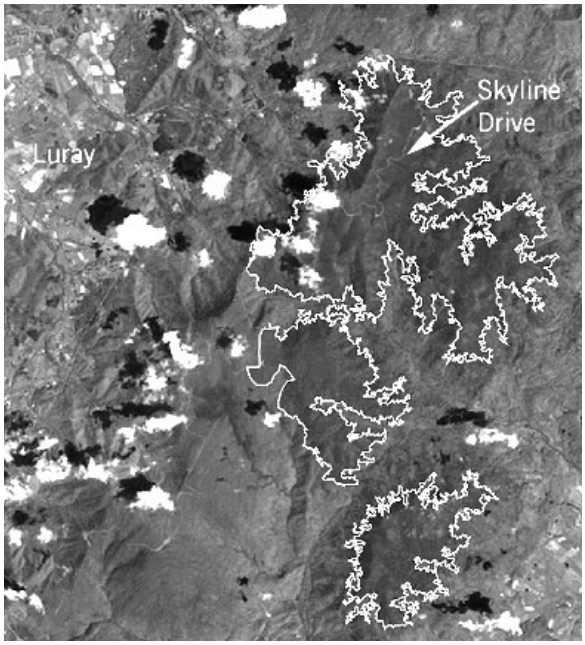


Figure 6: Landsat image taken following the Shenandoah Fire Complex. The fire boundary is shown in white. Notice the proximity of Luray, west of the park, and portions of Skyline drive within the burned area.

Sources

Shenandoah National Park
Virginia Department of Environmental Quality
Virginia Department of Health
Virginia Interagency Coordination Center
Shenandoah Complex BAER report
Shenandoah Complex Summary of Incident Management Operations

Carlton '01
Florida, 2001

The Carlton '01 fire began as a controlled burn on 550 acres of the T. Mabry Carlton Reserve, a county park in Sarasota County, Florida. As winds increased, the fire spread, eventually encompassing 6,000 acres in April 2001. While 4,800 of the acres affected were in the reserve, 1,200 acres of private land burned in the city of Northport. Sarasota County and the Florida Division of Forestry (FDOF) were the two agencies involved in fire suppression, with total suppression costs estimated at over $600,000. Due to the large number of wildfires across Florida in the spring of 2001, the Federal Emergency Management Agency released fire suppression aid to support the cost of fire suppression. The focus of time, effort, and funding for the Carlton '01 fire was on evacuating surrounding residents and fire suppression.

The fire's primary economic impacts were on private lands. Forty residents were evacuated from their homes, and one home and one vehicle burned. A three and a half mile stretch of Interstate Highway 75 was closed from late afternoon to early morning, causing traffic backups. Damages to the T. Mabry Carlton Reserve occurred in a relatively isolated area. As a result, recreation and tourism were little affected by the fire. The fire destroyed much of the timber in the burned area, and salvage operations were conducted on public lands to recover the burned timber. Aside from salvage work, no additional rehabilitation projects were completed on public lands.

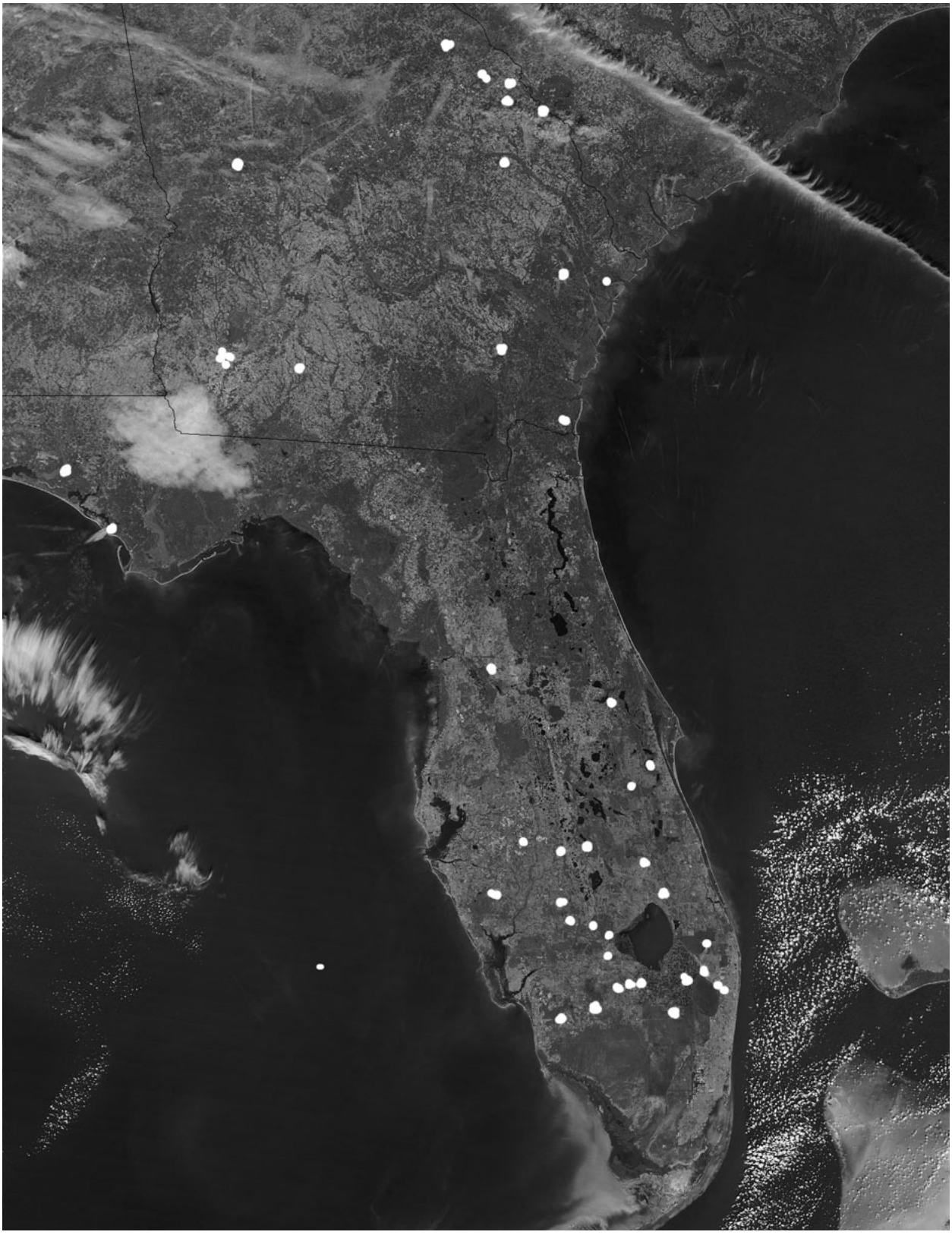
Impacts from the Carlton '01 fire were difficult to determine since the work was done at the county level, where neither the funds for data collection nor the procedures for publicly reporting these impacts exist. The Carlton 01 fire is the only case study fire in this report where federal land management agencies were not involved. As a result, much of the information that is readily available at the federal level was not collected. Sarasota County and FDOF information that was collected is now stored in boxes at a number of FDOF offices, and effectively inaccessible. Additionally, follow up work was not done for the Carlton '01 fire, either due to policy or funding restrictions or because rehabilitation was deemed unnecessary.

Suppression	>$600,000
Communities	40 houses evacuated, one house burned, minor damage to roofs
Transportation	Interstate I-75 closed for ~12 hours
Timber	Salvage work able to recoup value

Table 16. Major Impacts from the Carlton '01 fire

Sources

Florida Department of Forestry
Newspaper coverage of the fire



This photo, taken by NASA's MODIS satellite on April 4, 2003, provides an example of fire activity in Florida. Fires are indicated by white dots.

Star
California, 2001

The Star Fire began in a densely forested region of the Eldorado National Forest in California on August 25, 2001. Before it was contained on September 13th, the fire burned 2,417 acres on the Eldorado National Forest, 9,319 acres on the Tahoe National Forest, and 3,623 acres of private land, for a total of 15,359 acres. The Star Fire BAER Report estimates total suppression costs at $30 million. Although the fire did not threaten a wildland/urban interface, suppression costs were high due to the need to protect valuable timber resources and wildlife habitat in the region. BAER evaluation and emergency rehabilitation treatments, such as repairing roads and trails and monitoring noxious weeds, totaled $190,975 (Table 17). Aside from the costly suppression effort, the principle impacts from the Star Fire were on timber resources and wildlife habitat.

Information on timber and wildlife habitat impacts on national forest lands has been difficult to collect. Salvage timber sales have been appealed to the 9th U.S. Circuit Court, and access to information on impacts, costs, and restoration efforts has been frozen during the legal process. Therefore, the discussion below is limited to information available before the appeals process began.

Emergency Rehabilitation Projects	Cost
BAER Evaluation	$55,000
Noxious Weed Monitoring	$21,000
Geologic Hazard Monitoring	$2,475
Road and Trail Treatments	$112,200
Total	**$190,975**

Table 17. Summary of costs for immediate restoration work and analysis of Star Fire impacts

Timber damages in the burned region vary according to burn severity. The majority of the affected area (51%) burned at low intensity, while 38% and 11% of the burned area experienced medium and high intensity fires, respectively. On the Tahoe National Forest, tree mortality exceeded 75% on 3,620 acres. In addition, 25 even-aged plantations on the Tahoe National Forest were burned, 14 of which were completely destroyed in the fire. The other 9 plantations suffered between 10% and 85% mortality.

Environmental Impact Statements for restoration of 1,714 acres on the Eldorado and 5,530 areas on the Tahoe national forests call for treatments such as fuel reduction, salvage logging, and brush removal. Volume estimates for the salvage operations are not available, and will undoubtedly change as time passes. Delaying post-fire salvage operations shortens the window of opportunity to recover timber before insects and decay destroy its value. Burned trees from the Star fire are expected to lose 31% of their value in the first year, 53% after two years, and 67% after 3 years. One Forest Service employee estimated that current delays on the Tahoe National Forest have caused the loss of 13.5 million board feet of salvageable timber at a cost $2.6 million. Salvage logging on private lands faced fewer hurdles. One private landowner salvaged 18.4 million board feet on 2,800 acres within a year of the fire.

The Star fire burned a variety of forest types and destroyed habitat for federally listed threatened and endangered plant and animal species. Canyon live oak, white fir, red fir, and mixed conifer dominated forests burned, including 7,600 acres designated as "old forest." In addition, the fire damaged Protected Activity Centers (PACs) for the California Spotted Owl (1,137 acres) and the Goshawk (570 acres). Results of a preliminary field analysis identified 893 acres as potential habitat for four sensitive plant species: Cypripedium montanum, Botrychium spp., Phacelia stebbinsii, and Horkelia parryii. The Star fire's impacts on wildlife habitat, especially the loss of old forests, may have significant long-term effects on these populations.

The Star fire

Fire Suppression	$30 million
BAER	$190,975
Timber	Treatments proposed on 7,244 acres; Delays impacting timber volume and value
Wildlife Habitat	Loss of 7,600 acres of old forest and PACs for California Spotted Owl and Goshawk

Table 18. Summary of Star Fire impacts

Sources

Eldorado National Forest

Tahoe National Forest

USDA Forest Service, Pacific Southwest Region

Star Fire BAER Report

Red Star Restoration Plan/Environmental Impact Statement (EIS)

Newspaper documentation of Star Fire and legal action

Double Trouble
New Jersey, 2002

The Double Trouble Fire began as an illegal campfire in New Jersey's Double Trouble State Park, and burned more than 1,400 acres of pinelands before it was finally contained on June 4, 2002. The fire caused the evacuation of more than 100 homes and a convalescent center, and damaged or destroyed 13 homes and 23 outbuildings. Although the total acreage of the Double Trouble fire was small, its location in coastal New Jersey had two important impacts. First, the fire required cooperation among state police, the New Jersey forest fire service, and local officials and firefighters. Second, the fire closed a 24-mile section of the Garden State Parkway on Sunday, June 2nd, a toll road and major thoroughfare for weekend and vacation traffic leaving popular beach destinations in southern New Jersey.

Fire suppression costs quickly escalated as the blaze approached more populated areas adjacent to Double Trouble State Park. The Federal Emergency Management Agency reacted quickly to list the fire as a federal disaster, allowing 75% of the suppression costs to be reimbursed under the Federal Fire Management Program, a part of the President's Disaster Relief Fund. Suppression costs for firefighters and equipment totaled nearly $120,000 (Table 19).

Suppression Effort	Cost
Firefighters	$54,524
Vehicles (Engines, Dozers, Water Tenders, Aircraft, Support Vehicles)	$57,623
Food/Beverages	$4,145
Damaged Equipment	$3,000
Foam	$600
Total	**$119,892**

Table 19. Fire suppression costs for the Double Trouble fire

The Garden State Parkway is a toll road that parallels the New Jersey coastline and carries much of the north-south non-commercial traffic in New Jersey. The Parkway generates operating revenues with a series of tolls. In June 2002, toll revenues totaled more than $17.3 million, or nearly 50 million car-uses. The Double Trouble wildfire closed a 24-mile stretch of the middle of the parkway for 12 hours. The timing of the closure, a Sunday afternoon during the summer months, when many vacationers visit the New Jersey Shore, was a major inconvenience. Based on incident management reports for the parkway and New Jersey State Police, it is estimated that the direct costs for this closure were $15,345 (Table 20). Indirect costs, such as lost toll revenues, are not monitored by the Garden State Parkway. Toll revenues for June 2002 were 2% lower than in June 2001. However, it is difficult to determine the degree to which the fire-related closure contributed to the reduction in toll revenues.

Closure	Cost
Garden State Parkway	
Manpower	$7,461
Equipment	$3,278
State Police Manpower	$4,606
Total	**$15,345**

Table 20. Cost of Garden State Parkway closure during Double Trouble Fire (June, 2002)

Property Damage	13 homes, 23 outbuildings, and 3 vehicles damaged or destroyed
Suppression Costs	$119,892
Garden State Parkway Closure	$15,345
Evacuation (1-2 days)	100+ homes, convalescent center

Table 21. Summary of impacts from the Double Trouble Fire

Sources

New Jersey Highway Authority, Garden State Parkway

New Jersey Forest Fire Service

Double Trouble State Park

Hayman
Colorado, 2002

The Hayman fire was the largest wildfire in Colorado history. The fire burned 137,760 acres of the Pike National Forest and private lands within 20 miles of the Denver and Colorado Springs metropolitan areas, home to nearly 3 million people. Direct impacts from the Hayman fire were high: fire suppression cost more than $39 million; 38,000 people were evacuated from their homes; and 133 residences, 1 commercial building, and 466 outbuildings were destroyed in four counties. Emergency rehabilitation efforts on burned areas began before the flames were completely contained. BAER assessment and project implementation has cost nearly $24.8 million to date (Table 22), and a second BAER assessment is scheduled to be completed in June 2003. Due to its size, intensity, and proximity to major population centers, the Hayman fire created a variety of important impacts. Below, we explore the fire's impacts on the Denver municipal water supply system and public health, and the costs of future restoration on private and federal lands.

BAER Projects		**Cost**
Land Treatments		
Aerial Hydro-mulching	6,955 acres	$19,139,865
Aerial Dry-mulching	4,500 acres	$3,195,000
Mechanical Scarification	15,000 acres	$637,500
Heritage Sites	2 sites	$1,340
Other Land Treatments	6 sites	$12,438
Noxious Weed Treatments	495 acres	$103,950
"Colorado Cares" Volunteer Work	125 projects	$8,700
Flood Warning Signs		$2,600
Flood Warning System		$67,350
Seed		$407,000
Subtotal Land Treatments		**$23,575,743**
Roads and Trails		$136,708
BAER Evaluation		$135,800
Monitoring		$39,019
Implementation Logistics	45 days	$900,000
Total		**$24,787,270**

Table 22. BAER costs for Hayman Fire

The Cheeseman Reservoir area, an integral part of the Denver municipal water supply system, suffered the highest burn severity from the Hayman fire (Figure 7). The fire consumed ground cover and rendered soils hydrophobic, creating dangerous conditions for flooding and erosion. Restoration of watershed function in this region is essential; the main stem and north fork of the South Platte River combine to deliver more than 60% of Denver's municipal water supply. A preliminary assessment suggested that a single major storm event could significantly affect this portion of the Denver water system for several days, leaving between 1.2 and 1.3 million people short of water.

Controlling runoff to minimize sedimentation has been a primary goal of emergency rehabilitation projects. Denver Water has spent nearly $4 million on watershed restoration in an effort to avert significant

Project	Cost
Seeding and Straw Mulching	$1,411,920
Log and Straw Bale Dams; Contour Felling	$922,696
Sediment Traps	$29,358
General Restoration	$1,461,918
General Costs	$99,331
Total	**$3,925,223**

Table 23. Denver Water costs associated with Hayman fire (through 2/25/03)

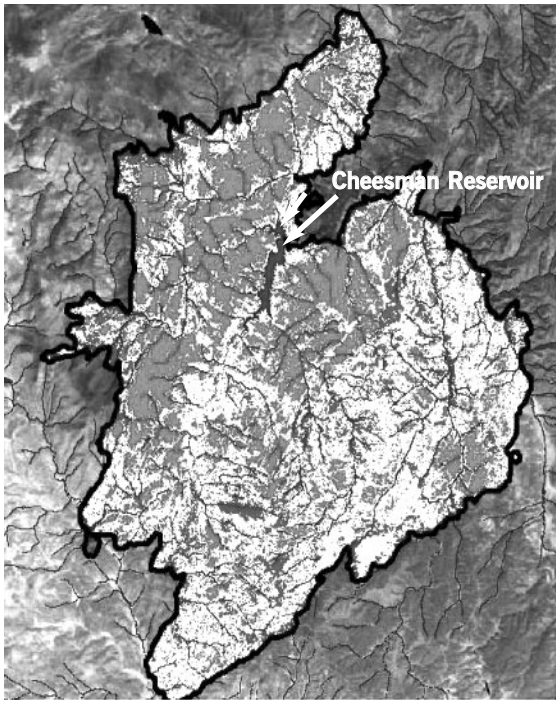


Figure 7. Burn severity map from the Hayman Fire BAER report. Darker areas within the fire boundary are the more severe. The Cheeseman Reservoir area, near the center of the map, suffered high burn severity.

damages to the reservoir area (Table 23). Denver Water has also incurred additional water treatment costs attributable to the Hayman fire (Table 24). Restoration work will hopefully prevent flooding, erosion, and long-term water treatment problems, such as occurred following the 1996 Buffalo Creek fire.

In 1996, the Buffalo Creek fire burned the area surrounding the Strontia Springs Reservoir, and damages from that fire continue to cause impacts on the Denver water system today. Thunderstorms following the Buffalo Creek fire caused severe flooding, killing two people, and depositing an estimated 13 times the annual debris and sediment load into the reservoir in a single event. Denver Water will incur costs for more frequent dredging to remove sediment and debris from the reservoir and higher overall water treatment costs. Effects on the Denver water supply from the Hayman fire could be similarly long-lived.

The primary public health concern from the Hayman fire was exposure to smoke. On June 9th, smoke from the Hayman fire blanketed the Denver area, creating the worst air quality ever recorded in Denver (Figure 8). Visibility was reduced to under 3 miles, and one fatality from smoke-related asthma has been attributed to the poor air quality. Smoke eventually spread over the entire northeast corner of the state of Colorado and into Nebraska and Wyoming, impacting more than 1.8 million people. The Colorado Department of Public Health and Environment enacted their Emergency Response System for the first time in the department's history. In addition to monitoring fine particulate matter (PM 10 and PM 2.5) in affected neighborhoods, they provided

	July	August	September	Total Cost
Water Treated (million gallons per day)	8,188	7,888	5,017	
Cost of Chemical Treatments				
Aluminum	$15,025	$6,625	$0	$21,650
NaOH	$24,929	$14,296	$0	$39,225
CL_2	$8,318	$14,461	$2,073	$24,852
Nitrogen	$1,430	$114	$0	$1,544
Fluoride	$696	$0	$0	$696
Total Cost				**$87,967**

Table 24. Denver Water 2002 water treatment costs attributable to Hayman Fire

smoke forecasts for the Hayman fire that were broadcast via radio, television, and telephone hotlines. Fortunately, persistent winds helped dissipate the smoke, preventing more serious health impacts in the Denver area. Immediately following the fire, the department conducted a small follow-up study of respiratory and cardiovascular disease incidence before and after the fire. This study did not show a clear association between air quality and increased disease incidence. At present, the department is not monitoring the long-term impacts of smoke on its population.

The Hayman fire burned more than 15,700 acres of private land scattered throughout the burned area. Watershed restoration on private lands is critical to avoid flooding, erosion, and possible loss of life and property. The principle federal source of funding for rehabilitation of private lands is the Natural Resources Conservation Service (NRCS) Emergency Watershed Program (EWP). NRCS has requested more than $10 million in EWP funds for the Hayman fire. Under this program, private landowners may apply to receive technical and financial assistance for rehabilitation work on their land. Private landowners or their sponsors must pay or provide in-kind support for 25% of the project costs. Volunteer efforts, coordinated by the Coalition for the Upper South Platte (CUSP) and state conservation districts, have been instrumental in implementing EWP projects and helping landowners to meet their 25% matching requirements. Since the fire, CUSP has organized 3,200 volunteers, completing 45 projects with 21,000 volunteer hours. CUSP has also served as a central source of information for landowners throughout the recovery and restoration process, coordinating inter-agency efforts within local communities.

Hayman fire restoration will require several more years of intense effort to restore watershed condition, alleviate fuel loading and forest overcrowding, and protect the Denver water supply. On the Pike National Forest, $4 million has been budgeted for restoration work in 2003 (Table 25). Only $200,000 of this total is expected to come from the National Fire Plan budget; the remainder will come from the U.S. Forest Service Region 2 budget. In addition to watershed restoration and noxious weed treatments, work in 2003 will focus on reopening the burned area for recreation.

The USDA Forest Service Rocky Mountain Research Center is coordinating a thorough evaluation of the impacts from the Hayman fire, including social and economic impacts. The preliminary report was released in January 2003, and the final report is due later this year. This report, which will provide more detail on the full range of the fire's impacts, represents a new level of research and data collection effort following wildfires. A Forest Service study of the full range of impacts from wildfire has not been completed for any of the other case study fires considered in this report.

Visitor information/control
Noxious weed control
Road repair
Reforestation
Landlines
Recreational facilities
Habitat restoration
Public affairs
Watershed restoration/monitoring
Salvage & hazard tree removal
Additional BAER team assessment
Budget: $4 million

Table 25. Hayman Restoration Team 2003 priority areas

One of the measurable improvements between the Hayman and previous fires was the ease of access to fire information. Because of the fire's impacts to the wildland/urban interface and controversial ignition by a Forest Service employee, the Hayman fire received a substantial amount of national publicity during the 2002 wildfire season. Public attention on the Hayman Fire situation has remained high due to the nature of the fire's impacts and public access to information has been improved through the creation of a Hayman Fire web page and a centralized information center run by CUSP. The timely maintenance of the Hayman Fire web page throughout the restoration process has allowed the public to access up-to-date information.

Suppression	$39,000,000
Structures Destroyed	133 homes, 1 commercial building, 466 outbuildings
Evacuation	38,000 people
Smoke	1 Fatality, 1.8 million people impacted
Denver Water	$4,013,189
Recreation	Interruption of hunting, fishing, and recreational visits; Pike National Forest closed one month
Rehabilitation/Restoration	
BAER	$24.8 million
EWP	$10 million
2003 Restoration	~$4 million

Table 26. Summary of Hayman Fire Impacts

Figure 8. Photos showing the Hayman fire's impact on Denver air quality on June 8 (left) and June 9 (right) 2002.

Sources

Pike National Forest
Denver Water
Natural Resources Conservation Service, Denver CO
Coalition for the Upper South Platte
Colorado State Forest Service
Colorado Department of Public Health and Environment
Colorado Department of Natural Resources
Hayman Fire BAER Report
Interim Hayman Fire Case Study Analysis

Rodeo-Chediski
Arizona, 2002

Between June 18 and July 7, 2002, the Rodeo and Chediski fires burned a combined 462,614 acres, making it the largest wildfire complex in Arizona history. Fire suppression for the Rodeo-Chediski fire cost an estimated $40.4 million. The fire destroyed 470 structures and forced more than 30,000 people to evacuate from the communities of Carrizo, Cibeque, Hon-Dah, Lakeside, McNary, Pintop, and Show Low. Environmental and social impacts from the fire will extend for many years into the future.

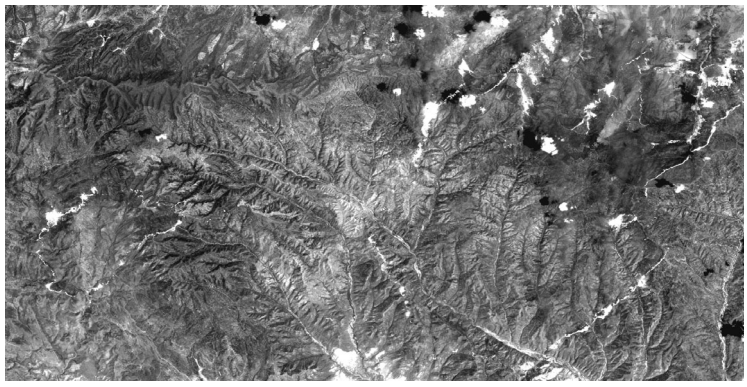


Figure 9. Satellite image of Rodeo-Chediski fire burning

The Rodeo-Chediski fire is a tale of two ownerships, federal and tribal. Although 177,439 acres burned in the Apache-Sitgreaves and Tonto National Forests, an even larger area, 276,512 acres, burned in the Fort Apache Reservation, home to the White Mountain Apache Tribe. Due to differences in funding and management objectives, both short and long-term impacts from the Rodeo-Chediski fire will play out differently for the Forest Service and White Mountain Apache Tribe. As a result, we explore the cost of restoration and the fire's impacts on timber, recreation, and wildlife separately for federal and tribal lands.

Impacts to National Forests

Following the fire, a BAER team was organized to evaluate damages to the Apache-Sitgreaves and Tonto National Forests. The primary goals of BAER projects on national forest land were soil stabilization and reforestation of severely burned watersheds. The BAER assessment and emergency rehabilitation projects cost a total of $10.4 million in 2002 (Table 27). Additional watershed treatments and reforestation efforts are expected to be among the most costly aspects of future restoration (Table 28). Table 28 lists five alternatives for restoration in 2003-2004, ranging in cost between $12 and $20 million, yet the Apache-Sitgreaves National Forest only expects to spend approximately $1 to $3.5 million on restoration in 2003 due to budget restrictions. Although the final 2003 restoration budget has not been competed, the planning document summarized in Table 28 provides some insight into the magnitude and priority of future efforts.

Project	Cost
BAER Evaluation	$1,273,143
Land Treatments	
Seeding	$2,822,265
Ground Cover Projects	$5,791,390
Fish Hatchery Project	$6,500
Heritage Site Project	$28,000
Channel Treatments	$36,000
Road and Trails	$416,646
Structures	$5,368
TOTAL	**$10,379,312**

Table 27. Forest Service BAER costs through Dec. 16, 2002

Damages to timber on national forest land were substantial, especially in areas with high burn severity. An estimated 300 million board feet of timber was damaged or destroyed by the fires. Four salvage timber sales totaling 24.9 million board feet were offered in January 2003. A lawsuit was filed at that time, and the future of these four sales is still uncertain. A subsequent restoration plan and Environmental Impact Statement currently under consideration may suggest removing an additional 55 to

Project	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
Implementation Team	$3,437,247	$3,437,247	$2,095,892	$1,577,460	$14,663
Watershed Treatments	$5,883,250	$3,750,000	$3,750,000	$3,750,000	$3,750,000
Roads/Facilities	$392,000	$165,000	$165,000	$165,000	$165,000
Reforestation	$6,836,626	$6,465,000	$6,465,000	$6,465,000	$6,465,000
Recreation	$450,250	$381,000	$381,000	$381,000	$381,000
Land Lines	$206,700	$251,700	$251,700	$251,700	$251,700
Wildlife	$1,060,500	$440,000	$440,000	$453,000	$453,000
Range	$1,492,240	$453,000	$453,000	$460,000	$460,000
Heritage	$154,500	$141,000	$141,000	$141,000	$141,000
Education/Interpretation	$252,000	$83,000	$83,000	$83,000	$83,000
Total Restoration/ Rehabilitation	**$20,165,313**	**$15,566,947**	**$14,225,592**	**$13,707,160**	**$12,144,363**

Table 28. Planning document for Rodeo-Chediski restoration on National Forest land; costs for 2003-2004.

105 million board feet. However, the window of opportunity for these operations is closing; half of the timber volume under consideration is expected to be lost to insects and decay by January 2004. The fire burned 106 miles of trail on the Apache-Sitgreaves National forest, and closure of these trails has limited recreation in the burned area. Hazard tree removal and soil stabilization along the trails is needed before the area can be reopened. Future flooding events in the burned area will worsen trail conditions and threaten public recreational facilities, such as in Lewis Canyon.

The Rodeo-Chediski fire burned habitat for federally listed species, and erosion and sedimentation threaten to impact three important fisheries. Twenty Mexican spotted owl Protected Activity Centers (PACs) were burned; four PACs were completely destroyed and nesting habitat was eliminated in an additional six. The degree to which this habitat loss will impact Mexican spotted owl populations in the area is unclear. The fire also damaged the Black Canyon Lake, Canyon Creek, and other important fisheries on national forest land. To date, only $6,500 has been spent on fisheries projects, although watershed rehabilitation and erosion mitigation efforts will also help to avoid future damages to stream habitats.

Suppression	$40.4 million
Evacuation	> 30,000 persons
Structures Destroyed	470
BAER Costs for Federal Lands	$10.4 million
Expected Cost of 2003 Restoration	$1-3.5 million
Timber Damages	300 MMBF

Table 29. Summary of Rodeo-Chediski fire impacts on national forest lands

The wildland-urban interface after the Rodeo-Chediski fire

Rodeo-Chediski fire burning

Impacts to Fort Apache Reservation Land

The Rodeo-Chediski fire caused significant environmental, social, and economic damages on the Fort Apache Reservation. A separate BAER team was assembled through the Bureau of Indian Affairs fire management office to assess damages to the Fort Apache Reservation. Details of the plan are not publicly available, since the report and maps contain sensitive tribal information such as the location of burial and sacred sites on the reservation. Several key BAER team recommendations are known, however. The report calls for nearly $10 million in emergency funds over the next three years to rehabilitate high burn severity areas, fire suppression impacts such as bulldozer lines, and severely damaged watersheds. Flood mitigation efforts surrounding the communities of Cibecue and Carrizo are an essential part of these early projects—more than 75% of their respective watersheds burned. However, the feasibility of all rehabilitation efforts depends on the availability of funding.

Following the fire, the Federal Emergency Management Agency (FEMA) set aside $20 million to assist with damage recovery on the Fort Apache Reservation. However, as of April 2003, the tribe had not received any of these FEMA funds. The central issue behind the funding dispute is sovereignty. Concern among the White Mountain Apache Tribe is that the tribe's economic information is confidential, and a government-to-government aid transaction need not publish these sensitive data. FEMA officials argue that they must adhere to their funding guidelines. Under FEMA regulations, government-funded restoration requires the completion of an Environmental Assessment under the National Environmental Protection Act (NEPA). The NEPA process includes a period for public comment, during which time the tribe's confidential information could be released. Until this issue is resolved, the tribe will not receive much-needed funding. In addition to implementation of BAER recommendations, the tribe planned to use the FEMA funds to conduct salvage logging operations.

Forest management is a central part of the White Mountain Apache Tribe's economy. The tribe's timber company, the Fort Apache Timber Company (FATCO), was shut down during the Rodeo-Chediski fire at a cost of $500,000 in lost wages and $4 million in pending timber sales. The fire destroyed more than 700 million board feet of timber on the Fort Apache Reservation, valued between $237 and $300 million. Due to insect damage and decay, the window for salvage operations is expected to last only two years. FATCO has plans to log 150 million board feet in areas where ground-based operations are feasible. However, the logging and milling capacity on the reservation cannot handle the volume of timber that is expected to be cut in the

next two years. For the first time in the tribe's history, the tribe has sold two large salvage logging contracts to outside bidders. The sales total an additional 240 MMBF, with all logging being done by helicopter.

Prior to the Rodeo-Chediski fire, recreation and tourism industries were a mainstay of the tribe's economy. The Fort Apache Reservation is a popular destination for fishing, camping, and whitewater rafting. The degree to which fire damages impact these activities remains to be seen. The White Mountain Apache Tribe also sells hunting permits on the reservation. In past years, permit sales have grossed as much as $975,000 for the tribe. Habitat damages, closure of the burned area, and aesthetic impacts from the fire may reduce these revenues in coming years. The tribe also operates the Hon Dah Casino on the reservation. Closure of the casino due to the fire cost an estimated $3.3 million through September 2002. The Rodeo-Chediski fire may also have long-term social impacts. Although no one has directly measured these impacts, the emotional impacts with respect to environmental damages from the fire are likely quite high.

Impact	Estimated Cost/Loss
Evacuation	1,500 persons
Timber	$237,000,000- $300,000,000 700 million board feet
Closure of Sawmill	$500,000 in wages
Pending Timber Sales	$4,000,000
Hon Dah Casino Closure	$3,300,000 (through Sept 03)
Hunting Permits	$975,000
Restoration	
Reseeding	189,000 acres
BAER Recommendations	$10,000,000 (estimated)
FEMA Aid Promised	$20,000,000

Table 30. Summary of Impacts to Fort Apache Reservation and White Mountain Apache Tribe

Sources

Apache-Sitgreaves National Forest
Tonto National Forest
Federal Emergency Management Agency
Indian Country Today news articles
Newspaper coverage of the fire
USDA Forest Service BAER Report

Battle Creek
South Dakota, 2002

The Battle Creek fire burned 9,120 acres in the Black Hills National Forest and 3,300 acres of adjacent private lands. The fire burned within one mile of Mount Rushmore National Memorial, and the possibility of damages to Mount Rushmore elevated Battle Creek to a Class 1 fire and to the number one priority fire in America in August 2002. A Type 1 Crew, Type 1 Team, and 8 air tankers aided fire suppression efforts by US Forest Service, South Dakota Division of Wildland Fire Suppression, National Guard, Pennington Country Sheriff's Office, and volunteer firefighters. On August 29th, after 14 days of burning, suppression costs were estimated at $7 million.

The proximity to Mount Rushmore and Rapid City, South Dakota created the potential for high economic damages from this wildfire. The fire caused road closures, damaged structures, and billowed smoke that impacted both Rapid City residents and the 16,000 visitors that flock to Mount Rushmore each day. Due to a quick response from firefighters and favorable weather, the economic impacts from the Battle Creek fire were modest. We highlight four important costs from the Battle Creek fire in the tables and text below: damages and restoration recommendations from BAER and Rapid Assessment Team (RAT) reports, impacts to timber sales, damages to private lands, and impacts on Mount Rushmore tourism.

Immediately following the Battle Creek Fire, a BAER team was assembled to identify and mitigate ecological damages and safety hazards. A total of $323,000 was spent on the assessment, hazard tree removal, and trail, road, and fire line rehabilitation. A RAT team was also assembled to recommend projects for ecosystem restoration on National Forest lands. Based on the RAT report, the Black Hills National Forest requested $4.3 million for restoration projects in 2003 and 2004 (Table 31). The US Forest Service budget for restoration projects in 2003 is approximately $7 million nationwide. For a relatively smaller fire such as the Battle Creek, the Black Hills National Forest is not likely to receive money from the national budget; as a result, any restoration projects must be funded by the Region 2 budget. Table 31 shows the amounts that the Black Hills National Forest requested from Region 2 in 2003 for restoration of damaged areas—5% of the amount originally requested to implement all recommended restoration projects.

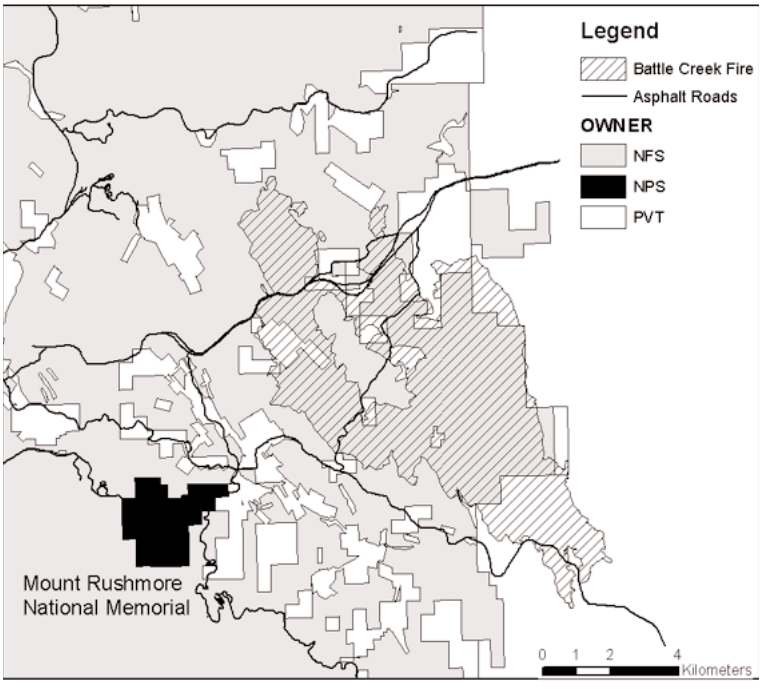


Figure 10. Map of the Battle Creek Fire, showing land ownership, roads, and proximity to Mount Rushmore

Restoration Project	2003-2004 National	2003 Region 2
Road Rehabilitation	$745,000	$100,000
Noxious Weed	$385,000	$60,000
Range Structures	$165,000	$40,000
Repost Boundaries	$170,000	$0
Teepee Gulch Road	$85,000	$15,000
Interpretive Signs/ Visual area Enhancement	$100,000	$0
Stand Exams	$54,500	$0
Monitoring seed cast	$7,800	$0
Regeneration survey	$32,000	$0
Fire Restoration	$15,000	$0
Tree Planting	$1,400,000	$0
Travel Management	$76,000	$0
Flume Trail Signage	$1,500	$0
Hazard Fuels/Fuel Breaks	$450,000	$0
Wildlife Structures	$20,000	$0
Travel Management for big game protection	$600,000	$5,000
Cave, mine, threatened species survey	$16,000	$0
Total	**$4,322,800**	**$220,000**

Table 31. Rapid Assessment Team recommended restoration projects and the related funding requests from the USFS national budget and the resubmitted budget to Region 2

The Battle Creek fire affected the Beagle, Bitter, and Hollow timber sales. The Beagle sale was nearly complete when the fire began, whereas the Bitter and Hollow sales had been planned and marked, but not sold. All three sales were modified following the fire, and the layout of the sale was redrawn in each case. A policy of "black before green" was incorporated into the sales. The overall impact on the volume in each sale was minimal, since the addition of volume in severely burned areas was offset by reductions in less impacted areas. Although the fire caused a postponement of the Bitter and Hollow sales while plans were modified, the overall affect of having planned timber sales in the burned area accelerated the salvage process. Bids on the Bitter and Hollow sales were slightly lower because of the inclusion of black timber, but overall, the prices were more affected by the Canadian market than the fire.

The majority of the private lands that were damaged are managed for timber. Salvage work on private lands began soon after the fire, and in most cases, the value of the timber has been recouped. The fire destroyed three homes on private lands, although the value of these properties is not known. Additionally, the Black Hills Electric Coop and Qwest Telephone Company incurred damages to utility lines of $50,000 and $81,000, respectively. Financial and technical assistance to private landowners, through the Natural Resources Conservation Service and the South Dakota Resource Conservation and Forestry Service, will be funded by a $154,000 grant from the state. However, this grant will be divided between landowners affected by the Grizzly Gulch, Little Elk, and Battle Creek fires. Restoration priorities and cost-share details will be decided in March 2003.

Visitation to the Mount Rushmore National Memorial was not significantly affected by the fire, despite the closure of the main access highway to Mount Rushmore (Highway 16) and smoke from the fire. Nearly 16,000 people visit Mount Rushmore on an average day in August. During the three-day closure of Highway 16, visitation to the National Memorial dropped by an average of 12% each day. However, visitation for the month of August was up 7.1% overall from 2001. The South Dakota Department of Transportation spent $18,000 to mitigate erosion hazards on Highway 16. The Forest Service requested $100,000 to provide interpretive signage about wildfire along Highway 16 for the 2,000,000 visitors to Mount Rushmore each year, but given budget constraints, this project is unlikely to be funded.

Economic Impact	Cost
Suppression	$7,000,000
BAER	$323,000
RAT (Reqested/Expected)	$4,323,000/$220,000
Timber Sales	Minor impacts
Tourism	Minor impacts
Private Lands	
Utility Lines	$131,000
Structures	3 Homes
SD DOT Roads	$18,000

Table 32. Summary of Economic Impacts for the Battle Creek Fire.

Sources

Black Hills National Forest
Natural Resources Conservation Service, Rapid City SD
Mount Rushmore National Memorial
South Dakota Resource Conservation & Forest Service
South Dakota Department of Transportation
South Dakota Department of Environmental & Natural Resources, Air Quality
Qwest Communications
Black Hills Electric Coop
Battle Creek Fire BAER and RAT Reports

Biscuit
Oregon and California, 2002

The Biscuit Fire burned almost half a million acres in Oregon and California in the summer and fall of 2002, becoming the largest fire in the history of Oregon. Ninety-nine percent of the acres burned were on federal land, including 489,145 acres on the Siskiyou and Six Rivers National Forests and 8,753 acres of Bureau of Land Management (BLM) land in Oregon. The private land that burned was mostly inholdings within the public land matrix. Since the fire was not declared out until November 9, 2002, many of the rehabilitation and monitoring projects are still in the planning stages. Therefore, the total costs for various rehabilitation projects have not yet been budgeted. The Forest Service has conducted an extensive public process within the Biscuit fire rehabilitation and restoration work. They maintain a website and post relevant documents, including the BAER team report and Fire Assessment completed by the Siskiyou and Six Rivers National Forests. A large portion of the area burned was within the Kalmiopsis Wilderness Area, which is subject to minimum intervention requirements under the Wilderness Act.

Suppression costs for the Biscuit fire, totaling $150 million, are the largest costs thus far. Based on the Forest Service's assessment, some of the greatest impacts of the fire were to federally–listed species and to the timber on the national forests (Table 33). Remediation projects for developed recreation sites and watershed restoration projects will also have significant costs.

Suppression	$150 million
Threatened Species (Northern Spotted Owl)	49 activity centers and 11 nests inside fire area
Value of Burned Timber (FS land)	~$309 million
Repair to Recreation Infrastructure	$2,422,050 - $2,442,050
Watershed Remediation	$13,200,000
Structures Burned	4 homes, 9 outbuildings

Table 33 - Major environmental, social, and economic impacts of the Biscuit fire.

The fire burned through several Late Successional Reserves (LSR), set aside for northern spotted owl habitat. Loss of late-successional habitat may lead to a temporary decline in the owl population in the area. However, the Forest Service expects the spotted owl to remain viable in the affected national forests. According to the Forest Service Fire Assessment, the marbled murrelet, another federally-designated threatened species, lost some habitat in the Siskiyou National Forest, but the species is not expected to decline as a result of the fire.

The severity of the fire varied extensively; roughly 20% of the area within the fire perimeter was unburned or burned with very low severity, while 16% burned with high severity. However, timber damages on the 497,898 acres of national forest that burned were extensive. The Forest Service estimates the value of burned timber (including timber in the Late Successional Reserves) at $309 million dollars. However, this figure merely reflects the value of the standing dead timber, not the value or amount of timber to be removed in salvage logging operations.

The Forest Service is planning extensive projects to restore recreation sites, including campgrounds, trails, and signs destroyed by the fire (Table 34). Some of these facilities were also affected by the presence of fire camps during the suppression phase of the fire. These projects are estimated to cost over $2,400,000.

In comparison, the economic impacts to private property were much smaller that those to public property values. During the Biscuit fire, four homes, nine outbuildings and one lookout burned. Communities in the vicinity were put on alert, but no communities were actually evacuated. Only individuals who are highly affected by smoke were encouraged to evacuate.

The watershed and soil erosion impacts from the fire have been surprisingly minimal. Most areas have experienced minimal erosion, and reseeding and reforestation projects have been targeted at specific areas with high erosion potential. The preliminary watershed stabilization and erosion control work was done on national forest land by the Forest Service BAER teams and on Bureau of Land Management land under the BLM -Medford Emergency Stabilization and Rehabilitation (ESR) Plan. The ESR plan encompassed the restoration work planned for BLM lands. Under the Forest Service BAER projects, $61,000 was spent on assessment and stabilization of cultural and archaeological resources. The Forest Service is continuing to work on designing additional rehabilitation and monitoring projects. These projects will involve work to improve culverts, fix roads, and plant trees to manage water flow and soil erosion (Table 35).

Forest Service Recreation projects	**Cost**
Campgrounds	$89,950
Repair Lookout	$75,000
Trailhead (replacing toilets)	$55,500
Trail Repair (318 miles)	$1,939,100
Trail Signs	$15,000
Inappropriate ATV Access	$40,000 – 60,000
Trail Bridges	$207,500
Preliminary total	**$2,422,050 - $2,442,050**

Table 34 - Forest Service projects planned to restore recreational facilities

Federal Agency	**Watershed and Soil erosion remediation**
Forest Service BAER Team	$9.4 million (amount requested)
BLM Emergency Rehabilitation	~ $3.8 million (work spread over 4 years)
Forest Service Remediation Projects	Still in planning stages
Preliminary total	**13.2 million**

Table 35 - Federal watershed and soil remediation projects and costs

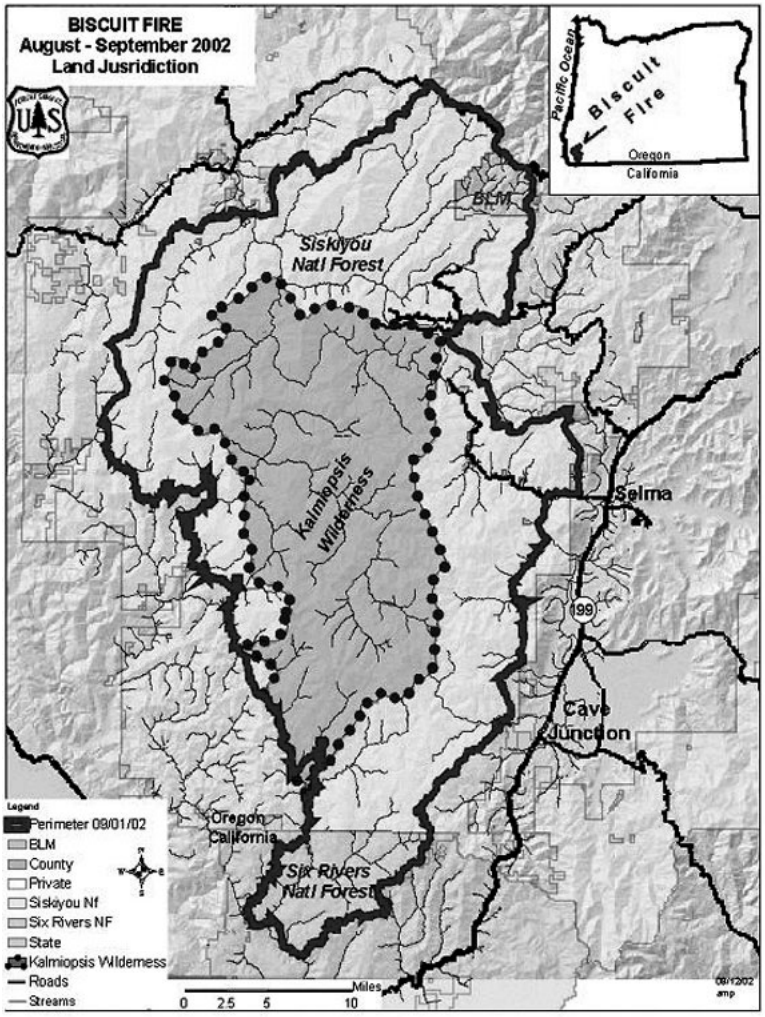


Figure 11: Biscut fire boundary

Sources

Biscuit Fire BAER report

Biscuit Fire Assessment for Siskiyou and Six Rivers National Forests

Staff at BLM Medford Office

Staff at Siskiyou and Six Rivers National Forests

"Biscuit Fire Destroyed Portion of Northern Spotted Owl Habitat" The Oregonian January 25, 2003

Biscuit Fire website, http://www.biscuitfire.com/

BLM-Medford Press release "Emergency Stabilization and Rehabilitation Plan Approved for the Bureau of Land Management portion of the Biscuit Fire." http://www.or.blm.gov/Medford/newsreleases/Medbiscuit_emer_rehab_plan_approved.htm

Case Study Summary

The ten case study fires in this report highlight a number of key points regarding the nature of impacts from large wildfires at the wildland/urban interface and the availability of information on a variety of wildfire impacts. These conclusions can be divided into four main categories. First, the case study summaries provide an opportunity to characterize the nature, magnitude, and duration of wildfire impacts. Second, we review the availability of information for the thirteen categories of wildfire impacts considered in this report with respect to our goal of understanding the short and long-term environmental, social, and economic impacts of wildfire. We contacted a variety of sources to complete the case study fire summaries: federal, state, and local governments; tribal entities; private landowners and businesses; non-profit agencies; and government and university research groups. Since each of these sources monitors wildfire impacts differently, we next discuss the variations between sources regarding data collection priorities and access to information. Finally, we describe the improvement in availability of wildfire impact information as federal and state agencies invest more time and resources in documenting wildfires and disseminating information via the Internet.

Nature of Wildfire Impacts

The magnitude of environmental, social, and economic impacts from wildfires is a function of the size, intensity, and location of the burn. Table 36 shows selected data for each wildfire impact category from the 10 case study fires in this report. For large wildfires at the wildland/urban interface, the short and long-term impacts from wildfire can be substantial. Below, we highlight other important findings from the case study fires.

Eight of the ten case study fires burned in areas where pre-fire forest conditions had deviated from the historical fire regime.

The Forest Service has created a map of current condition classes for forest areas in the lower 48 states (Figure 12). Classes 1, 2, and 3 refer to the extent to which the forest has deviated from the historical fire regime and to changes in species composition, structural stage, stand age, and canopy closure that may affect the fire regime or fire frequency. Changes to the historic fire regime may be due to a variety of factors, including fire exclusion, timber harvesting, grazing, exotic plant species, insects and disease, or other past management activities. Class 1 indicates that the forest is at or near the historical fire regime, and fire frequencies, species composition, and structure are consistent with the historical trends. Class 2 indicates a moderate level of alteration in fire regime, vegetation attributes, fire frequencies, and risk of key ecosystem component loss. Class 3 signifies the highest degree of alteration from historic conditions and the greatest risk of losing key ecosystem attributes.

Six of the ten fires analyzed for this report burned in condition class 3 forests, and eight of the ten fires occurred principally in forests with moderate to high deviation from historic forest and fire regime conditions (Table 37). The Carlton 01 and Shenandoah Complex were the only two case study fires that burned in areas where current conditions were consistent with historical forest and fire attributes.

Impact	Case Study Fire	Example
Fire Suppression	All Fires	Suppression costs ranged from $120,000 (Double Trouble) to $150 million (Biscuit).
Structures Destroyed	All Fires	Number of structures destroyed ranged from 0 (Shenandoah Complex) to 133 homes, 1 business, and 466 outbuildings (Hayman).
Fire size	All Fires	Fire size ranged from 1,400 acres (Double Trouble) to 500,000 acres (Biscuit).
Alteration of wildlife habitat	Star	Loss of Protected Activity Centers (PACs) for CA Spotted Owl and Goshawk and 7,600 acres of old forest types.
	Biscuit	Loss of 49 PACs for northern spotted owl and 11 nests.
Watershed and water supply damages	Canyon Ferry Complex	$745,300 for watershed remediation.
	Hayman	Damage to Denver Water reservoir; $4 million spent on restoration and water treatment to date.
	Biscuit	$13.2 million for watershed remediation.
Public recreation facilities damaged	Biscuit	Damage to trails, campgrounds, and signs; restoration expected to cost $2.4 million.
Evacuation of adjacent communities	Cerro Grande	18,000 people evacuated for 1 week.
	Carlton	40 homes evacuated for 1 day.
	Double Trouble	100+ homes and convalescent center evacuated for 1-2 days.
	Hayman	38,000 people evacuated.
	Rodeo-Chediski	30,000+ evacuated from Fort Apache Reservation towns and surrounding communities.
Tourism impacts	Canyon Ferry Complex	Decline in recreational visits to Helena National Forest by 80% due to fire related closures.
	Shenandoah Complex	Possible reduction in visitation revenues during fire; overall tourism impacts uncertain.
	Hayman	Interruption of recreation in South Platte watershed, closure of the Pike National Forest for 1 month.
	Rodeo-Chediski	On Fort Apache Reservation, loss of permit revenue for camping, hunting, and fishing ~$1 million, $3.3 million for casino closure.
	Battle Creek	Mount Rushmore National Memorial within 1 mile of fire boundary, however tourism increased by 7% over 2001.
Timber damages	Star	Salvage logging proposed on 7,244 acres. Delays in harvesting burned timber will affect volumes and value.
	Rodeo-Chediski	1 billion board feet damaged on tribal and federal lands, valued at more than $300 million.
	Battle Creek	Minor impacts to existing timber sales. Sales redrawn to include burned timber.
	Biscuit	Value of burned timber estimated at $309 million, but most timber is in wilderness area and not salvageable.
Cultural and archaeological sites	Cerro Grande	671 cultural and historical sites were within the fire boundary; 511 were in low burn severity areas.
	Canyon Ferry Complex	26 historical sites within the fire boundary. Restoration cost $48,520.
	Shenandoah Complex	7 historic structures damaged because of leaf buildup.
Rehabilitation and restoration costs	Cerro Grande	$121+ million spent on restoration of LANL, Bandelier National Monument, and Los Alamos.
	Canyon Ferry Complex	$8.1 million spent on restoration, reforestation, resurveying, invasive species, and soil stabilization.
	Shenandoah Complex	$95,000 spent on BAER rehabilitation and restoration projects.
	Star	$190,975 spent on BAER projects.
	Hayman	$24.8 million for BAER, $10 million for EWP, and $4 million for Forest Service restoration in 2003.
	Rodeo-Chediski	$10.4 million for BAER and $1-3.5 million for restoration on federal lands; $10 million for BAER on Fort Apache Reservation.
	Battle Creek	$4.3 million requested for 2003-2004 restoration, expect to spend $220,000.
Health impacts	Shenandoah Complex	Degraded air quality in eastern Virginia, but smoke-related illnesses or other impacts were not monitored.
	Hayman	1 fatality. 1.8 million people impacted in Colorado, Wyoming, and Nebraska.
Transportation	Carlton 01	Closure of Interstate 75 for 12 hours.
	Double Trouble	Closure of the Garden State Parkway, a toll-road, for 12 hours. Cost: $15,000. No estimate of lost toll revenue.
	Battle Creek	Closure of Highway 16 for three days. Cost to SD DOT: $18,000.

Table 36. Selected data for each wildfire impact category form the 10 case study fires

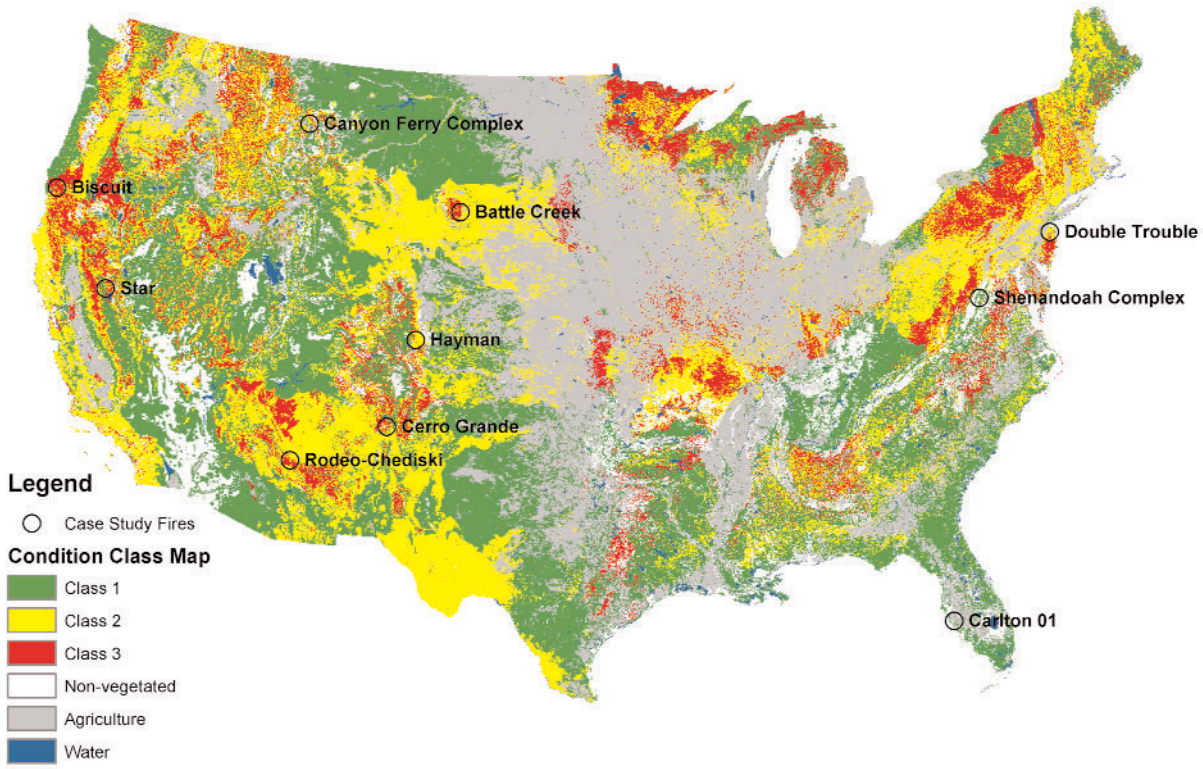


Figure 12. The ten case study fire locations overlaid on the Forest Service current condition class map (2000 version). The marker for each case study fire does not indicate the fire size or shape.

Fire Name	Size (acres)	Condition Class
Cerro Grande	42,875	3
Canyon Ferry Complex	43,994	2
Shenandoah Complex	24,223	1
Carlton '01	6,000	1
Star	15,359	3
Double-Trouble	1,400	3
Hayman	137,760	2
Rodeo-Chediski	462,614	3
Battle Creek	12,420	3
Biscuit	~500,000	3

Table 37. Case Study fire size and condition class, based on the Forest Service map of current fire regime condition classes (2000 version). Condition class 3 signifies forest areas with significantly altered fire regime, fire frequency, and vegetation attributes from their historical range.

Fire size is not a clear indication of the magnitude of the fire's impacts.

The Biscuit fire was the largest case study fire in this report, burning nearly 500,000 acres in Oregon and California. Fire suppression costs were the highest due to its size, but the total economic impacts from this fire will not match those for the Cerro Grande, a fire that burned less than one tenth the area of the Biscuit. We found that total environmental, social, and economic impacts are a function of multiple factors, including fire size, location, and burn intensity.

The most costly economic impacts from wildfires are damages to structures and private property.

The Cerro Grande fire damaged structures on private, county, and Los Alamos National Laboratory land. Settlement of these damage claims has cost the federal government more than $800 million. Damages to timber resources on private or tribal lands can be equally costly. The Rodeo-Chediski fire destroyed more than 700 million board feet on the Fort Apache Reservation. Recovering the value of this burned timber, valued between $230 and $300 million, will be critical to the White Mountain Apache tribal economy.

Long-term environmental impacts depend on the ecosystem, weather, and federal budgets.

The magnitude and duration of environmental impacts from wildfires depend on a variety of factors, including the nature of the burned ecosystem, weather, and the availability of sufficient restoration funds. Due to the size and severity of the Hayman fire, the forest may require hundreds of years to return to pre-fire conditions. Other ecosystems that experience fires commensurate with the historic fire regime will recover more quickly. Post-fire flooding events or re-burns can dramatically increase the time needed for recovery of the burned landscape.

The ability to conduct restoration work on burned areas also affects the trajectory of landscape recovery and the duration of erosion, invasion by noxious weeds, and other continuing wildfire impacts. Due to the severity of the 2002 fire season, restoration funds from the Forest Service budget may not be available for many smaller fires. For example, the Battle Creek fire burned 12,420 acres of the Black Hills National Forest and private lands in South Dakota. The forest originally requested $4.3 million for restoration of burned areas in the 2003-2004 budget. However, budget cuts at the national level, and the likelihood of other high-priority fires receiving limited national funds, resulted in the Black Hills ultimately requesting only $220,000 from the Forest Service Region 2 budget for restoration in 2003, leaving many restoration projects unfunded.

The magnitude of impacts to ecosystem condition depends on the surrounding landscape.

The availability of comparable habitat in the surrounding landscape will determine the degree to which critical habitat loss impacts a population of a federally listed species. Similarly, watershed impacts depend on fire location, burn intensity, and the time needed to recover ecological function. This landscape context for wildfire impacts is rarely provided.

The magnitude of economic and social impacts depends on land ownership and the group responsible for funding rehabilitation and restoration.

Restoration on public lands, funded by state or federal appropriations, may have lower direct economic impacts on individuals than damages to private or tribal lands, where fewer and smaller sources of funds are generally available. The social impacts from wildfires, including damages to viewsheds, cultural or historic sites, and emotional stress associated with the loss of homes, also depend on ownership.

Most wildfire impacts are negative.

The overwhelming majority of wildfire impacts are negative. Wildfire suppression costs and emergency rehabilitation are a substantial burden for federal and state budgets. Damages to unique ecosystems, old forest types, or specific wildlife habitat can substantially alter the landscape. Wildfires add stress to communities and individuals, and these social impacts can be long-lived. Finally, wildfire impacts include a number of hidden costs, such as administration of funds and contracts, and monitoring the effectiveness of various recovery projects.

Not all wildfire impacts are negative.

During interviews and data collection for the case study fires, we identified several positive impacts from wildfire. Fire-related alteration of wildlife habitat can be beneficial for certain species, especially in areas where early-seral habitat is rare. While the overall impact of wildfires on tourism is undoubtedly negative, our investigations of visitation to Shenandoah National Park and Mt. Rushmore National Memorial suggested that certain types of tourism are unaffected or even enhanced by wildfire. Finally, fire suppression efforts provide short-term jobs and economic benefits to small towns that lodge and feed fire crews. Long-term restoration projects following fire may provide continued employment and help avert larger, more costly fires in the future.

This report does not consider the full range of positive and negative wildfire impacts.

Although we provide information on a number of important wildfire impacts, we did not consider the full range of positive and negative wildfire impacts. Consideration of carbon, tax revenues, and insurance costs, for example, were beyond the scope of this study. We also did not consider the magnitude of other natural and anthropogenic influences on the landscape, such as beetle infestations, hurricanes or other natural disasters, or other variations in park visitation, which could provide added context for the wildfire impacts discussed in this report. Negative impacts from wildfire restoration, such as smoke impacts from prescribed burns, are also not explicitly considered.

Nature of Available Data

One of the goals of this research was to discover what information is available for each of the selected impact catagories. Each wildfire has unique impacts, depending on the size, intensity, and location of the burn. Not unexpectedly therefore, we found that information on each of the wildfire impacts considered in this study was not available for every fire. Nevertheless, we were able to find information for each category from at least one, usually several, of the case study fires (Table 38). While conducting research for this report, we gained some useful insight into the nature of available wildfire impact data. Our insights are summarized as follows:

Impact	Availability of Information
Alteration of wildlife habitat	• Negative impacts are reported in BAER report. • Positive impacts are not well documented.
Watershed and water supply damages	• BAER report includes burn severity by watershed and estimated flood flow increases from watershed damages. • Water supply damages may be available from water authorities or state agencies.
Public recreation facilities damaged	• Federal and state agencies record physical damages. • Closure information is rarely summarized. • Impacts to viewshed or experience are not monitored.
Evacuation of adjacent communities	• Data on the number of persons and length of displacement are often part of the BAER fire summary. • Impacts from displacement are rarely calculated (e.g., temporary housing costs).
Tourism impacts	• Park visitation information exists, but wildfire impacts are not specifically calculated. • State-level data, when available, are annual estimates.
Timber damages	• Controversy exists over reporting "lost" volumes--what burned vs. what is recoverable through salvage operations. • Damaged volumes are in BAER report, salvage details are in Environmental Impact Statements for restoration projects.
Cultural and archaeological sites	• Damage or destruction of ruins is documented in BAER report.
Rehabilitation and restoration costs	• Total is a combination of BAER projects and separate restoration efforts. • Costs are generally available for each agency, but totals must be calculated and interpreted for each fire.
Health impacts	• State Public Health departments monitor air quality, but rarely participate in active wildfire monitoring. • Follow-up studies on smoke-related illnesses are rarely completed.
Transportation	• Good information is available for road closures, but no estimates are made of lost toll revenue or social impacts of delays and closures.

Table 38. Summary of data availability based on the case study summaries for each wildfire impact category in this report

Information is rarely summarized specifically to examine wildfires.

For example, both Shenandoah National Park and Mt. Rushmore National Memorial monitor visitation, yet neither had analyzed the changes in tourism revenue during or following the Shenandoah Complex or Battle Creek fires, respectively. As a result, characterizing wildfire impacts often requires some interpretation and calculation, even when data are available for individual fires.

Current data collection policies capture only a snapshot-in-time of wildfire impacts.

Data collected for this study only provide a description of impacts at one point in time. Rapid assessments immediately following a fire, such as BAER reports, provide much of the information that is available for individual fires. Many wildfire impacts, especially environmental impacts, are dynamic and long-term. Continued monitoring of wildfire impacts through a reassessment of BAER categories several years after the fire would help to characterize these impacts. Dynamic modeling of existing data would also augment other data collection efforts.

Long-term social impacts are rarely calculated.

Short-term social impacts from wildfire, such as evacuations or road closures, are often included in BAER reports. However, long-term public health, transportation, and other social impacts have not been documented for many wildfires. On-going research efforts are beginning to include measures of social impacts, including emotional stress from property loss, reduction in property values, and damage to viewsheds. It is unclear whether these categories will be monitored during subsequent fire seasons.

BAER categories are not easily summarized for all fires.

Currently, BAER report data are not summarized for all large fires at the national level. Modifying the BAER report format to facilitate the combination of information from individual fires would be an important first step towards making data on a variety of wildfire impacts available in a summary format. For example, for individual fires, BAER reports separate the number of houses that burn from damages to other structures. At the national level, houses, outbuildings, and other structures are combined into a single statistic. Retaining the detail from the original BAER data collection would provide more useful information at the national level.

Scientific literature may contain clear examples of the short and long-term impacts from wildfire.

The scientific research community continues to add to existing literature on pre-fire forest management, post-fire environmental impacts, and economic analyses of many of the impacts considered in this report. While it was not within the scope of this report to summarize the available literature on these topics, the wealth of information from the research community cannot be overlooked when considering the next steps in data collection, risk assessment, and wildfire management. These studies often characterize the dynamic nature of impacts from wildfire, and provide important examples and techniques for modeling existing data in a dynamic fashion. Risk assessment and modeling techniques from flooding or other natural disasters may also provide techniques that could be used for wildfire.

Differences in Types and Availability of Information by Source

Using leads from agency web pages and the BAER report for each fire, we contacted employees at regional and field offices for the Forest Service, Bureau of Land Management, Bureau of Indian Affairs, Bureau of Land Reclamation, Natural Resources Conservation Service, and Federal Emergency Management Agency. In addition, we contacted state officials, local government personnel, and non-profit agencies that were involved with suppression, restoration, or monitoring of wildfire impacts. Throughout our data collection effort, we encountered helpful and interested personnel at all levels. However, several interagency differences in data collection and data availability are noteworthy:

Information availability from federal agencies varies.

Basic wildfire information, such as BAER reports and Environmental Impact Statements for restoration projects, is generally available from federal agencies. Additional information on specific wildfire impacts is more difficult to locate, since current agency policies do not mandate collection and publication of other wildfire data in a standardized format. Collecting these data may require contacting several locations within the agency. For example, many financial data, such as BAER costs, are maintained by the Forest Supervisor's office for each national forest; yet fire suppression costs must be collected separately for each federal agency that supplied

personnel for the suppression effort. Wildfire-related expenditures may also receive separate accounting codes for subsequent years. This type of accounting can complicate the summary process, since budget and expenditure categories cannot simply be summed to determine final costs of wildfire impacts. However, cost data from federal agencies are extremely well documented, often providing the costs down to the penny for million-dollar restoration projects.

Monitoring of wildfire impacts varies by state.

States differ in the strength and scope of their wildfire programs. For example, western states contend with wildfire issues more frequently than many eastern states, and are often more advanced in their handling of wildfire impact information. States also vary in their priorities for monitoring wildfire impacts. For example, quantifying loss of rangeland is more important in South Dakota than in New Jersey.

FEMA and NRCS are well suited to provide information on damages to private lands.

One of the most difficult data collection issues when examining wildfire impacts is understanding the impacts on private landowners. For large wildfires that damage substantial amounts of private land, summarizing these damages can be difficult. However, involvement of the Natural Resources Conservation Service and Federal Emergency Management Agency in emergency rehabilitation projects and recovery efforts enhances the availability of information on impacts to private lands.

Tribal entities are more cautious about disclosing information than federal agencies.

The Rodeo-Chediski fire provides a good example of the sensitive nature of impacts to tribal resources.

Businesses keep track of damages to facilities and property.

The businesses that we contacted were quite open about the nature and costs of wildfire impacts. Most businesses must account for these damages on their books, or for insurance purposes.

Researchers are a good source of specific information, but not a practical source for long-term data collection.

A number of studies are being conducted on the environmental, social, and economic impacts of specific wildfires. These reports, when available, will provide excellent information on the nature and extent of damages within their study areas. However, long-term or consistent nationwide data collection on a range of wildfire impacts may require policy changes rather than research.

Information "freezes" affect data availability.

Information freezes affected our ability to access information from a number of sources, including the Bureau of Indian Affairs (BIA), Tahoe National Forest, and Double Trouble State park in New Jersey. The BIA web page has been offline during the duration of our study due to the Cobell Litigation. The Eldorado and Tahoe National Forests have denied requests for information because of pending litigation for salvage timber sales. Finally, seasonal closures of state and local facilities also limit access to information. For example, staffing at Double Trouble State Park is minimal during the winter months.

Improvements in Data Availability Between 2000 and 2002 Wildfires

The availability of general information regarding wildfire impacts, such as BAER reports, Environmental Impact Statements, road and trail closures, and plans for future restoration work has improved dramatically between 2000 and 2002 wildfires. Much of this improvement is because of increased Internet capacity at federal and state agencies during this period, and to more general improvements in data format. Most data files are now posted in Adobe PDF format, making them small enough for most Internet users to download quickly. Most 2002 case study fires have specific web pages devoted to providing updated information during wildfire suppression efforts and throughout restoration and recovery. The only 2000 or 2001 case study fire with a web page is the Cerro Grande fire. Several additional improvements in data availability are also noteworthy.

Overall, access to information has improved dramatically.

Today, Internet resources are more common and user-friendly, and updated more frequently than ever before. As a result, interested parties are able to easily access information. However, the information posted is still limited to BAER reports, Environmental Impact Statements, and the number of fires, acres, and structures burned.

Access to new wildfire impact information is also improving.

Coordinated efforts between BAER teams and US Geologic Survey and Forest Service geographic information system and remote sensing specialists are helping to create maps of burned areas and identify the most severely burned areas for immediate rehabilitation and restoration. Forest Service researchers are beginning to examine the social impacts from wildfires; the final version of the Hayman Fire Case Study Analysis should be released later this year.

Information from county and local governments is still difficult to access.

County and local government information on wildfires may not be readily available, especially for older fires, due to budget and personnel constraints.

Retiring employees take experience and information with them.

For two case study fires, key state and federal agency contacts had recently retired, taking years of experience out the door with them. Although improvements in online data availability may help to correct this problem, top-level agency personnel may still be the best resource for information on older fire events.

A continuing commitment to information collection is critical.

Since the total costs of rehabilitation, restoration, and other impacts are not known for several years following a fire, commitments from federal, state, and local agencies to data collection must be similarly long-lived if the true cost of wildfire is ever to be fully understood.

Conclusions and Recommendations

This report summarizes the current status of wildfire impact information from federal, state, and local sources in order to begin a dialogue on what data are needed to inform policy makers and improve assessments of the risks and benefits of wildfire. Based on our survey of 10 large wildfires, we provide examples of the magnitude of a variety of wildfire impacts, many of which are not directly calculated by federal agencies or summarized at state or national levels. These case studies also provide an opportunity to assess the utility of data on a broad array of wildfire impacts for policy formulation and wildfire management.

Our conclusions on data availability and the magnitude of indirect and continuing wildfire impacts generate two important questions. First, are data on these additional wildfire impacts useful for policy makers and managers at state or national levels, and therefore worth the costs of data collection? And, if so, how can we effectively conduct data collection, disseminate information, and incorporate this knowledge into policies and practices at state and federal levels?

We highlight a number of discontinuities between data from individual fires and summary information available from state and federal agencies. Modest changes to data collection protocols might help to retain details from BAER reports or other local sources without substantially altering the cost and format of current data collection efforts. The National Interagency Fire Center may provide the appropriate structure for coordinating data collection from federal agencies and disseminating additional wildfire information.

Given the dynamic nature of many wildfire impacts and the long time horizon for ecosystem recovery, modeling existing data is an important technique to supplement other data collection efforts. Environmental and economic models exist for evaluating and predicting a variety of wildfire impacts, although these techniques are not explicitly considered in this report. As a result, our recommendations for additional data collection may not be commensurate with data requirements for modeling efforts.

Finally, this report documents the availability of information and characterizes wildfire impacts, but it does not investigate the landscape conditions, fire suppression, or other management decisions that increased the likelihood of large wildfires, or the management alternatives that could avoid similar fires in the future. We present only one component of the wildfire issue. In order to implement the results of this study, similar reports on the cost, effectiveness, and impacts of preventive management actions, and evaluation of risk assessment, forest management, and fire management policies will be necessary.