

*The trend of increasing wildfire intensity and size likely due to increasing fuel hazards is only one consequence of fire suppression. Another legacy of the fire exclusion paradigm has far-reaching implications: an organizational mindset that persistently frames the wildland-urban interface fire problem in terms of fire suppression and control, to the exclusion of potentially more effective alternatives. The author argues that it is time to change the paradigm.*

# THE WILDLAND- URBAN INTERFACE FIRE PROBLEM

*A CONSEQUENCE OF THE FIRE EXCLUSION PARADIGM*

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**T**he fire destruction of hundreds of homes associated with wildfires has occurred in the United States for more than a century. From 1870 to 1920, massive wildfires occurred principally in the Lake States but also elsewhere. Wildfires such as Peshtigo (Wisconsin, 1871), Michigan (1881), Hinckley

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(Minnesota, 1894), Adirondack (New York, 1903), the Big Blowup (Idaho-Montana, 1910), and Cloquet (Minnesota, 1918) extended across millions of acres, destroying towns and causing several thousand civilian fatalities.<sup>1</sup> This period produced significantly greater destruction of property and lives than has occurred in the past fifty years. More recently, the home destruction problem related to wildfires became nationally recognized in 1985 and has become known as the wildland-urban interface (WUI) fire problem. The initial fire management response to the WUI

fire problem, principally organized by the U.S. Forest Service and the National Fire Protection Association, resulted in the 1986 Wildfire Strikes Home conference.<sup>2</sup> The current nationally supported Firewise program developed out of that initiative.<sup>3</sup> Since 2000, federal and state wildland fire management policy has recognized the WUI fire problem as a principal issue in a number of documents including the National Fire Plan (2000), Federal Wildland Fire Management Policy (2001), 10-Year Comprehensive Strategy (2001), and the Healthy Forests Restoration Act (2003).

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*These homes near Lake Arrowhead, California, were destroyed on October 22, 2007, as part of the Grass Valley Fire, and serve as a WUI fire disaster example. Although the homes initially ignited from the wildfire, structures continued to ignite and burn after the wildfire had largely ceased its high-intensity spread.*

Wildfire exclusion started as a prime directive in the early years of the U.S. Forest Service and became a broad national perspective. Chief Forester Henry Graves stated in 1913 that “the necessity of preventing losses from forest fires requires no discussion. It is the fundamental obligation of the Forest Service and takes precedence over all other duties and activities.”<sup>4</sup> Although several prominent foresters and researchers, like Coert DuBois of the Forest Service and H. H. Chapman of Yale University, promoted the benefits of wildland burning in the 1920s and 1930s, the questioning of fire control policies was considered a threat to nationally organized forestry programs. For the next four decades the public land management policy largely addressed wildfires as unwanted—to be prevented, and if not prevented, to be suppressed at the smallest area possible (the fire exclusion paradigm). Policy began to recognize wildland fire as a historical, ecological factor in the late 1960s and early 1970s.<sup>5</sup> Current policy recognizes that wildland fire can be an important ecological process and provides latitude for planned burning (prescribed fire) and designating unplanned fires as desirable (fire use). However, in practice the nationwide total number of wildland fires suppressed as wildfires overwhelmingly dominates the fire

occurrence statistics. For example, the ten-year (1998–2007) average number of total wildland fires per year designated for suppression is approximately 80,000 occurrences, compared with 327 designated as desirable.<sup>6</sup> Although some agencies have more management latitude in principle, the proportion of fires suppressed suggests that an exclusion approach largely continues. The term “fire exclusion paradigm” in the article’s title refers to this organizational culture and operational practice of preventing and suppressing nearly all wildland fires.

As a consequence of these practices, fire suppression (i.e., the fire exclusion paradigm) has significantly contributed to the reduction of fire occurrence in most areas of the United States. The National Fire Plan report states, “As a result of the all-out effort to suppress fires, the annual acreage consumed by wildfires in the lower 48 states dropped from 40 to 50 million acres (16 to 20 million hectares) a year in the early 1930s to about 5 million acres (2 million hectares) in the 1970s.”<sup>7</sup>

In some ecosystems, such as the ponderosa pine (*Pinus ponderosa*) forests in the western U.S., the reduction of fire occurrence has resulted in significant changes to the species composition and increases in the amount of live and dead





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*This historical photo series shows how an initially open forest (with management activity) dominated by ponderosa pine (*Pinus ponderosa*) has become increasingly vegetated by predominantly Douglas-fir (*Pseudotsuga menziesii*). Historically, such a site had a fire every decade or so that maintained ponderosa pine in an open condition. For more on changes in the ponderosa pine ecosystem, see “Giant Pines and Grassy Glades”: *The Historic Ponderosa Pine* in *Forest History Today Spring 2008*.*

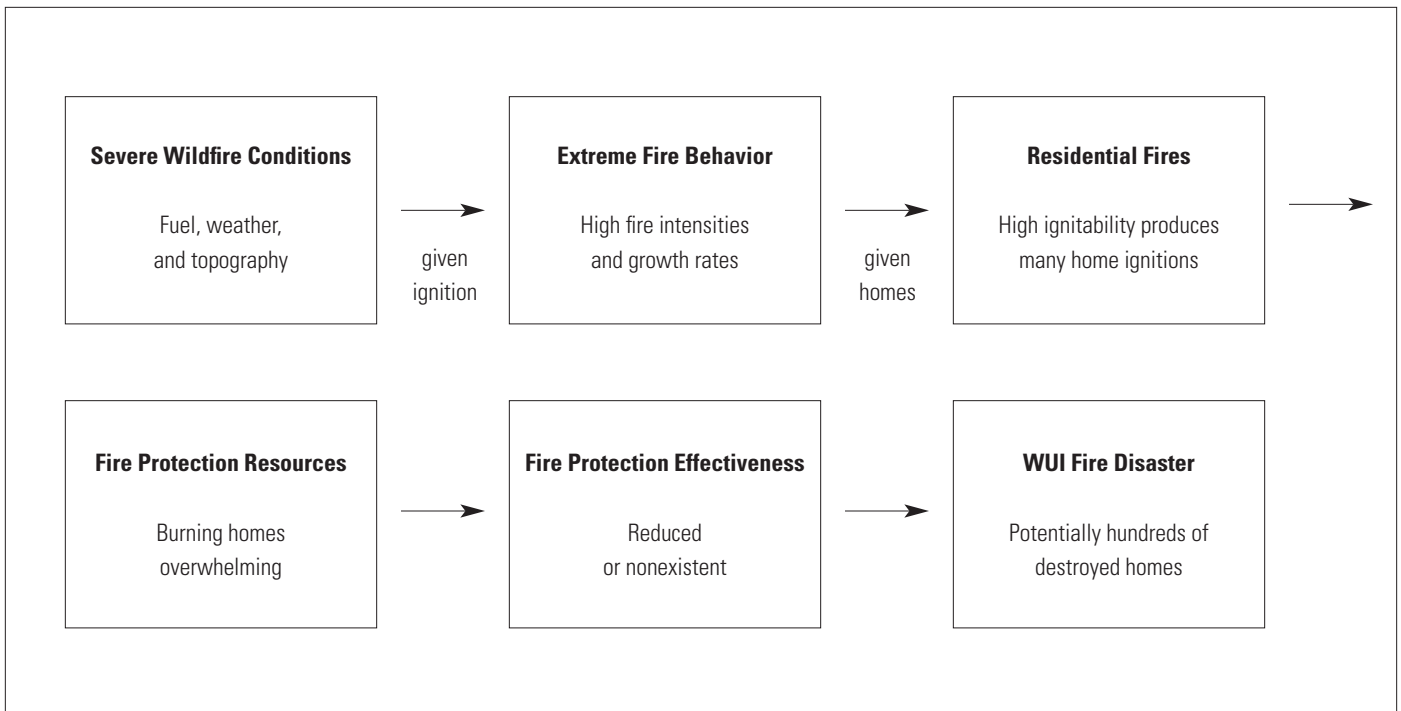
vegetation.<sup>8</sup> Furthermore, it has been shown that aggressive fire suppression over many years has changed vegetation fuel structures.<sup>9</sup> This has produced fuel accumulations and arrangements that have enhanced the potential for the extensive areas of high-intensity wildland fires experienced in recent years.

## DEFINING DISASTER

One might assume a direct relation between increased wildfire intensity and WUI residential fire destruction; that is, the increased potential for extreme fire behavior as a consequence of fire suppression (i.e., the fire exclusion paradigm) should inevitably exacerbate the WUI fire problem. Although the title of this essay seems to imply this connection, that is ironically not the intent. We cannot assume a direct causal linkage between extreme wildfires and WUI fire disasters. An examination is required as to how homes ignite and cause WUI fire disasters. This examination in turn provides the basis for further discussion proposing that the consequence of the fire exclusion paradigm is principally about framing the WUI fire problem in terms of wildfire control rather than the home ignition potential.

By definition, wildland-urban interface fire disasters depend on homes igniting during wildfires. If homes do not ignite and burn during wildfires then the WUI fire problem largely does not exist. We would have extreme wildfires without WUI fire disasters. Disasters do not occur during most conditions when normal fire protection capabilities can limit the residential fire spread. Wildland fire suppression operations successfully control ninety-seven to ninety-nine percent of all wildfires at initial attack, and structure firefighters typically limit a fire within a single structure or prevent the fire from spreading beyond that structure.<sup>10</sup> However, when residential development is exposed to extreme wildfire conditions, numerous houses can ignite and burn simultaneously, overwhelming firefighters and reducing fire protection effectiveness. Thus, WUI fire disasters principally occur during the extreme fire behavior conditions that account for the one to three percent of the wildfires that escape initial attack control.<sup>11</sup> Table 1 lists WUI fire disasters between 1990 and 2007. Every one of these disasters occurred because extreme fire behavior conditions overwhelmed the firefighting resources.

The WUI fire disaster context can be generally described as a set of contingencies. The disaster sequence starts when a wildfire or multiple wildfires burn during extreme fire conditions. The combination of vegetation, weather conditions, and topography produces fast-spreading, intensely burning fire behavior that overwhelms suppression efforts. If the extreme wildfire spreads close enough to residential development with its flames and firebrands (lofted burning embers), hundreds of ignitable homes can be simultaneously exposed. Although protection may be effective for some homes, an extreme wildfire's high intensities and high rate of area growth (rapid spread and spot ignitions) ignites too many houses and threatens firefighters' safety, preventing them from protecting all structures. With homeowners likely evacuated and firefighters unable to protect every house, initially small, easy-to-extinguish ignitions can result in total home destruction. Note in the disaster sequence shown in Chart 1 that given an extreme wildfire, the WUI fire disaster requires ignitable homes. If homes are sufficiently resistant to ignition and do not ignite during the extreme wildfire exposure, then the homes



**Chart 1.** The WUI fire disaster context depends on exposure of vulnerable homes to uncontrollable, extreme fire behavior. If the number of burning and vulnerable homes overwhelms the fire protection capability, fire protection effectiveness is reduced, and many homes are left without protection. If homes are ignition-resistant then many homes do not ignite and fire protection is not overwhelmed by the ignitions that do occur. Thus, an extreme wildfire can occur without a WUI fire disaster.

**Table 1.** Wildland-Urban Interface Disasters During Extreme Wildfires (1990–2007)

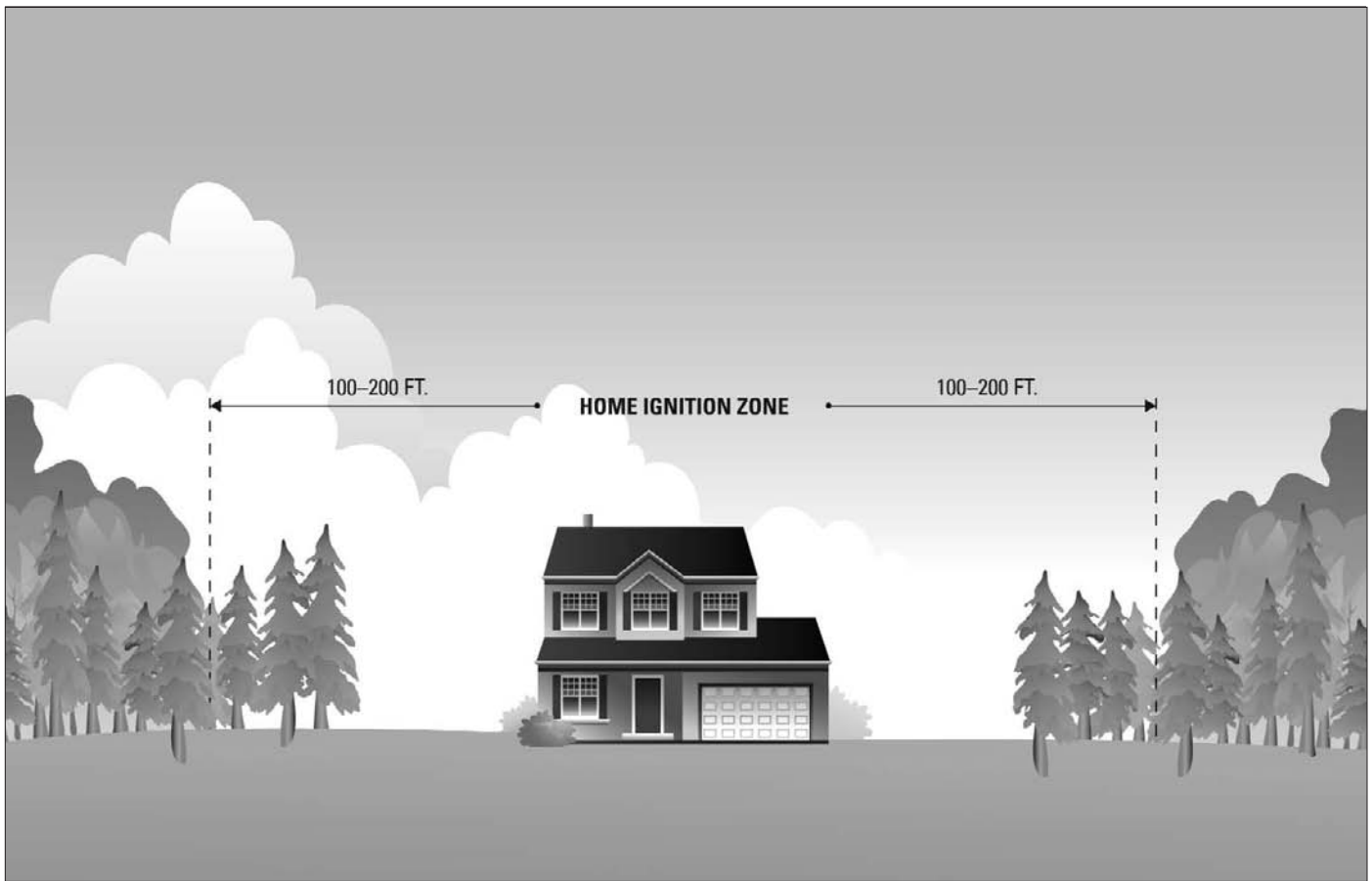
Year	Incident	Location	Homes destroyed (approx.)
1990	Painted Cave	Santa Barbara, CA	479
1991	Spokane “Firestorm”	Spokane, WA	108
	Tunnel/Oakland	Oakland, CA	2900
1993	Laguna Hills		
	Old Topanga	Laguna and Malibu, CA	634
1996	Millers Reach	Big Lake, AK	344
1998	Florida Fires	Flagler and Volusia counties, FL	300
2000	Cerro Grande	Los Alamos, NM	235
2002	Hayman	Lake George, CO	132
	Rodeo-Chediski	Heber-Overgaard, AZ	426
2003	Aspen	Summerhaven, AZ	340
	Old, Cedar, etc.	Southern CA	3640
2006	Texas-Oklahoma Fires	Texas and Oklahoma	723
2007	Angora	Lake Tahoe, CA	245
	Witch, Slide, Grass Valley, etc.	Southern CA	2180

survive without firefighter protection: we have an extreme wildfire but not a WUI fire disaster. Thus, WUI fire disasters principally depend on home ignition potential.

Research shows that a home’s ignition potential during extreme wildfires is determined by the characteristics of its exterior materials and design and their response to burning objects within one hundred feet (thirty meters) and firebrands (burning embers). This area—a home and its immediate surroundings—is called the home ignition zone. Homes ignite and burn by meet-

ing and sustaining the requirements for combustion—that is, by maintaining sufficient fuel (house), heat (adjacent burning objects), and oxygen (air). During extreme WUI fires, the requirements for combustion can be met in two principal ways: from flames—radiation and convection heating—and from firebrand ignitions directly on a house (burning ember spot ignitions).<sup>12</sup>

Computational modeling and laboratory and field experiments that describe the heat transfer required for ignition have shown that the large flames of burning shrubs and tree canopies



*The home ignition zone principally determines a home's ignition potential. The zone includes the home in relation to its surroundings within 100–200 feet of the home.*

(crown fires) must be within one hundred feet to ignite a home's wood exterior. Actual case examinations find that extreme wildfire behavior does not occur within most residential areas; rather, most destroyed homes ignite from smaller flames and directly from firebrands. The evidence is unconsumed vegetation surrounding most destroyed homes (pages 21 and 25). Thus, given an extreme wildfire, the home ignition zone principally determines the potential for a WUI fire disaster.

## PREVENTING DISASTER

The above research suggests an alternative for preventing disastrous home destruction without the necessity of controlling wildfires under extreme conditions. Addressing conditions within the home ignition zone can significantly reduce the home ignition potential. Thus, given ignition-resistant homes, extreme wildfires can spread to residential areas without incurring WUI fire disasters. However, WUI ignition resistance (a wildfire compatibility approach) is largely not the primary method used for disaster prevention. Although the home ignition zone approach for preventing WUI fire disasters has been adopted by the national Firewise program, fire suppression remains the principal approach.

The wildland fire management approach for preventing WUI fire disasters largely addresses the wildfire outside the home ignition zone rather than a home's ignition potential as determined by the conditions within the home ignition zone. Since 2000,

agency fire management policy initiatives have emphasized fire suppression. For example, the U.S. Departments of Agriculture and Interior produced a report in response to the home destruction (principally Los Alamos) and wildfires of 2000 that became known as the National Fire Plan. This report designated fire suppression at the federal, state, and local levels as the first priority.<sup>13</sup> Several years later a multiagency plan was developed called the 10-Year Comprehensive Strategy. This plan is currently in effect and promotes multiagency collaboration for reducing wildfire risks, including the risk of WUI fire disasters. The first goal of the strategy directs the improvement of wildfire prevention and suppression. In general, the 10-Year Comprehensive Strategy promotes a fire suppression approach for preventing WUI fire disasters without significant consideration for home ignition potential.<sup>14</sup> Vegetation fuel reduction treatments, as reported in the Healthy Forests Report of May 2007, also indicate a wildfire modification and control approach that does not address a home's ignition potential.<sup>15</sup> Agency WUI fuel treatments largely do not address home ignitability but rather areas outside the home ignition zone. Fuel treatments in the vicinity are expected to protect homes by creating conditions that enable successful fire suppression.

Wildfire operations appear to be consistent with the above policy as indicated by the significant U.S. Forest Service expenditure of suppression resources for WUI protection. A November 2006 Office of Inspector General (USDA) report on large wildfire suppression costs states,





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*This is a typical WUI fire disaster scene with unconsumed and green vegetation surrounding burned structures (Grass Valley Fire). The homes ignited from low-intensity surface fires and firebrands (lofted burning embers). The trees then caught fire from the burning homes. The totality of destruction is due to the lack of fire suppression rather than the intensity of the initial ignition sources.*

*FS managers and staff stated that WUI protection was the major driver of FS suppression costs, with some staff estimating that between 50 to 95 percent of large wildfire suppression expenditures were directly related to protecting private property and homes in the WUI.... When FS protection responsibilities are directly adjacent to WUI development, FS line officers feel compelled to aggressively suppress wildfires because the fires threaten privately-owned structures, even if the fires pose no threat to FS resources.<sup>16</sup>*

Those findings are consistent with Forest Service Manual directives regarding WUI fire protection. Section 5137 of the manual defines Forest Service structure protection measures in terms of wildfire control. “The Forest Service’s primary responsibility and objective for structure fire protection is to suppress wildfire before it reaches structures.”<sup>17</sup>

The evidence from policy documents, fire management operations, and manual directives indicates that wildfire suppression and activities in support of suppression constitute the principal approach for preventing disastrous residential fire destruction. Yet the evidence suggests that reasonable levels of fire suppression cannot prevent WUI fire disasters. The

inevitability of wildfires, including the extreme wildfires that account for the one to three percent of the fires that escape control, is axiomatic. But WUI fire disasters occur during this one to three percent of uncontrollable wildfires. This might suggest the inevitability of WUI fire disasters; however, it is the home ignition zone that principally determines the potential for WUI fire disasters. The continued focus on fire suppression largely to the exclusion of alternatives that address home ignition potential suggests a persistent inappropriate framing of the WUI fire problem in terms of the fire exclusion paradigm.

Preventing WUI fire disasters requires that the problem be framed in terms of home ignition potential. Because this principally involves the home ignition zone, and the home ignition zone primarily falls within private ownership, the responsibility for preventing home ignitions largely falls within the authority of the property owner. Preventing wildfire disasters thus means fire agencies helping property owners mitigate the vulnerability of their structures. The continued fire management focus on fire suppression suggests the WUI fire problem persists largely as a consequence of framing the WUI fire problem primarily in terms of the fire exclusion paradigm. □




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## NOTES

1. S. J. Pyne, *Fire in America* (Seattle: University of Washington, 1982), 199–218. This section discusses the Great Lakes fires of 1870–1920.
2. J. Laughlin and C. Page, eds., *Wildfire Strikes Home! Report of the National Wildfire/Urban Fire Protection Conference*. NFPA SPP-86. (Quincy, MA: National Fire Protection Association, 1987).
3. The website for Firewise (<http://www.firewise.org>) provides the principal communication outlet and information resource for the federal and state support national wildland-urban interface program.
4. Pyne, *Fire in America*, 260.
5. *Ibid.*, 110 and 261.
6. See [http://www.nifc.gov/fire\\_info.html](http://www.nifc.gov/fire_info.html) for wildland fire statistics for total wildland fires and wildland fire-use fires.
7. “Managing the Impact of Wildfires on Communities and the Environment: A Report to the President in Response to the Wildfires of 2000” (September 8, 2000): 7, accessed at <http://www.forestsandrangelands.gov/reports/documents/2001/8-20-en.pdf>.
8. M. A. Finney and J. D. Cohen, *Expectation and Evaluation of Fuel Management Objectives*. RMRS-P-29. (USDA Forest Service, 2003): 353–66; and S. F. Arno and J. K. Brown, “Overcoming the Paradox in Managing Wildland Fire,” *Western Wildlands* 17(1) 1991: 40–46.
9. “Managing the Impact of Wildfires,” 7.
10. S. L. Stephens and L. W. Ruth, “Federal Forest-fire Policy in the United States,” *Ecological Applications* 15(2) 2005: 532–42.
11. J. P. Menakis, J. D. Cohen, and L. Bradshaw, “Mapping Wildland Fire Risk to Flammable Structures for the Conterminous United States,” in K. E. M. Galley, R. C. Klinger, and N. G. Sugihara, eds., *Proceedings of Fire Conference 2000: The First National Congress on Fire Ecology, Prevention, and Management* (misc. pub. 13) (Tallahassee, FL: Tall Timbers Research Station, 2003), 41–49.
12. See <http://www.firelab.org>. Under “Research Projects, Wildland-Urban Fire Research,” numerous publications can be found describing the computational modeling, experiments, and actual WUI fire disaster examinations that contributed to insights on how homes ignite.
13. “Managing the Impact of Wildfires.” The fire suppression priority is identified on 21; a budget summary that identifies suppression and suppression support budget items for most of the suggested funding is provided on 30–33.
14. “A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment: 10-Year Comprehensive Strategy Implementation Plan” (Western Governors Association, May 2002), 10–12, accessed at [http://www.westgov.org/wga/initiatives/fire/implem\\_plan.pdf](http://www.westgov.org/wga/initiatives/fire/implem_plan.pdf).
15. Healthy Forests and Rangelands, *Healthy Forests Report* (May 2007): 1; accessed at [http://www.forestsandrangelands.gov/reports/documents/healthyforests/2007/healthy\\_forests\\_report\\_05142007.pdf](http://www.forestsandrangelands.gov/reports/documents/healthyforests/2007/healthy_forests_report_05142007.pdf).
16. U.S. Department of Agriculture, *Audit Report: Forest Service Large Fire Suppression Costs*. USDA Office of Inspector General, Report no. 08601-44-SF (2006): 7–8.
17. *Forest Service Manual, Title 5100: Fire Management*, Sections 5137 and 5137.02. Accessed on June 12, 2008, at [http://www.fs.fed.us/cgi-bin/Directives/get\\_dirs/fsm?5100](http://www.fs.fed.us/cgi-bin/Directives/get_dirs/fsm?5100).

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