During the fire season of 2000, approximately 8.4 million acres burned, hundreds of private homes were destroyed, and emergency teams evacuated thousands of residents. Although this was not a typical fire season, is not surprising and will likely become the norm. The US Departments of Interior (USDI) and Agriculture (USDA) spent significant physical and financial resources protecting private citizens’ lives and property. In addition to suppression costs, which were estimated at $1.3 billion (National Interagency Fire Center 2001), damage to public lands, rehabilitation, emergency aid for businesses and unemployment, and reimbursement of firefighting efforts will add to the total federal cost of wildfire. As a result of the increasing complexity and expense of fires in the wildland-urban interface and beyond, USDI and USDA likely will be forced to evaluate strategic and tactical fire management activities in the future.

Given increasing management challenges, it is time to reevaluate the structure of federal fire organizations, and to address increasing management complexity and rising federal expenditures. This article suggests an alternative means of funding that would allow for development of a national fire management organization focused on all aspects of wildland fire—fuels treatment, prevention, and detection—in addition to suppression. Additional private funds would provide a means to reallocate fire budgets with more emphasis on preparedness and would guarantee emergency funding in years when it was necessary.

Scope of the Problem

Wildfire is becoming a serious social issue as damages and expenditures in-
crease with each decade. Although erratic, both the number of wildfires and acres burned have increased over the past decade (table 1). Federal expenditures for wildfire suppression have also increased erratically (table 2). For the 2000 fire season, federal agencies spent $1.3 billion on suppression; this amount exceeds suppression costs for 1994 and 1998 combined, the latter being a benchmark year that includes the Yellowstone National Park fires.

Fire suppression and fuel loading. Since the early 20th century, wildfire has been perceived socially and scientifically as an agent of destruction rather than a necessary ecosystem function, as evidenced by the popular Smokey Bear campaign. Research focused on minimizing damaging fire effects was the underlying foundation for management actions such as the “10 am policy,” in which the goal was to extinguish all fires by 10 in the morning (Pyne et al. 1996). Decades of successful suppression have resulted in a significant accumulation of forest fuels, which has in turn led to important ecological changes. In forests once dependent on fire, fire-prone climax species have replaced fire-tolerant species, resulting in ladder fuels and significant increases in dead and downed woody debris (Mutch 1994). Combined with relatively low precipitation and high temperatures, these factors generate conditions conducive to large conflagrations. Although efforts to reduce fuel loading and restore fire to fire-dependent ecosystems have increased over the past decade, such ecological changes are not likely to be reversed in the near future.

With respect to reintroducing fire into fire-dependent ecosystems and reducing hazard, federal agencies have made a concerted effort to increase prescribed burning. Table 3 (p. 6) shows that the number of acres treated increased more than two-fold between 1995 and 1999 for all federal agencies combined.

Development in the wildland-urban interface. Fuel-loading alone, however, is only part of the problem. An unprecedented number of people now live in areas of high fire danger; when these areas catch fire, tremendous physical and financial damage can result. Moreover, fire management within and around the urban interface adds significantly to the complexity of protection (McLeod 1999). In the past several years, wildfires near urban areas have consumed hundreds of homes and thousands of acres of natural resources as federal agencies are forced to focus on protecting private property and lives. For example, Californians in 1991 experienced the Oakland–Berkeley Tunnel Fire, which destroyed approximately 2,500 homes and caused an estimated $1.7 billion in insured damage (Fellows 1998). Similarly, an escaped prescribed fire during the summer of 2000 from the Bandelier National Monument burned into the Los Alamos Canyon, forcing 18,000 people to be evacuated and destroying 250 homes (Guidette 2000).

Further complicating fire management in the urban interface is the lack of public awareness, as urban dwellers who relocate to forested areas often do not fully appreciate the risks of living with fire. Property owners and developers may resist fuel treatments they believe will detract from aesthetics. Similarly, land-use patterns in the urban interface increase risk of loss and lead to diffusion of responsibility among government agencies, thus creating adverse incentives for individual

<table>
<thead>
<tr>
<th>Year of fires burned</th>
<th>Number of fires</th>
<th>Acres burned</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>154,573</td>
<td>7,398,889</td>
</tr>
<tr>
<td>1989</td>
<td>121,714</td>
<td>3,261,732</td>
</tr>
<tr>
<td>1990</td>
<td>122,763</td>
<td>5,452,874</td>
</tr>
<tr>
<td>1991</td>
<td>116,953</td>
<td>2,237,714</td>
</tr>
<tr>
<td>1992</td>
<td>103,830</td>
<td>2,457,665</td>
</tr>
<tr>
<td>1993</td>
<td>97,031</td>
<td>2,310,420</td>
</tr>
<tr>
<td>1994</td>
<td>114,049</td>
<td>4,724,014</td>
</tr>
<tr>
<td>1995</td>
<td>130,019</td>
<td>2,315,730</td>
</tr>
<tr>
<td>1996</td>
<td>115,025</td>
<td>6,701,390</td>
</tr>
<tr>
<td>1997</td>
<td>89,517</td>
<td>3,672,616</td>
</tr>
<tr>
<td>1998</td>
<td>81,043</td>
<td>2,329,709</td>
</tr>
<tr>
<td>1999</td>
<td>93,702</td>
<td>5,661,976</td>
</tr>
<tr>
<td>2000</td>
<td>122,827</td>
<td>8,422,237</td>
</tr>
</tbody>
</table>

**Table 1. US wildfire statistics, 1988–2000.**

*Cost per acre may be higher because of the number and characteristics of large fires in 1994 and, subsequently, the types of resources deployed (Wakimoto 2000, pers. commun.).

Inefficient federal budget system. In addition, federal fire management budgets are fraught with problems regarding how they are determined and allocated. The funding structure provides disincentives, given that the budget currently emanates from two distinctly different sources. Funding for preparedness activities (e.g., prevention, detection, initial attack, and fuels management) is determined annually. The USDA Forest Service uses a program called NFMAS (National Forest Management Analysis System), which determines the most efficient level of funding for the year. The National Park Service uses a similar program, FIREPRO, which also determines the annual budget (Donovan et al. 1999). Although both programs are based on economic information, they do not take into account emergency suppression funding. Alternatively, the budget used for emergency suppression is unlimited (US Congress 1989).

The managerial implications of the dual budgets are becoming increasingly serious as the risk of catastrophic wildfire increases. The dual budgets do not provide incentives to allocate funds efficiently; too little may be allocated annually for activities such as fuels treatments, prevention, and detection (Bell et al. 1995). On the other hand, because the emergency budget is unlimited, there are strong incentives to spend more on seasonal firefighting and suppression efforts than may be efficient (Anonymous 2001). Collectively, the dual budgets are shortsighted in terms of ecosystem effects and investment-return relationships. Returns on fuels management activities, funded out of the limited annual budget, often are manifested in the future as reduced fire hazard, damage, and suppression costs. However, because of the dual budgets, investment-return relationships are not economically linked, thereby leading to allocation inefficiencies between suppression and preparedness activities (Hesseln et al. 1998).

Suppression expenditures are only a fraction of the full costs of wildland fires. Not considered are the costs of uninsured property damage, insurance claims, federal aid for lost employment, unemployment insurance, low-cost loans for small businesses, and rehabilitation (FEMA 2000). In addition, the President’s Disaster Relief Fund is designed to reimburse firefighting efforts, including expenses for field camps, equipment use, repair and replacement costs, tools, material and supplies, mobilization, and demobilization activities (FEMA 2000).

Extensive use of emergency funding and resources may promote a lack of focus on extensive training and use of permanent employees skilled in all aspects of fire management. Emergency fire crews are composed largely of students and temporary employees with little experience in preparedness activities. Rather than assembling and training emergency crews as needed, it may be more efficient to refocus agency efforts on long-term management rather than short-term emergency efforts. Moreover, there is a strong need for nationwide expertise for both annual and emergency efforts. If efforts could be combined, the most efficient program may result in more fuels treatments across a broader landscape. Changing the funding approach may help provide a better focus on fire management as a whole rather than individually on preparedness and suppression.

**Seeking Private Capital**

Restructuring federal fire management efforts would require major changes in budgeting procedures. And using the capital markets for large-scale events would release annual funding to be made available for preparedness efforts. Bell et al. (1995) strongly recommend increasing the use of prescribed fire and adopting a long-term approach to programming. They suggest increasing annual funding for fuels treatments from approximately $11 million (in 1994) to between $100 and $200 million. Currently, the cumulative effects of fuels management are not financially evaluated from a long-term perspective. By not taking a long-term investment-return approach, returns on fuels management activities in terms of reduced future losses and reduced suppression expenditures are sometimes negative (Hesseln 2000). By augmenting the annual budget to redirect emergency funding and by taking advantage of the vast capital markets, additional resources could be used to fund a permanent national fire management or-

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**Table 3. Number of acres treated using prescribed fire, by federal agency, 1995–2000.**

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Bureau of Indian Affairs</td>
<td>21,000</td>
<td>16,000</td>
<td>37,000</td>
<td>48,287</td>
<td>83,875</td>
<td>3,353</td>
</tr>
<tr>
<td>Bureau of Land Management</td>
<td>56,000</td>
<td>50,000</td>
<td>72,500</td>
<td>200,223</td>
<td>308,000</td>
<td>125,600</td>
</tr>
<tr>
<td>Fish and Wildlife Service</td>
<td>209,000</td>
<td>180,000</td>
<td>324,000</td>
<td>285,758</td>
<td>300,508</td>
<td>201,052</td>
</tr>
<tr>
<td>Forest Service</td>
<td>570,300</td>
<td>617,163</td>
<td>1,097,658</td>
<td>1,489,293</td>
<td>1,379,960</td>
<td>728,237</td>
</tr>
<tr>
<td>National Park Service</td>
<td>62,000</td>
<td>52,000</td>
<td>70,000</td>
<td>86,126</td>
<td>135,441</td>
<td>19,072</td>
</tr>
<tr>
<td>Total</td>
<td>918,300</td>
<td>915,163</td>
<td>1,601,158</td>
<td>2,109,687</td>
<td>2,207,784</td>
<td>1,077,314</td>
</tr>
</tbody>
</table>

*Source: National Interagency Fire Center (2001).*
ganization with expertise in all areas of fire management.

Catastrophe (cat) bonds may provide a revolutionary way to generate significant capital, which will provide a unique opportunity to restructure forest fire management, both organizationally and financially. With private capital, federal agencies could strive to increase preventive fire management efforts on a national scale.

Catastrophe bonds were developed as a creative response to capital shortages in the insurance industry. Typically, insurers require some form of investment to hedge against natural disasters such as hurricanes and earthquakes. Claims issuing from these disasters can exceed the insurer’s assets, resulting in bankruptcy for the insurer. Examples include Hurricane Hugo in 1989, which resulted in losses estimated at $4.2 billion, and Hurricane Andrew, which in 1992 resulted in more than 700,000 insurance claims in Florida and caused nine insurers to go bankrupt (Cashin 1995). In the past, reinsurance provided the hedge necessary to overcome unusually numerous and extensive claims. However, as reinsurance rates increased, the insurance industry sought new alternatives in the form of bonds.

Cat bonds are financial instruments that financially secure underlying risk. They operate like ordinary bonds in that they are loans made to investors in return for periodic interest payments and return of the principal when the bond matures (Jones 1999). Investors who purchase cat bonds provide the up-front capital that will be available to an insurer if a catastrophic event results in a predetermined level of damage; if damage from a disaster reaches this level, the bond is triggered. For example, an investor who purchases a catastrophe bond to secure hurricane risk at a specified interest rate will receive interest payments and return of the full principal if there is no hurricane between the specified dates, usually between the beginning and end of the hurricane season. If there is a hurricane, and damages reach or surpass the predetermined level, the investor will lose all or some of the principal (depending on the terms of the agreement) and all of the interest.

One of the most successful examples of this financial instrument was the cat bond launched by the US Automobile Association (USAA) in 1997, which amounted to $477 million to cover hurricane losses—$164 million with principal protection and $313 million that did not protect principal but offered a better return. The principal from the bonds would provide the company with $400 million of additional coverage in the event of a hurricane that resulted in losses to USAA of at least $1 billion (the remaining $77 million was placed in escrow to be invested to repay principal in the event of a large hurricane). The duration of the bond was one year from the date issued. If hurricane losses did not reach the trigger amount of $1 billion, investors would get their principal back as scheduled, in addition to interest payments. However, if a hurricane reached or exceeded the trigger amount, depending on the total amount of claims, investors with principal protection would receive their principal back over a period of 10 years but would forego interest. Meanwhile, bondholders without principal protection would lose all their principal and interest (see Reinebach 1997).

Cat bonds have been around since 1993, but they were not immediately embraced. They are now gaining popularity as rating agencies and sophisticated modeling techniques allow investors to better gauge risk. As financial alternatives, they offer an investment vehicle that is not correlated with market risk (Zolkos 1997), which provides investors with an appealing way to diversify portfolios. Similarly, cat bonds have been made more attractive to investors because of their higher returns—10 to 12 percent as compared to US Treasury bonds at approximately 6 percent (Hodges 1997). Cat bonds are also ideal for the agency issuing the bond because they can provide a relatively large capital base with which to absorb catastrophic losses—the private capital market is estimated to be $26 trillion (Whitney 1999). For these reasons, cat bonds may be a viable way for the federal government to capitalize on market activity to fund wildfire expenditures in extreme fire years.

Using Cat Bonds

The government could offer catastrophe bonds as a way to cover emergency expenditures in years when fire damage reaches a predetermined level. This level, to be used as a trigger amount or a proxy for a trigger amount, could be based on acres burned, federal firefighting expenditures, or some combination of the two. Capital from bonds could then be used to cover anything fire-related, from suppression expenditures to rehabilitation. Bonds would be priced according to the risk of loss, which could be estimated using a combination of meteorological data, historical fire occurrence data, and a range of fire effects and correlated damage estimates. Risk would be assessed at the national level. A variety of bonds could be issued to attract a wide array of investors: those who were risk averse and wanted their principal guaranteed, as well as those who were more interested in higher returns and were willing to purchase nonguaranteed bonds. Furthermore, bonds issued by the government may prove more attractive to investors than those offered by industry because of the government’s low

Because much of the cost of wildland fire protection is incurred in the wildland-urban interface, people living there should take an active role in their protection by assuming financial responsibility.
risk of default. The exposure period could be a single fire season or a series of fire seasons, depending on how the bond was structured.

Before implementing a catastrophe bond offering, several factors deserve consideration. First, because much of the cost of wildland fire protection is incurred in the wildland-urban interface, people living there should take an active role in their protection by assuming financial responsibility. During the fires of 2000 in the Bitterroot Valley, many homes were physically protected by federal agencies, and those who lost homes will receive some aid through FEMA. For those who purchase private insurance, premiums do not always reflect risk and potential damage from wildfire, thus leading residents to make inefficient decisions about fire protection. Although property damage and loss due to wildfires seem high in severe fire years, the total value of annual insurance claims resulting from wildfire is insignificant compared with the total value of annual structural fires not caused by wildfire (Insurance Services Office 1997), and insurance underwriting policies make little if any adjustment to premiums for private property protection. Although some have embraced zoning in the wildland-urban interface as a way to make homeowners more responsible, it is largely an unpopular idea (Insurance Services Office 1997). Because homeowners do not bear the full cost of their decisions, taxpayers shoulder the burden.

Depending on the structure of the bond offering, problems of moral hazard may arise (Reinebach 1998). If, for example, the trigger amount is measured in dollars, this may create adverse incentives to inflate claims and damage estimates. Further complicating the trigger amount is the fact that full damages are often not determined for many years after a fire as a result of reclamation costs and reimbursement to agencies that aided in suppression efforts. Similarly, damage estimates for nonmarket values such as recreational experiences and wilderness values are difficult to calculate and are not widely agreed on. One way to avoid these nonmarket valuation problems would be to use the number of acres burned as a proxy for damage instead of a dollar amount.

**Conclusion**

The current structure of the federal fire management organization is increasingly strained as wildland-urban populations and fuels hazards increase. Public pressure is building to protect private structures and lives, particularly where federal and private lands meet. Furthermore, disjointed federal fire budgets are a disincentive to manage for long-term activities at the landscape scale. By taking advantage of the vast capital in private markets, federal organizations could be restructured with an emphasis on developing a national fire management program well versed in all fire management and fuels treatment activities. Permanent federal staff would augment temporary emergency fire-suppression personnel, and management could focus on prevention and fuels treatments, as well as other preparedness activities. By enhancing human capital, the agency would develop the necessary expertise to efficiently manage both prescribed and wildland fires. The strength of taking a capital approach to federal funding is not to solve financial capital shortages, but to reallocate funds based on effectiveness while providing the necessary funding in the event of a catastrophe, thus enabling agencies to shift their focus from regional firefighting to national fire management.

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