Wildfire Experience in the Western United States: A Current Perspective

(The published Japanese version of this pre-translation draft may differ slightly)

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July, 2004

On 3 December 2003, the President of the United States signed into law the Healthy Forests Restoration Act of 2003. Strong bipartisan support had quickly moved this legislation (H.R. 1904) through the Congress, and federal agencies quickly moved to execute its provisions[1] Expeditious passage and implementation of this legislation was driven by catastrophic wildfire events of the previous 2 years and a collective recognition by the Congress of worsening wildfire conditions in the Nation's forests, especially in the western states. In this article we place the current fire situation in its historical perspective; we examine the major factors driving fire occurrence and size, and, we explore how fire control agencies are responding to the challenges posed.

For millennia forest fires have periodically burned the western forestlands of North America. Expansive forest ecosystems have naturally evolved, and can only sustain themselves, in the presence of periodic disturbances such as those caused by fire. In the absence of these disturbances the dominant forest tree species, as well as many other biological components of these fire-dependent ecosystems, would be replaced by other, less fire-tolerant, species. Under rather commonly encountered edaphic and climatologically conditions of the western United States many well-known and important coniferous species such as Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), ponderosa pine (*P. ponderosa*), western larch (*Larix occidentalis*), and Sequoia redwood (*Sequoia gigantea*) form stands that would be replaced by later seral species in the absence of fire or its ecological equivalent. These fire-dependent species are referred to as being fire-climax under those conditions where fire disturbance is required for their stand maintenance. Ecosystems defined by broad-leafed species as the dominant component can also be dependent upon fire for their continuance. Oregon white oak (*Quercus garryana*) and quaking aspen (*Populus tremuloides*) are broad-leafed species that can, within much of their individual ranges, form stands exemplifying their classification as fire climax species. Mixed coniferous/broad-leafed fire-climax stands are also found. An example of a combination of broad-leafed and coniferous species that have collectively evolved under the strong influence of frequent fire is the chaparral biome of coastal California. This ecological evidence clearly suggests the important role that fire has played in the development of these wide-spread

[1] http://www.healthyforests.gov/projects/index.html

ecosystems. The proposition that fire has been a long-time, periodically-occurring phenomenon within these ecosystems is also supported by supplemental physical evidence provided by dendrochronologic and stratigraphic studies (Agee 1993, Hallett et al 2003).

Schmidt et al. (2002) have evaluated fire conditions in fire-influenced ecosystems on all public and private land of the contiguous 48 states of the Union. These lands were classified by Schmidt et al. using five Historical Natural Fire Regimes. The Historical Natural Fire Regime classification is based on fire frequency (mean number of years between fires) and fire severity (a measure of the impact of the fire on the dominant overstory vegetation) that would exist in the absence of fire suppression activity. Then, using the expert opinion of regional ecologists and fire managers, these lands were evaluated and sorted into Fire Regime Current Condition Classes. (This two-way classification scheme is illustrated in table 1.) These condition classes identify the current level of departure from the previously determined historical fire regime. There are three condition classes which they describe as follows:

> Condition Class 1: Fire regimes are within an historical range, and the risk of losing key ecosystem components is low. Vegetation attributes (species composition and structure) are intact and functioning within an historical range.
>
> 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 (either increased or decreased). This results in moderate changes to one or more of the following: fire size, intensity and severity, and landscape patterns. Vegetation attributes have been moderately altered from their historical range.
>
> 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. This results in dramatic changes to one or more of the following: fire size, intensity, severity, and landscape patterns. Vegetation attributes have been significantly altered from their historical range.

Schmidt et al. present results for public and private land of the contiguous 48 states excluding that land which is agricultural, barren, urban developed, or under development. The total area classified in this manner is approximately 5.0 million square kilometers. The percentage distribution of this total area by condition class for each historical fire regime is given in table 1 which the authors broadly interpret as follows.

The authors note that 61% of the total area[2] is within fire regimes I and II and that these areas should, based on historical patterns, experience periodic fire with a maximum average return interval of 35 years. These areas are generally at low elevations and are heavily used and impacted by a full range of human activities. Typical of fire regime I are pine, oak, or piñon-juniper forests. It is observed that 59% of this area[3] departs from its historical fire regime range primarily due to fire exclusion and other factors related to human intervention. Fire regime II is typified by grass, brush and other low vegetation often referred to as chaparral (Figure 5). Lands within these two fire regimes that are also in current condition class 2 or 3 are deemed, of all the land considered in this study, to be at greatest risk of presenting serious economic and environmental losses due to catastrophic fire. A total of 1.6 million square kilometers fall into this high risk grouping. The Cedar Fire of 2003, the largest and most costly fire in California history, is an example of wildfire occurring on lands that would generally fall within this classification (Figure 4). A four-year drought had left two-thirds of Southern California forests with above normal levels of beetle and drought killed trees (CDF 2003). This fire, caused by a hunter lighting a fire, burned 110,000 hectares, destroyed 2,232 residences, 22 commercial buildings and 566 other structures, and caused 14 fatalities and 113 injuries (USFS 2003).

Of all five fire regimes it is regime IV that has the highest proportion of its area in condition class 3. Fire regime III has the second highest percentage of its area in this, the worst condition class. Due to its generally more isolated location, land within these two fire regimes has been impacted less by human activities than land within fire regimes I and II. Accordingly, these lands present less, if still substantial, ecological risk due to the impact of fire. Primary factors adversely affecting fire conditions in these two fire regimes are fire exclusion, introduction of exotic species, grazing, and timber harvesting. Western forests typically included in these two fire regimes are many of the intermountain forests of either lodgepole pine or Douglas-fir. A notable example of fire on land within this general classification was that of the Yellowstone National Park Fire of 1988 that made national and international news (Figure 6). This fire, started by lightning, burned 318,000 hectares of the Park and involved the largest fire fighting effort ever conducted in the United States. It is now widely acknowledged that such fires do not

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[2] (34.3+26.9)
[3] ((14.0+6.2)/34.3)(100)

cause irreparable harm and are, in fact, a necessary component for the proper functioning of these ecosystems.

With 72 % of its vegetated surface in condition class 1, fire regime V land departs least from historical conditions. The higher elevation forests of the interior west, exemplified by the spruce-fir type, and the low, wet coastal Douglas-fir and western hemlock forests, are typical examples of this classification. These forests have been impacted primarily by roading and harvesting activities and there is some associated fire threat posed to the ecosystem. The Biscuit Fire that burned in Oregon during the summer of 2002 is a good example of fire within this classification. In the summer of 2002 President Bush visited the Oregon site of this fire to promote his "Healthy Forest" policy initiative that resulted in the previously mentioned legislation. The BAER team (2002) reports that this particular fire was caused by lightning and burned 200,000 hectares in a mosaic pattern (Figure 1). Only 15% of the area was heavily burned and environmental damage over the entire area is quite limited. Many fire-dependent species are reseeding the burned areas (Figures 2 & 3). Little direct economic damage was incurred with only 4 homes and 9 outbuildings being lost due to the fire along with a variety of minor recreational structures. No lives were lost.

All three of the fires mentioned here occurred under very different Historical Fire Regimes and within Condition Classes that are generally representative of each regime. While the areas burned in all three cases were of similar magnitude the economic and ecological results were quite different. In all three cases however initial fire suppression efforts were ineffective. A review of fire suppression effectiveness starting in the early 1960's offers some additional indication of a change in suppression effectiveness. While the total number of fires reported by all government agencies has declined steadily since the early 1980's the average area burned per fire has tripled during this same period (Charts 1 & 2). A long-term, downward trend in average fire size reached a minimum in the late 1970's but then began to increase. It is even more worrisome that this upward trend in average fire size appears to be accelerating. Wildfires within the jurisdiction of the California Department of Forestry (CDF) during this same period also reflect these national trends (Charts 3 & 4). Inspection of the longer term trend of average fire size for CDF jurisdiction fires indicates the growing effectiveness of fire suppression efforts in

California from the early 1940's into the 1980's (Chart 5). It might even be argued that the 2003 fire season while anomalous with respect to current levels of suppression effectiveness is not entirely out-of-line with historical levels. It is essential however that an evaluation of the 2003 California fire season within this longer perspective also include consideration of the values being lost to wildfire. In this regard there has been a dramatic increase in the dollar loss-per-acre associated with wildfires in California. It has gone, in real terms, from approximately $20 per acre in the mid-1940's to over $600 per acre in the first years of this decade (Chart 6). Direct economic loss as wildfires impinge more frequently upon residential and business areas serves to increase public awareness and concern. High variability in these losses from year-to-year undoubtedly accentuates the public perception of a problem when a year or two of extreme economic loss follows a period of relatively low wildfire damage. It is this increased public demand for effective reduction of wildfire losses that is driving the search for a more cost-effective response to wildfire control. A more effective response must however be built on a better understanding of the factors that determine wildfire occurrence and behavior.

Pfilf et al. (2002) identify three key variables that must be considered when analyzing and managing wildfire: climate and weather, human impacts, and forest health. Of these 3 factors it is climate driven fluctuation in weather patterns that is the most important consideration; it is also least subject to human control. Webb et al. (2004) identify three indices of oceanic/atmospheric processes that correlate with climatic conditions in the United States: the El Niño Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), and the Atlantic Multidecadal Oscillation (AMO). It is the two, more persistent, decadal conditions that are most important in the development and continuance of long-term droughts in the United States. Based on their analysis of current data, Webb et al. warn that the on-going drought in the southwestern United States is "comparable to or more severe than the largest-known drought in 500 years", and that we may be only halfway through it (Figure 7). Droughts of this intensity and length put the forests under extreme stress and lead to fire conditions that make effective fire control problematic and very expensive (SAF(1) 2004). In support of this view of limited suppression effectiveness, recent investigation has shown that wildfire occurrence in western timberlands continues to show a strong response to climatic factors quite similar to that which preceded organized wildfire control efforts (Westerling and Swetnam 2003).

There has been a strong migration of people into rural forested areas. Protecting these people and their property from wildfire has become a major undertaking. Agencies such as the United States Forest Service (USFS) and the CDF have had to re-prioritize their suppression activities diverting more resources to the wildland-urban interface at the expense of overall forest fire suppression effectiveness (Figure 8). One of the conclusions arrived at in a major study by the USFS (2000) was that lack of funding for this changing human impact "almost guarantees inadequate resources, inefficiencies and ultimately excessive costs". In testimony before the Governor's Blue Ribbon Fire Commission (2004) Andrea Tuttle, Director of the CDF, testified to the plight of her Agency and how it was forced by "public pressure" to make "expensive and ineffective" use of its resources in the defense of "cities and subdivisions (developed) on top of an ecosystem which is 'built to burn'".

Injurious forest insects and disease have always been present. Generally found at endemic levels they can, and do, reach epidemic levels under certain conditions. These conditions can develop naturally within a stand over time but human intervention has, in many cases, increased stand susceptibility. A policy of fire exclusion has promoted the development of unhealthy forests. A policy of suppressing stand-thinning, low-intensity fires has been the long-time, general, if not universal, policy in western forests. It is possible to effectively exclude most fire from the forest, especially during periods of more favorable climatic conditions. During these wetter, cooler portions of the long-term climatic cycle light-intolerant, drought-susceptible species are favored by an effective fire-exclusion policy. As a consequence, stands where fire exclusion is successfully applied often become heavily overstocked and multistoried. With the subsequent cyclical change to hotter, drier climatic conditions these stands become stressed due to intense competition for available moisture. These drought-weakened trees are less resistant to insect and disease outbreaks. Insect and disease killed trees in these stands create extremely high fuel loadings per hectare. Because of the incursion of light intolerant species into the stand understory, many stand structures exhibit "fuel ladders" that tend to promote the movement of controllable surface fires up into unstoppable crown fires (Figure 9). Fires in these unhealthy stands, with heavy fuel loadings and a strong vertical fuel structure, are impossible to suppress with current fire-fighting technology under a wide range of weather conditions and they will burn until they run out of fuel or the fire weather abates.

Given the demonstrated inability of current fire-suppression strategies to address the evolving fire problem, there is growing recognition that a higher proportion of wildfire control resources should be directed toward activities other than direct fire-suppression (Pfilf et al. 2002). The Healthy Forests Restoration Act of 2003 has become a major driving force behind the reorientation of fire control agencies toward higher levels of fuel management and fire prevention activity.

As the 2004 fire season begins amid signs of increased wildfire incidence, Congressional leaders are pressing the USFS for action on fuel reduction (SAF(2) 2004). Reducing fuel loadings to acceptable levels on forest land will take decades to accomplish however, and treatment priorities must be established. Due to intense public pressure a high level of attention is now being given to risk reduction in the wildland-urban interface. Over 60 percent of the budget for hazardous fuel reduction has been targeted on those areas. Controlled burning under carefully selected conditions has been the preferred method of fuel reduction (Figure 10). But the agencies at this time have neither sufficient experience nor adequate personnel to conduct extensive controlled burning – especially within the wildland-urban interface. Some controlled burns will escape and destroy resources; smoke will have health impacts, and, there are many forest stands with fuel loads simply too high for the safe use of controlled burning. For these reasons new techniques and equipment will have to be developed before treating many areas (Figure 11).

Given the necessarily slow abatement of the forest fuel hazard, prevention has become a focus of immediate attention by the legislature (SAF(2) 2004). Historically, fire prevention activities have been quite effective and more recent history supports its effectiveness. Fire starts on forest lands of the Western States have declined from 1980 to the present despite an increasing number of people residing within the wildland-urban interface (Chart 1). It is quite likely that this decline is largely due to increased public awareness of the danger and response to prevention efforts. That fires caused by human activity continue to far exceed those of natural ignition sources is confirmed by recent data from the Western States (ODF 2003). These human activities are the target of fire prevention programs. Despite a declining budget the CDF has developed and maintained a remarkably effective prevention program even in the face of a declining budget (Brown et al. 1990) (Chart 3). Federal funds are forthcoming to supplement state expenditures on prevention programs but not nearly at the levels requested by the states. With fuel loadings and man-caused ignition sources continuing to remain at high levels it is important for state and federal organizations to maintain effective suppression of those fires that do start.

Early fire detection and initial attack[4] are key components in cost-effective reduction of losses due to wildfires. The effective integration and execution of these two components is the primary determinant of the level of loss associated with a fire once it has started. It is particularly crucial during periods of extreme fire weather that fires be aggressively attacked while still small. Once a fire escapes initial attack it drains fire control resources and degrades the capability of agencies to respond to new fires. Time is the critical factor, and for most forest lands getting ground forces quickly to a fire is often problematic. In many cases aircraft have become an essential resource in achieving timely fire suppression (Figure 12). While airtankers can restraint the excessive spread of a fire, ground forces are ultimately required for its complete control (Figure 13). Traditional hand crews and tanker trucks are often adequate but new equipment is being developed to counter more serious fires in isolated areas (Figure 14). At the present time there is a serious concern that airtankers will not be available in sufficient numbers during the 2004 fire season. Concerns about the air-worthiness of many older aircraft have arisen after two fatal crashes involving airframe failure during the 2002 fire season. Air-worthiness inspections are taking place and some of the grounded aircraft have been put back into service. Because of the age of the current airtanker fleet studies are now underway for the conversion of newer aircraft, including the Boeing 474, into airtankers. The current and foreseeable need for effective wildland fire suppression has stimulated research in equipment development and integration. The result should be more cost-effective fire suppression.

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[4] Initial attack is defined by the National Wildfire Coordinating Group as: "The actions taken by the first resources to arrive at a wildfire to protect lives and property, and prevent further extension of the fire"(NWCG 2004).

Most state and federal level fire control agencies have been under severe budget restrictions for several years. In the face of declining budget appropriations they have sought the most cost-effective distribution of their limited resources among their various activities within the limitations of the budgeting process. Most agencies have funded programs in prevention, fuel modification, detection, and suppression. They can also call upon emergency funding if unanticipated (and unbudgeted) fire suppression situations develop. In most cases political leaders have been reluctant to adequately fund activities that can be postponed, such as fuel modification. For this reason there have been calls that some harvesting operations, and funds generated by them, be used to improve forest health and reduce fuel loadings (Pfilf 2002). The Healthy Forests Restoration Act of 2003 uses this approach and, in fact, it has been criticized by some environmental groups fearful of its misuse (Sierra Club 2004). Other creative approaches to fire control in the absence of direct agency funding have also been proposed. For example, in California recommendations were made to provide state income tax credits to landowners who reduce fire hazards in certain high risk areas, and, to encourage the insurance industry to evaluate property insurance rates by their level of defense against wildfire (California Board of Forestry 1996). State and federal fire control organizations have come to the realization that reliance on fire prevention and suppression are insufficient and that sustained widespread fuel modification is required. Funding for fuel modification, while still very limited within state budgets, is becoming increasingly available from the federal government. Greater reliance is now being placed on controlled burning, mechanical, and other methods of fuel reduction but many issues remain to be addressed. Among these problems are those associated with the health impacts of smoke from controlled burning, liability for damages incurred by escaped fires, the impact of fire on threatened and endangered species, and, the role that silvicultural methods including timber harvest should play.

In summary, fire has played an essential role in North American forests. Many of the forests important to commercial and recreational activity have their origin in fire disturbance. This relationship, although known to silviculturalists, was not fully recognized when establishing and enforcing what amounted to a fire exclusion policy by fire control agencies. With the exclusion of fire the nature of the forest began to change. Tree species composition and density were slowly, almost imperceptibly changing. As climatic conditions became hotter and drier the forest stands were subjected to extreme water stress. Insects and disease spread across large areas killing much of the stand and exacerbated the problem of already heavy fuel loads. For some time the fire control agencies were able to respond to the increased fire intensity occasioned by these changes. Through technological advances, such as the use of airtankers starting in the 1950's, and improved fire planning, communication, and control tactics suppression costs and burned area per fire were held to ever lower levels. By the early 1980's these efforts could not be sustained in the face of the ever growing fuel loadings. During this latter period effective fire prevention efforts did afford some relief from the increasing losses due to wildfire. Demographic changes however, with more and more people moving into the wildland-urban interface, presented the agencies with an additional challenge. The value of the land being protected rose dramatically as homes were built in the forest. Protecting homes and commercial properties became a politically important priority; suppression money was inefficiently spent and suppression costs increased even as area burned per fire continued to increase. The situation was politically and financially unsustainable; fire control agencies could not respond effectively with only a prevention and suppression strategy; fuel modification was the only feasible alternative. After a century of fire exclusion returning the forest to its historical level of fire occurrence across the vast acreages involved will take time and money. How to finance that return to a sustainable forest environment is now the issue.

Figures

Figure 1.

USFS Photograph: "Bear Camp Area"

From: http://www.biscuitfire.com/baer_photo2.htm)

Figure 2.

USFS Photograph: "Knobcone Pine Opened Up After Fire"

From: http://www.biscuitfire.com/baer_photo.htm

Figure 3.

USFS Photograph: "Jeffrey Pine Cone Opened Up After Fire"

From: http://www.biscuitfire.com/baer_photo.htm

Figure 4

USFS Photograph: "Wind driven fire, 2 miles north of Julian"

From: http://www.pnw-team2.com/2003/cedar/pictures/langford-album1/index.htm

Figure 5

USGS Photograph: chaparral

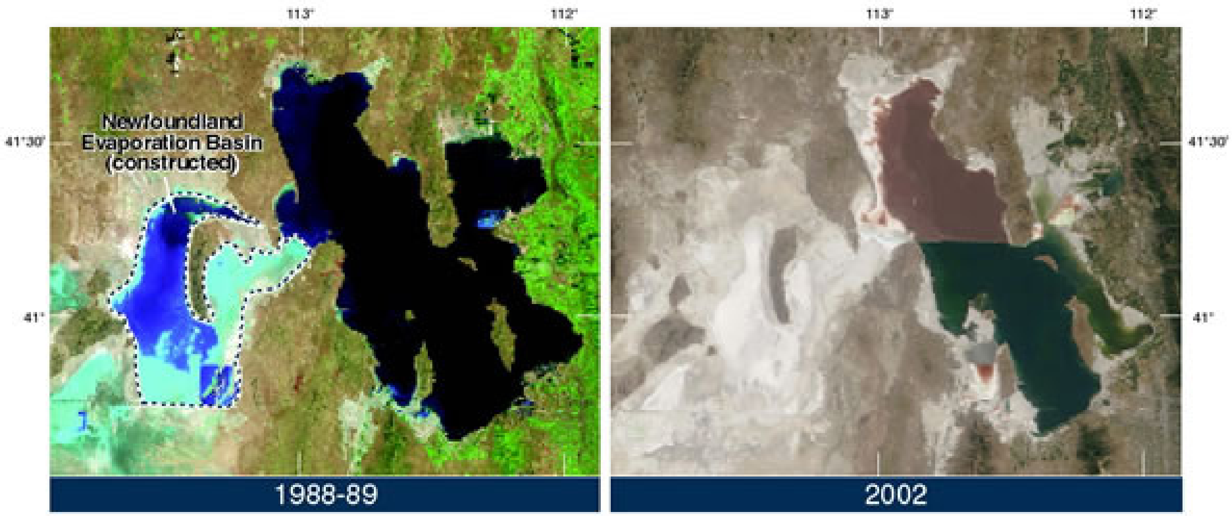
From: http://www.werc.usgs.gov/news/2002-04-24a.jpg

Figure 6

USGS Photograph: Yellowstone National Park fire, 1988.

From: http://www.usgs.gov/2001openhouse/images/9-fire.jpg

Figure 7.



Comparison satellite views of the Great Salt Lake in Utah showing remission of the shoreline during the current drought.

From: http://water.usgs.gov/pubs/fs/fs-037-03/

Figure 8.

Fire at the Wildland-urban Interface

From: http://www.or.blm.gov/Medford/rr_fuel_project/fuel_mtg_maps_pres_displays.htm

taken out of the PDF file labeled: "Fire in the landscape and treatment types"

Figure 9.

Understory development can lead to a "fuel ladder" into the crowns.

From: http://www.srs.fs.usda.gov/gallery/landscapes_and_vegetation.htm

Figure 10.

Controlled burn for forest fuel reduction

From: http://www.or.blm.gov/Medford/rr_fuel_project/fuel_mtg_maps_pres_displays.htm

Figure 11.

The slash reducing machine called the "Slashbuster" in action.

From: http://www.or.blm.gov/Medford/rr_fuel_project/fuel_mtg_maps_pres_displays.htm

Figure 12.

P-3 Orion making a fire retardant drop.

http://www.fs.fed.us/fire/contracting/airtankers/airtankers.htm

Figure 13.

Ground attack with airtanker support.

From: http://www.nps.gov/meve/fire/longmesa.htm

Figure 14.

"The Proteus is an all-terrain fire fighting vehicle with the ability to perform in remote inaccessible areas. It is also excellent for front line fire suppression, fire line placement, fire line control, burnouts, mop up, water transfers, and prescribed burn control."

From: http://www.usda.gov/oc/photo/02cs1264.htm

Tables

Table 1.

		Condition Class Number			
	Fire Regime Number and Description	1	2	3	Row Sum
I	0-35 Years Frequency, Low Severity	14.1%	14.0%	6.2%	34.3%
II	0-35 Years Frequency, Stand Replacement	15.4%	10.7%	0.8%	26.9%
III	35-100+ Years Frequency, Mixed Severity	10.2%	9.0%	4.3%	23.5%
IV	35-100+ Years Frequency, Stand Replacement	4.2%	2.8%	2.8%	9.9%
V	200+ Years Frequency, Stand Replacement	3.9%	1.1%	0.4%	5.4%
	Column Sum	47.9%	37.6%	14.6%	100.0%

This table was developed from data available in the article by Schmidt et al.

http://www.fs.fed.us/fire/fuelman/popden/docs/fuelman.pdf

which is found at:

http://www.fs.fed.us/fire/fuelman/index.htm)

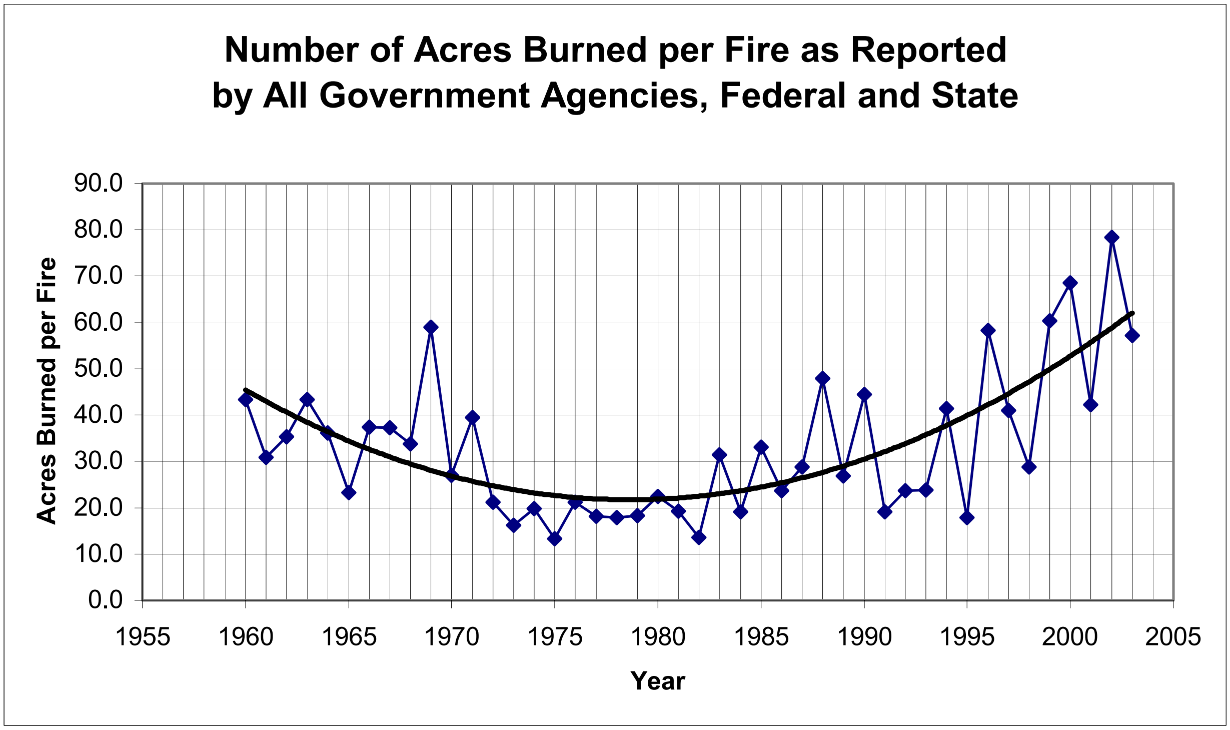
Charts

Chart 1.

These figures are based on end-of-year reports compiled by all wildland fire agencies after each fire season, and are updated by March of each year. The agencies include: Bureau of Land Management, Bureau of Indian Affairs, National Park Service, US Fish and Wildlife Service, USDA Forest Service and all State Lands.

1960-2003 Data available from: http://www.nifc.gov/stats/wildlandfirestats.html

Chart 2.



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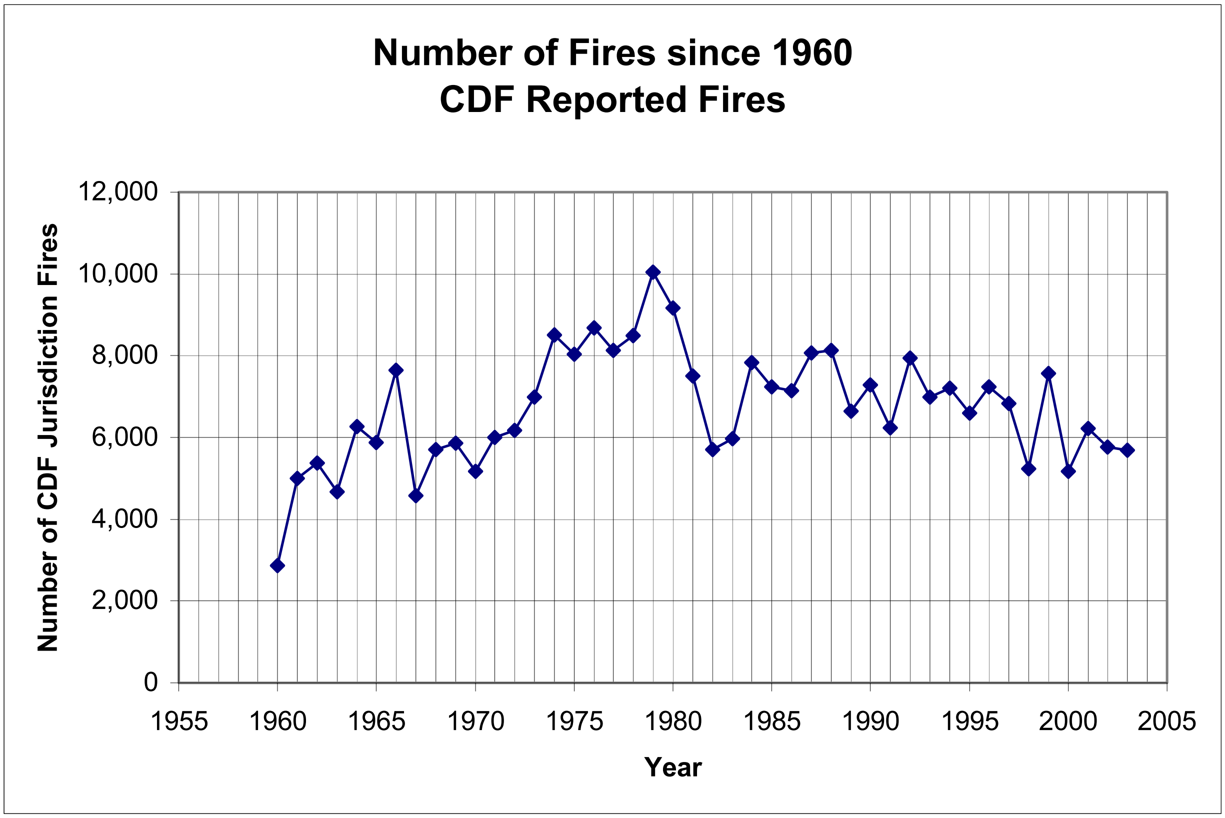
1960-2003 Data available from: http://www.nifc.gov/stats/wildlandfirestats.html

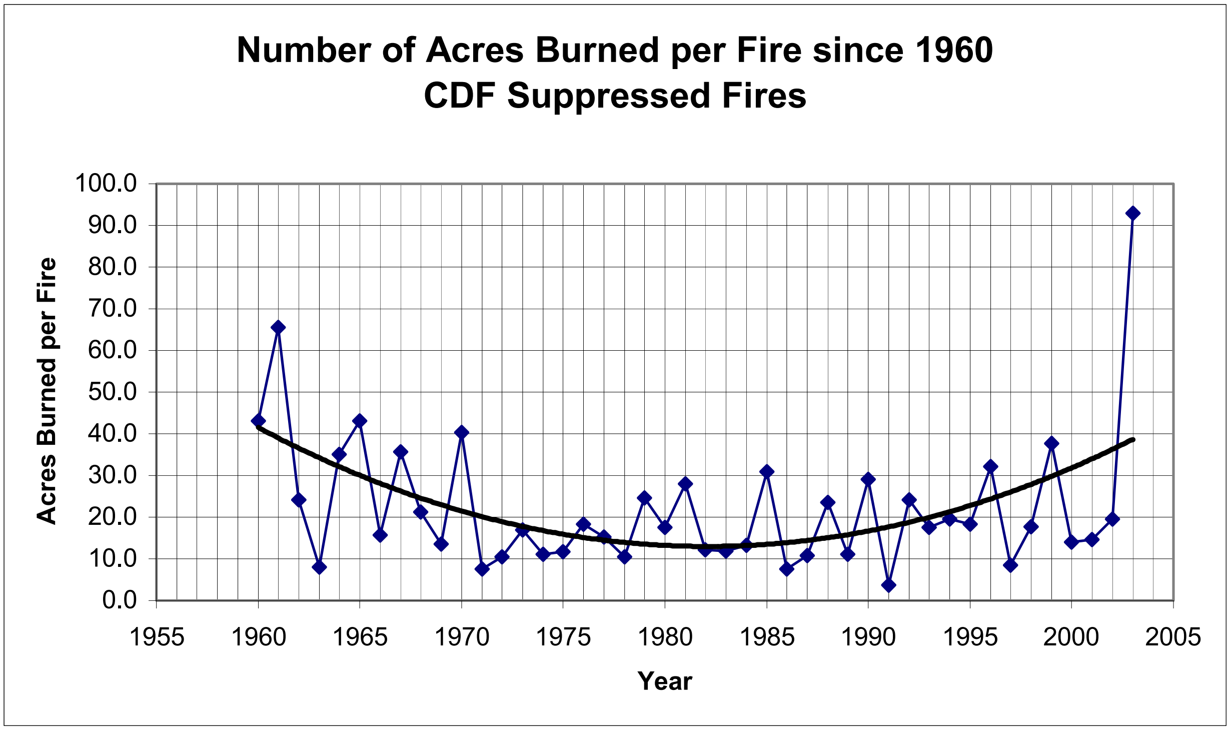
Chart 3.



Based on data available from the California Department of Forestry and Fire Protection (CDF).

http://www.fire.ca.gov/FireEmergencyResponse/HistoricalStatistics/PDF/Firehistory.pdf

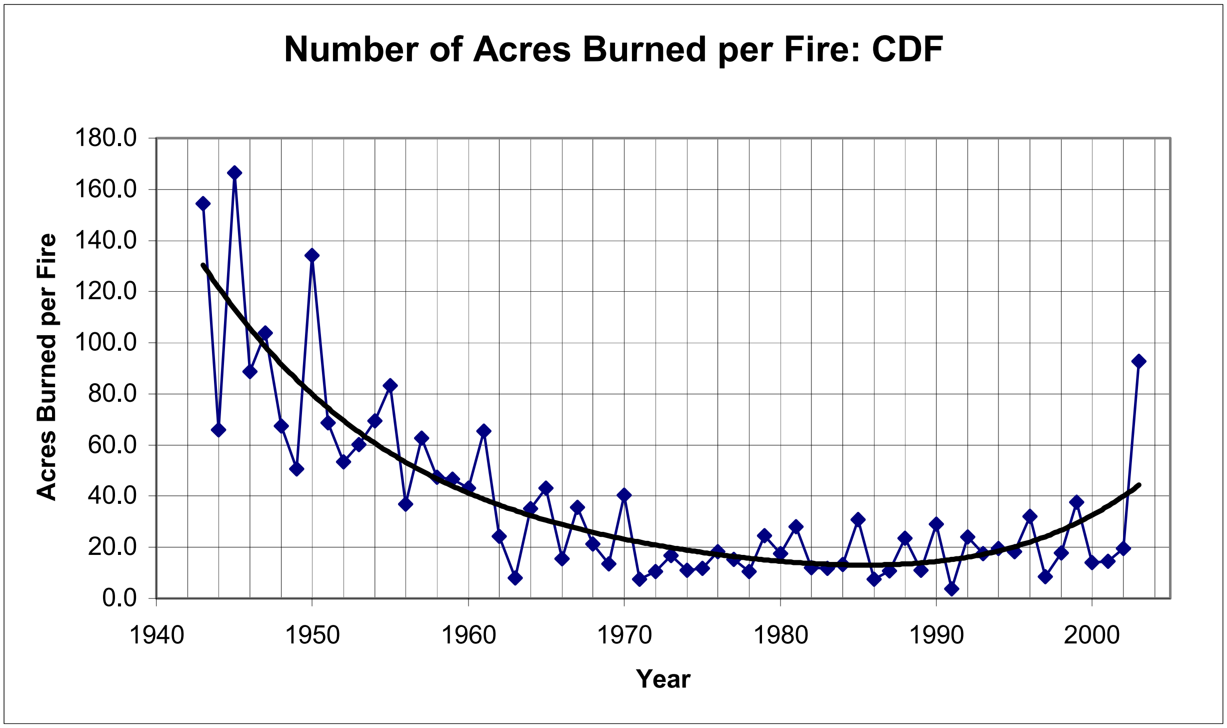
Chart 4.



Based on data available from the California Department of Forestry and Fire Protection (CDF).

http://www.fire.ca.gov/FireEmergencyResponse/HistoricalStatistics/PDF/Firehistory.pdf

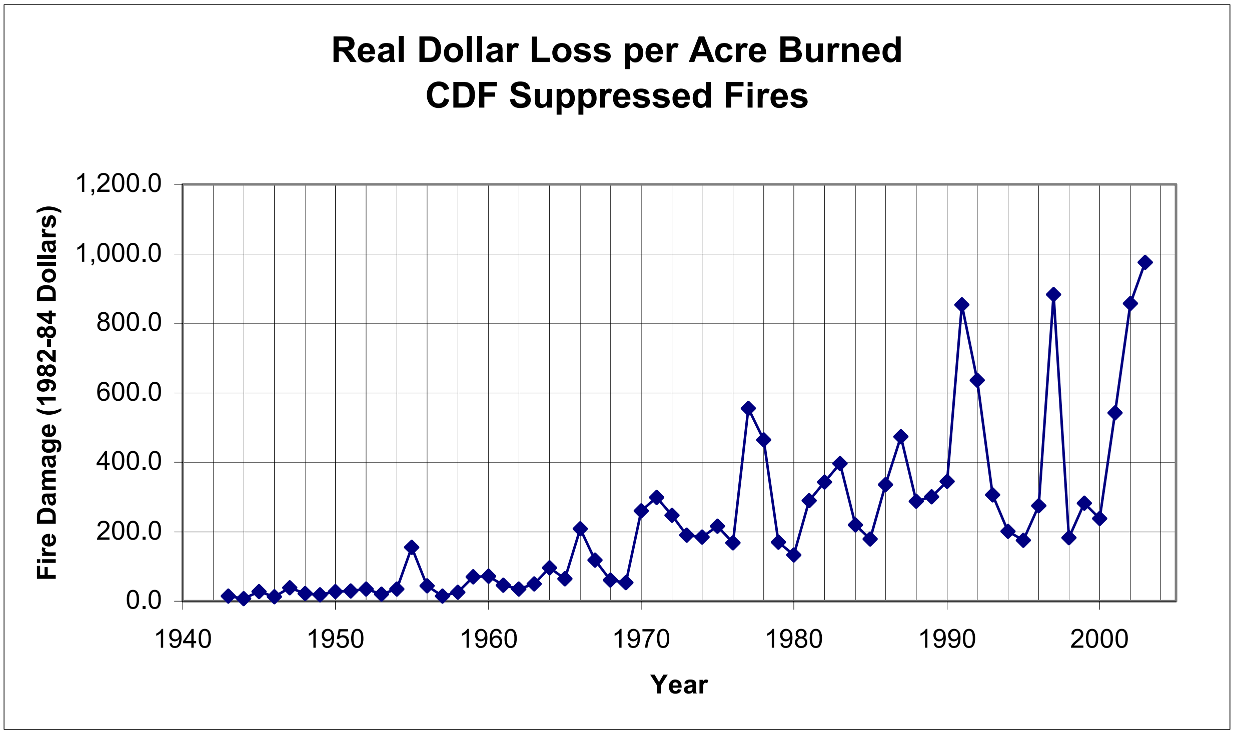
Chart 5.



Based on data available from the California Department of Forestry and Fire Protection (CDF).

http://www.fire.ca.gov/FireEmergencyResponse/HistoricalStatistics/PDF/Firehistory.pdf

Chart 6.



Based on data available from the California Department of Forestry and Fire Protection (CDF).

http://www.fire.ca.gov/FireEmergencyResponse/HistoricalStatistics/PDF/Firehistory.pdf

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