Be careful what you wish for: the legacy of Smokey Bear

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A century of wildfire suppression in the United States has led to increased fuel loading and large-scale ecological change across some of the nation's forests. Land management agencies have responded by increasing the use of prescribed fire and thinning. However, given the continued emphasis on fire suppression, current levels of funding for such fuel management practices are unlikely to maintain the status quo, let alone reverse the effects of fire exclusion. We suggest an alternative approach to wildfire management, one that places less emphasis on suppression and instead encourages managers to balance short-term wildfire damages against the long-term consequences of fire exclusion. However, any major change in wildfire management, such as the one proposed here, will shift the costs and benefits of wildfire management, inevitably raising opposition.

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For 60 years, Smokey Bear has successfully championed fire suppression in the United States, but his success has come at considerable cost. Indeed, it could be likened to the British victory over American rebels at Bunker Hill in 1775, about which it was said, "A few more such victories would surely spell ruin for the victors". We examine the historical roots and consequences of US wildfire suppression policy. In addition, we critically assess current efforts to ameliorate the effects of a century of wildfire suppression. Finally, we offer an alternative approach to wildfire management that places less emphasis on suppression.

Decades of aggressive wildfire suppression have caused a number of profound ecological changes in some of the nation's forests. First, the composition of some forests is shifting toward less fire-tolerant species (Arno and Allison-Bunnell 2002). For example, in the western US, Douglas-fir (*Pseudotsuga menziesii* var *glauca*) and grand fir (*Abies grandis*) are encroaching upon stands previously dominated by ponderosa pine (*Pinus ponderosa*; Agee 1993). Second, fire exclusion has allowed the density of many stands to increase (Figure 1), particularly in forest types that have historically experienced frequent, low-intensity fires. Third, the suitability of forests as habitat for a wide variety of wildlife species has been altered, as a result of changes in canopy cover and the composition and productivity of understory communities. Ecological restoration treatments in northern Arizona, for example, doubled the diversity of the butterfly community and increased the total abundance of butterflies by three- to fivefold (Waltz and Covington 2004). In addition to direct ecological effects, wildfire suppression results in a buildup of forest fuel, which in turn contributes to more extreme fire patterns. More intense fires can change the species composition of a stand (Hessburg and Agee 2003) and destroy seed banks (Busse *et al.* 2005) in some forest types.

Increased fuel levels, along with drought conditions and warmer temperatures in much of the western US (Westerling *et al.* 2006), have also resulted in an increase in wildfire suppression costs (Calkin *et al.* 2005). Federal wildfire suppression expenditures in the US exceeded $1 billion for the first time in 2000 and did so again in both 2002 and 2003. These record-high costs were accompanied by record levels of area burned (Figure 2).

In a nutshell:

- A century of wildfire exclusion in the US has substantially altered many of the nation's forests and resulted in wildfires that are more expensive and more difficult to control
- Current corrective policies, which emphasize fuel management, are often underfunded or infeasible
- We propose a fundamental change in the way wildfire suppression is funded, which would encourage managers to consider the beneficial effects of wildfire

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Historical origins of wildfire exclusion

For people raised in the Smokey Bear era, a policy of aggressive wildfire suppression may be taken for granted. However, in the early 20th century, there was an active debate about the appropriate role of fire in forest management. This debate was particularly intense in the southeast and the west, where fire had commonly been used as a management tool. Many landowners in these fire-prone regions recognized that, in some forest types, regular fire was necessary to remove fuel that would otherwise build (a and b) courtesy of the Forest History Society, Durham, NC

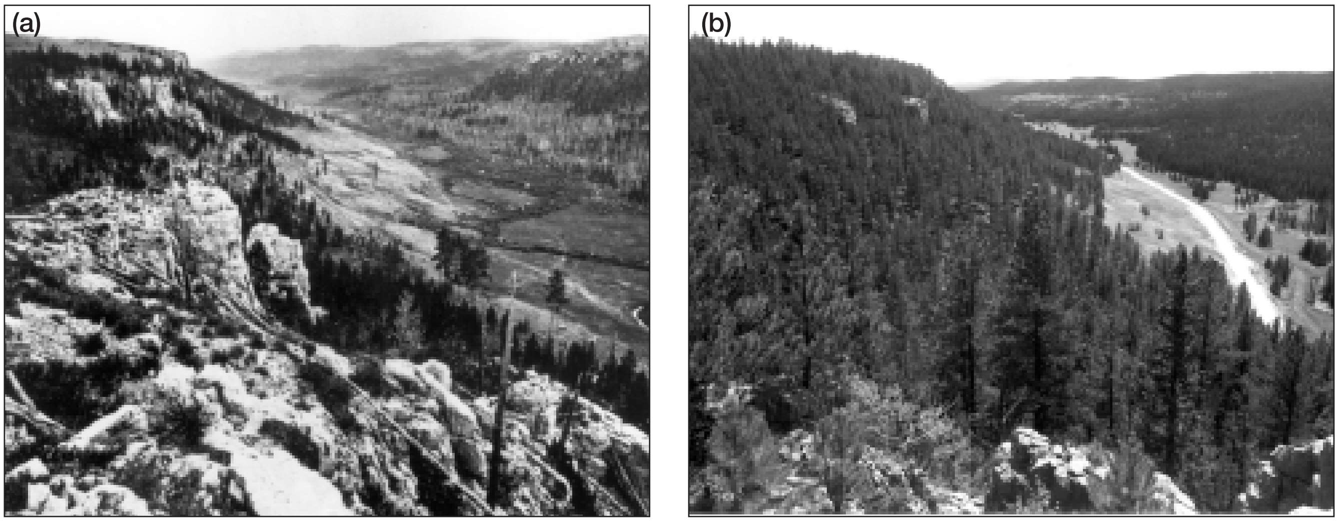

Figure 1. *(a) Photograph by William H Illingworth, taken on the 1874 expedition to explore the Black Hills of South Dakota led by Brevet Major General George Armstrong Custer. Looking down Castle Creek, tracks can be seen on the valley floor, indicating wagons had passed this location. Held by the South Dakota State Historical Society. (b) Repeat photograph of Castle Creek Valley taken by Richard H Sowell in ca 1974 from near the same position. This photo shows forest expansion in the area following a century of fire exclusion. Held by the South Dakota Agricultural Experiment Station.*

up and pose a risk of a more destructive fire, a view succinctly stated by GL Hoxie (1910):

> "Why not by practical forestry keep the supply of inflammable matter on the forest cover or carpet so limited by timely burning as to deprive even the lightning fires of sufficient fuel to in any manner put them in the position of master?... Fires to the forests are as necessary as are crematories and cemeteries to our cities and towns; this is Nature's process for removing the dead of the forest family and for bettering conditions for the living."

The majority of professional foresters, however, opposed the use of fire. Most had been trained at forestry schools in the eastern US, where the curriculum was heavily influenced by German forest practices, which emphasized a scientific, ordered approach to forest management. These foresters, who viewed fires as killing small trees that they believed would otherwise grow to maturity, pejoratively referred to the light burning approach advocated by Hoxie and others as "Indian" forestry, a perspective forcefully expressed by FE Olmstead in 1911 (in Carle [2002]):

> "It is said that we should follow the savage's example of 'burning up the woods' to a small extent in order that they may not be burnt up to a greater extent bye and bye. This is not forestry; not conservation; it is simple destruction…the Government, first of all, must keep its lands producing timber crops indefinitely, and it is wholly impossible to do this without protecting, encouraging, and bringing to maturity every bit of natural young growth."

The pioneering forester and conservationist, Aldo Leopold, applauded the explosion of small trees in a ponderosa pine forest in northern Arizona that followed removal of light fires (Leopold 1920):

> "It is also a known fact that the prevention of light burning during the past 10 years…has brought in growth on large areas where reproduction was hitherto largely lacking. Actual counts show that the 1919 seedling crop runs as high as 100 000 per acre. It does not require any very elaborate argument to show that these tiny trees, averaging only 2 inches high, would be completely destroyed by even a light ground fire."

Although the views of Olmstead and Leopold were shared by many foresters, some took a more nuanced view of fire, including, at least for a time, the second chief of the US Forest Service, Henry Graves (Stephens and Ruth 2005), as well as some academics (most notably Herman Chapman). However, a number of factors solidified the forestry profession's opposition to any use of fire. Foremost was the 1910 fire season, when 2 million ha of Forest Service land burned and 78 firefighters lost their lives. Wildfire exclusion was also consistent with the conservationist ideal of the Progressive Era, which was inclined to view fire as another force of nature to be tamed, not as a potential management tool.

Even after the Forest Service adopted a policy of fire exclusion, some foresters privately admitted that fire could be useful (Carle 2002). The following prescient statement was written in 1920 by SE White (White 1920):

"…keep firmly in mind that fires have always been in the forests, centuries and centuries before we began to meddle with them. The only question that remains is whether, after accumulating kindling by twenty years or so of 'protection', we can now get rid of it safely… In other words, if we try to burn it out now, will we not get a destructive fire? We have caught the bear by the tail – can we let it go?…In this one matter of fire in the forests, the Forest Service has unconsciously veered to the attitude of defense of its theory at all costs. There is no conscious dishonesty, but there is plenty of human nature."

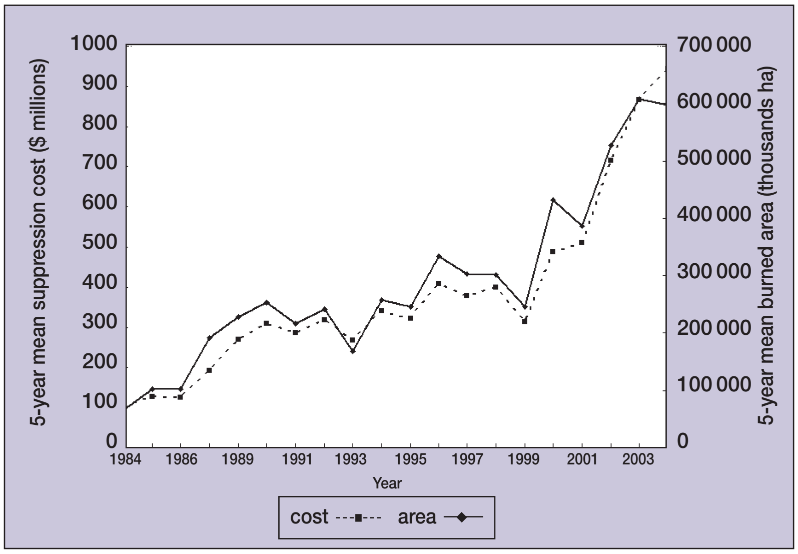

Figure 2. Five-year moving averages of the area burned by fires greater than 120 ha on US Forest Service land and corresponding suppression costs from 1984 to 2004 (2004 dollars). Data obtained from the National Interagency Fire Center (www.nifc.gov/stats/index.html).

However, the agency worried that any admission of a positive role for fire would be confusing; the message that fire was sometimes good and sometimes bad was considered too sophisticated for the general public. Therefore, the Forest Service continued with a policy of aggressive wildfire suppression, which was codified in 1935 by the "10 am policy" (so named because the policy stated that fires were to be under control by 10:00 am the following day), which called for:

"…fast, energetic, and thorough suppression of all fires in all locations, during possibly dangerous fire weather. When immediate control is not thus attained, the policy calls for… organizing to control every such fire within the first work period. Failing in this effort, the attack each succeeding day will be planned and executed with the aim, without reservation, of obtaining control before ten o'clock the next morning" (Gorte and Gorte 1979).

The 10 am policy, which guided Forest Service wildfire suppression until the mid 1970s, made sense in the short term, as wildfires are much easier and cheaper to suppress when they are small. Consider that, on average, 98.9% of wildfires on public land in the US are suppressed before they exceed 120 ha, but fires larger than that account for 97.5% of all suppression costs (Calkin *et al.* 2005). However, we have become victims of the unintended consequences of successful wildfire suppression: fuel loads have exceeded their historical range in many forests, important ecological changes have occurred, wildfires have become more difficult and expensive to control, and homeowners have been led to expect aggressive wildfire suppression, irrespective of costs (Arno and Allison-Bunnell 2002).

Current forest health policies

Two recent legislative and policy initiatives seek to redress the problems stemming from a century of aggressive wildfire suppression. In August 2000, the US Forest Service (Department of Agriculture) and the Department of the Interior (DOI) developed the National Fire Plan (NFP), and in December 2003 President Bush signed the Healthy Forests Restoration Act (HFRA). The provisions of the NFP and the HFRA emphasize the following three actions: modify forest fuel so that fires are easier to control and cause less damage; once a fire breaks out, ensure that fire managers have access to adequate firefighting resources; and after a wildfire has occurred, conduct emergency stabilization and rehabilitation activities that limit further damage and help the forest recover.

Collectively, these policies may seem to constitute a sensible response to the problem of rising wildfire costs and damages. However, given the scope of the problem, relying on fuel management to reverse the effects of a century of aggressive wildfire suppression is very expensive. We can get a rough idea of the extent of the problem from Schmidt *et al.* (2002), who used a fire regime condition class system to categorize forest land (Table 1). Classes 2 and 3 include those lands where fire regimes have been altered from their historical range (whether by wildfire suppression, grazing, timber harvesting, invasive species, or other causes). Let us consider only major forest types on federal land with relatively short fire recurrence intervals (ie less than 35 years) that naturally experience low-severity (not stand-replacement) fires. These forest types, where fuel treatments are most likely to be focused, have 14 million ha in classes 2 and 3 (11 million ha of ponderosa pine and 3 million ha of inland Douglas-fir). Condition class 3 lands, those most in need of fuel reductions, account for 52% of these 14 million ha, and for 6 million of the 11 million ha of ponderosa pine; 95% of these lands are on national forests, with the rest on DOI lands.

Table 1. Fire regime condition class descriptions

Class	*Fire regime*	*Management options*
Condition class 1	Fire regimes are within a historical range, and the risk of losing key ecosystem components is low.	Where appropriate, these areas can be maintained within the historical fire regime by treatments such as fire.
Condition class 2	Fire regimes have been moderately altered from their historical range. The risk of losing key ecosystem components is moderate. Fire frequencies have departed from historical frequencies by one or more return intervals.	Where appropriate, these areas may need moderate levels of restoration treatments, such as fire and hand or mechanical treatments, to be restored to the historical fire regime.
Condition class 3	Fire regimes have been significantly altered from their historical range. The risk of losing key ecosystem components is high. Fire frequencies have departed from historical frequencies by multiple return intervals.	Where appropriate, these areas may need high levels of restoration treatments, such as hand or mechanical treatments, before fire can be used to restore the historical fire regime.

Estimating the cost of fuel treatments is not straightforward, as neither the Forest Service nor the DOI collect reliable broad-scale cost data. Small-scale studies have found that the cost of fuel treatment varies widely. Prescribed fire can cost less than $125 per ha, whereas mechanical treatments such as thinning can cost well over $2500 per ha, so on a cost basis, prescribed fire is certainly preferred (Haines *et al.* 2001; Berry and Hesseln 2004). However, densely stocked stands, such as the one shown in Figure 3, often cannot be safely or effectively treated with prescribed fire unless they are first thinned mechanically. Indeed, fire prescriptions designed to burn such dense stands under manageable conditions of moderately high fuel moisture and humidity typically fail to reduce fuel loads enough to substantially lower wildfire risk (Fule *et al.* 2002). However, the cost of a mechanical treatment program of sufficient size to reverse the effects of a century of aggressive wildfire suppression would be prohibitive. Consider that at a cost of $2000 per ha, total expenditures to treat just the ponderosa pine in condition class 3 would amount to over $12 billion. The combined fuel management budget of the DOI and the Forest Service in 2005 was $464 million. Using this entire budget, it would take almost 26 years to thin all ponderosa pine in condition class 3. The problem becomes even more daunting when one considers that fuel management is not a one-time event. Areas that are successfully treated continue to add fuel each season and will require maintenance in the future.

The inadequacy of current fuel management budgets has been recognized by others. For example, The Brookings Institution noted in its *Quadrennial fire and fuel review report* that "Despite a significant expansion of the fuel reduction efforts, agencies will not have sufficient capacity nationally to treat enough hazardous fuel to substantially reduce threats to communities and other valuable resources" (The Brookings Institution 2005).

Not every stand with elevated fuel loads must be treated to achieve some land management objectives. Indeed, Finney (2001) showed that treating as little as 20–30% of a landscape strategically can greatly reduce the risk of wildfire. However, it is important to distinguish between the ecological and wildfire risk effects of fuel management. Treating a fraction of a landscape may reduce wildfire risk on the untreated portion of the landscape, but the ecological effects of a treatment generally do not spill over to untreated lands. In addition, the ecological consequences of replacing wildfire with fuel management are not clear; for example, prescribed fires conducted in the spring and fall may produce quite different ecological results from wildfires that occur during hot, dry summer weather.

Recent initiatives have a more fundamental problem than treatment cost. Although funding for fuel management has been increased, the policy of aggressive wildfire suppression that allowed fuel to accumulate in the first place remains largely unchanged. One of the performance measures currently used to judge the success of the Forest Service's suppression organization is the number of fires contained by initial suppression efforts. Wildland fire use plans (which allow letting wildfires burn in certain circumstances) notwithstanding, this performance measure, plus the intense public pressure on fire managers to avoid any serious fire damage, encourages aggressive wildfire suppression, which in turn leads to an increase in fuel loads and associated ecological problems. The Forest Service and other land management agencies are trying to alleviate the symptoms of fire exclusion without addressing the root cause. The challenge, then, is to design a suppression policy that balances the short-term goal of minimizing wildfire damage with the long-term adverse consequences of fire exclusion.

Two elements of current federal fire policy are particularly important in encouraging aggressive wildfire suppression (Donovan and Brown 2005). First, federal land management agencies have the authority to fund wildfire suppression with transfers from other programs within their agencies. These transfers are typically, though not always, made up by supplemental appropriations at the end of a fire season. Although the authority to borrow or appropriate from other programs may seem like a reasonable way to ensure adequate suppression funding for an

Figure 3. A densely stocked ponderosa pine stand.

uncertain fire season, unlimited suppression budgets encourage aggressive wildfire suppression with little concern for cost containment. For example, let us consider the use of an air tanker to drop retardant on a fire. A manager who decides to use the air tanker incurs no constraints on spending for other resources; conversely, if the manager chooses not to use the air tanker, the savings cannot be used for other purposes. More formally, the opportunity cost of suppression expenditures is zero. Add to this the intense pressure to minimize wildfire damages, and managers have little effective incentive to limit spending. As the fire historian Stephen Pyne noted, "no federally managed fire has been abandoned for lack of funds" (Pyne *et al.* 1996).

The second problem with current federal fire policy is that, with few exceptions, managers are directed not to consider the beneficial effects of wildfire when planning or executing suppression activities. These benefits vary, depending on the forest type, but generally include improvements to forest health and wildlife habitat, future aesthetic enhancements, and lower future wildfire suppression costs and damages because of reduced fuel loads. This shortsighted policy may simplify the current fire manager's job, but it transfers substantial costs to the future. Of course, such a policy is understandable. Avoiding short-term, clearly visible damages may seem more compelling than gaining future, poorly quantified ecological and fuel reduction benefits. In part, the policy may reflect "certainty bias" (Maguire and Albright 2005); when faced with an uncertain decision, people have a strong desire to see one alternative as more certain than another (Kahneman and Tversky 1979). As a consequence, people often overestimate the certainty of an existing course of action, leading to a bias toward the status quo, in this case a policy of aggressive wildfire suppression.

Lessons from flood control

Other natural hazard management policies can also result in cost shifting. For example, there are some instructive parallels between current wildfire management policies and flood control policies which, in the US and elsewhere, have historically relied on the use of levees to protect communities at risk (Pinter 2005). These levees have encouraged further development along rivers, adding to the damage when the levees do not hold, just as past effective wildfire suppression has encouraged home construction in forested areas, adding to damage if suppression is later unsuccessful. Furthermore, the levees often exacerbate flooding downstream, shifting costs spatially, whereas wildfire suppression shifts costs temporally, in the form of increased future suppression costs, ecological damage, and scenic impairment. In both cases a restricted frame of reference results in inefficiencies.

Flood and wildfire risks can be controlled in two basic ways: modify the event itself or reduce the values at risk. Both flood and fire policies have emphasized the former, via levees and aggressive wildfire suppression. However, in some locations, flood control policies are focusing on reducing the values at risk from flooding by restricting development in floodplains rather than attempting to control floods when they occur. To a lesser extent, there have been some efforts to reduce the values at risk from wildfire, such as by encouraging defensible space around houses. Making homes more fire resistant would, at least in principle, increase the opportunities to use wildfire to generate ecological benefits. However, the mainstay of wildfire management policy is still suppression.

Social justice

Federal funding of a large-scale fuel management program, along with continued federal support of aggressive wildfire suppression, also raises social equity concerns. Homeowners living in forested areas receive substantial benefits, including recreation opportunities, scenic views, and solitude. However, these properties need protection from wildfire, and fuel management and wildfire suppression costs are paid by all taxpayers, not just those living in forests. Homeowners surrounded by federal forests receive not only the forest amenities but also publicly-subsidized fire protection. Furthermore, as more people build houses in or near the forest, the demand for wildfire suppression increases, and more wildfire suppression results in more ecological harm to the forests held in trust for all citizens. A change in fire management policy that places less emphasis on wildfire suppression would shift costs away from taxpayers (via lower suppression costs and, in the

Figure 4. Tree mortality on the North Rim of the Grand Canyon in the wake of the Warm Fire, July 2006.

long run, lower ecological damage) and onto homeowners in the wildland–urban interface (via more effort at creating defensible space or higher property damage, at least in the short run).

An alternative approach

A number of proposals have addressed the shortcomings of current federal fire policy. The most frequent suggestion has been to give land-management agencies fixed suppression budgets, but allow them to carry over surpluses or deficits from year to year (Donovan and Brown 2005). This would provide managers with an incentive to limit spending, as savings from one fire could be used to suppress future fires or conduct fuel management activities.

To encourage consideration of the ecological benefits of wildfire, a manager could be provided with a two-part budget: a fixed component and a component that increased as the area burned in a year increased. Thus, if a manager aggressively suppressed wildfires, the area burned would decline and so would the manager's budget. This decline in budget would act as a proxy for the loss in wildfire benefits resulting from wildfire suppression, which would encourage managers to consider the tradeoff between the costs, including the ecological costs and benefits of suppression.

To understand how such an incentive structure would work, consider a forest with an annual wildfire management budget of $1 million plus $125 for every ha that burned in a fire season. Now suppose that a fire breaks out and a manager is trying to decide between two suppression strategies: either limit the size of the fire to 80 ha at a cost of $100 000, or allow the fire to grow to 250 ha but spend only $50 000 on suppression. (We make the simplifying assumption that the manager knows how the fire will respond to different suppression strategies, though reality is much less certain; Finney 2001). The more aggressive strategy is $70 000 more expensive: $50 000 in direct suppression costs plus $20 000 from reducing the number of burned ha by 170, with the $20 000 acting as a proxy for lost wildfire benefits on the additional 170 ha of land protected. The manager would, therefore, have an incentive to consider whether the resources protected by the more aggressive suppression strategy warrant the additional suppression cost and loss in budget. In contrast, under the current system, managers have little, if any, incentive to consider wildfire benefits or suppression costs.

Successful implementation of the alternative approach relies on selection of the fixed suppression budget and the per-unit budget addition for burned area. These two should be chosen so that the marginal benefits of suppression equal marginal costs over the long term. We do not wish to understate the difficulty of determining, even approximately, these quantities. Given the uncertainty about future weather and the challenges of estimating the full costs and benefits of wildfire, selection of these quantities will involve a good deal of judgment. Nevertheless, we are not without information on which to base such decisions; there are ample data on past wildfire effects and suppression costs and there is much accumulated knowledge and experience within the wildfire management community. We contend that it is a lack of political will more than a lack of knowledge that has impeded changes in the way wildfire suppression is funded.

It is important to consider the possibility of unintended incentives that might result from the proposed, or indeed any, change in the way wildfire suppression is funded. After all, the problems with the current funding mechanism were undoubtedly unintended. In particular, the proposed incentive structure requires mangers to trade off wildfire damages and suppression costs. Local land managers are probably best placed to make these sorts of tradeoffs. However, it is possible that managers might value resources very differently, which could result in resources in some areas being more aggressively protected than in others. Any changes in wildfire suppression funding should therefore be undertaken as incrementally as possible and, at each step, care should be taken to identify unintended incentives.

Other authors have suggested policy changes that place more emphasis on the benefits of wildfire (Stephens and Ruth 2005). Indeed, the US Forest Service has a wildland fire use program that allows some fires to be managed for resource benefits. However, under this program a fire must be designated as a wildland use fire and only a small minority of fires receive this designation. In contrast, the incentive structure outlined above would apply to all fires.

Conclusions

Although there is a consensus among managers and scientists that the long-standing policy of aggressive wildfire suppression has contributed to a decline in forest health, an increase in fuel loads in some forests, and wildfires that are more difficult and expensive to control, key elements of federal fire policy remain unchanged. Most importantly, continued aggressive wildfire suppression is still the order of the day. Although current initiatives also emphasize fuel management, funding is insufficient to remove the need for a fundamental rethinking of our wildfire suppression policy. We suggest that if the problem lies with wildfire suppression policies, then so should the solution. A more tolerant attitude toward wildfire must somehow become institutionalized in federal land-management agencies. Indeed, as wildfires become more difficult to control, we may have little choice but to accept increases in annual burned area. However, few would argue that the best way to address the problem of fire exclusion in forest types with short fire recurrence intervals is to wait for nature to self-correct with large, destructive wildfires (Figure 4).

To change the current approach to wildfire management would require a fundamental shift in public expectations of wildfire suppression, just as moving from constructing levees to protecting natural floodplains requires a fundamental change in thinking. There must be recognition that complete wildfire exclusion is neither desirable nor possible, and that maintaining forest health and controlling suppression expenditures necessitates burning large areas of forested land annually. Altering incentives by limiting suppression budgets would – even without the addition of the perhaps counterintuitive burned area budget supplement – help reach this goal. Also, the funding for fuel management, though inadequate to achieve its intended goal, may help to set the stage for a more accepting attitude toward wildfire; if fuel treatments were strategically sited to create fuel breaks, allowing some wildfires to burn would be less risky and thus perhaps more acceptable. However, any change in policy that trades short-term losses against ill-defined long-term gains will inevitably face opposition. Smokey Bear needs a more nuanced message and substantial campaign funds.

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