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WILDFIRES IN THE SOUTHWEST

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1. wildfires

ABSTRACT

This project examined the issue of wildfires in the Southwest and evaluated several high-level tactics for reducing the damage wildfires cause, concluding that while fire suppression is still necessary to protect communities, educating residents will have a greater influence over the damage caused by future large wildfires. This conclusion was based on an examination of causes of increasing fire damage and the relative influence of several methods for improvement.

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1. Problem Statement

Although ecological necessities, wildfires have been major natural disasters for humans for centuries. Ecosystems in the southwestern United States and elsewhere have evolved to co-exist with wildfire to such an extent that certain species, such as the ponderosa pine, actually require wildfires to maintain a healthy population [3]. As humans increasingly inhabit these regions, their habits, desires, and needs come into conflict with the natural cycles of fire and regrowth.

Fundamental policy changes have been made in the way the United States handles wildfires since the Yellowstone fires in 1988. Instead of trying to suppress every single fire that is ignited in the wilderness, efforts are expended primarily on protecting humans and their structures. As a result, some fires are allowed to burn with no more than observation.

However, wildfires are still a severe, potentially increasing, problem in the Southwest. The last decade, and especially the last few years, has seen vast acreage consumed by fires, and large amounts of destruction despite the best efforts of the firefighters. Thus, additional changes may need to be made to the way humans interact with their surroundings in order to protect them from wildfires.

This project examined possible improvements in human interactions with wildfires and to predict where the most significant improvements could be made. In order to break the problem into more manageable pieces, a rough division has been made of the possible solutions into technological methods and societal methods. While several options are examined, it is likely that many have not been covered in this document.

2. Characteristics of Wildfires

Many aspects of wildfires are important to integrating the natural fire cycle into human life. Most obvious is that wildfires can cause enormous amounts of damage to human structures and land used by humans. This is the hardest facet of wildfires to reconcile with human usage. The fires discussed in this document are listed with locations, acreage, and some additional statistics in Table 1.

Table 1 - Table of Fires Referenced

Fire Name	Date	Approx. Location	Lives Lost	Duration	Acres Burned
Storm King	07/06/94	Glenwood Springs, CO	14		
Coal Seam [11, 12]	06/08/02	Glenwood Springs, CO		17 days	12,209
Scott Able [13]	05/11/00	Ruidoso, NM	2	9 days	16,034
Cerro Grande	05/05/00	Los Alamos, NM		27 days	47,650
Hayman [9,10]	06/08/02	Lake George, CO		25 days	137,784

Fire Name	Houses Burned	Other Structures Burned	Total Structures Burned	Damage[1]	Costs[2]
Storm King					
Coal Seam	99	14		$6.4m	
Scott Able	64	18		$2.8m	$3.5m
Cerro Grande	110			$180m	$6.6m
Hayman	133	467	600	$38m	$42.2m

[1] Damages are based of insured damages published in referenced sources.
[2] Costs listed are for firefighting/suppression only; this figure does not include incidental damages.

2.1. Definition of a wildfire

According to the Southwest Area Wildland Fire Operations website, a wildfire is "an unwanted wildland fire." A wildland fire, in turn, is defined as "Any non-structure fire, other than prescribed fire, that occurs in the wildland." Essentially, this means that wildfires include all fires in the wilderness which were not set deliberately by humans or which do not remain within the bounds set for them by the people who started them. Additionally, a fire which begins in the wilderness but enters a town will remain a wildfire, even though it affects non-wilderness areas. [14] Another such definition, found in California's 1995 Emergency Response Plan, mentions the necessity of suppression [15].

2.2. Damage caused by wildfires

Wildfires cause many forms of damage to the people who experience them. These range from the damage done to the land and foliage of an area to actual structures destroyed to loss of business due to closures or loss of tourism to the injuries and loss of life suffered, typically by firefighters.

2.2.1. Acreage and Number

The first measure of the severity of a wildfire is the area it burns. A large fire may burn hundreds of thousands of acres, while a small fire may encompass a dozen or less. Most fires which are publicized burn an area on the high end of this scale.

Within Arizona and New Mexico, over 163,000 and 254,000 acres, respectively, have been burned on average each year over the past 10 years [6]. In Colorado during the year 2002 alone, over 900,000 acres were burned (http://www.nifc.gov/fireinfo/nfnmap.html). During that time, several fires have caused major damage in several towns, including Los Alamos, New Mexico, and Glenwood Springs, Colorado.

Over this time period, there have been 3,649 fires in Arizona and 1,986 fires in New Mexico per year on average[6]. While the majority of these fires are small, no more than 100 acres apiece, there are an alarming number of larger fires, which contribute disproportionately to the overall acreage burned.

2.2.2 Insured Property Damage

A measure which provides a better estimate of the impact on humans is how much human property is destroyed by the fire. An estimate of this may be achieved by examining the insurance claims filed due to a wildfire. For instance, the damage done by the Cerro Grande fire was estimated at $180 million [7], while that done by the Hayman fire was estimated at "over $39 million" [2] even though the Hayman fire burned nearly four times the acreage of the Cerro Grande fire.

2.2.3. Casualties

Wildfires are hazardous by nature, and it is impressive that as few firefighters have been killed in the course of duty as recent records indicate. However, there are some deaths, despite modern safety standards and training. An increased emphasis was placed on firefighter safety after the 14 deaths in the Storm King fire in 1994 near Glenwood Springs, CO. Since then, there have been only occasional deaths from wildfires. Two firefighters were killed combating the Scott Able fire in 2000, and two more in the Cramer fire in 2003 [4].

2.2.4. Loss of Business

As a side effect of a wildfire, many industries in the area may also suffer losses of business. These especially include tourist- and recreation-based industries. However, in certain cases, these may include much more visible industries. An example of this is the high impact of

the Cerro Grande fire on the Los Alamos National Laboratory. Among the costs listed for this fire are "Loss of business", "Loss of income", and "LANL Restoration" [1].

2.3. Causes

There are two major causes of wildfires. One is natural, when the fire is typically sparked by a lightning strike during a thunderstorm. The other is human-caused. Human-caused fires may be originated by many means. Some fires are caused accidentally; for instance, a fire may begin from a spark from a car engine. Others are fires are set deliberately.

Over the last 12 years, humans and lightning have caused roughly equal acreage to burn in the Southwest. According to the Southwest Area Wildland Fire Operations website, an average of 227,104 acres have been burned by human-caused fires per year in the Southwest, while 209,793 acres have been burned by lightning-caused fires [6].

2.4. Populations Affected

In order to fully comprehend this issue, it is important to not only understand the nature of wildfires but also the population which they affect. One of the important factors concerning the population of humans in the Southwest is that it is a growing population. Between 1990 and 2000, New Mexico grew 7% faster than the country as a whole [8].

The increase in population has several effects. One is that as more people live in areas at high risk for wildfire, the number of structures which require protection increases. Another is that the additional humans place an increased strain on the ecosystems, as they use water and other natural resources, and increase pollution. Finally, if the source of this increase in population stems from immigration, there are an increased number of people who need to be educated about living safely in fire-prone regions.

3. Existing Techniques

This section focuses on what tools firefighters and land managers are using to control the threat of wildfires. These have been divided into two groups, one dealing with the tools used to suppress a wildfire once it has begun, and the other dealing with the tools used to prevent wildfires.

3.1. Suppression

The techniques that firefighters use to contain a fire and to put it out if the manager in charge decides that is necessary fall under the heading of suppression. These may also include tools for protecting houses when a fire has come dangerously close to them. This section describes the major tactics used to control a fire after it has become a wildfire.

3.1.1. Fire Breaks

One of the methods often used to contain wildfires is to create a break in the fuel available for the fire. This creates a gap where the fire cannot burn through, although it is still possible for the fire to jump across. A fire break with this intention can be created manually or with bulldozers, and many roads provide fire breaks that already exist. However, they are usually created with hand tools [27].

3.1.2. Backburns

A backburn is another way to create a fire break. This is done by lighting a back fire that burns out some of the fuel that the wildfire would be likely to consume but which is easier to control. Obviously, this fire could also end up out of control, but under some circumstances this may be the most efficient way to eliminate ground fuels that would otherwise feed the larger fire.

3.1.3. Water Dumps

The traditional method for fighting fires is to pour water onto them. When fighting wildfires, it becomes difficult to procure and apply sufficient water to simply drown the fire, due to the large size of the fire. However, it can still be useful to dampen parts of wildfires occasionally, because this cools the fire [28]. When it is possible to drive fire engines out to meet the fire, they are used for this purpose. Additionally, air tankers are used to dump massive quantities of water over an area of fire.

3.1.4. Chemicals

Foam is frequently used to protect structures that are at risk. Fire retardant foams, sprayed over the structure, reduce the probability that the structure will catch on fire. Other foams may be used to cool a fire [28].

3.1.5. Prediction

Perhaps the most important tool technology provides fire managers is prediction of a fire's behavior. With a better understanding of how the fire is likely to act, the manager can allocate firefighting resources more effectively and safely. Creating simulations of fires and otherwise using computers to assist in predicting a fire's behavior could become more common as typical computing resources increase in power and decrease in cost.

3.2. Prevention

Putting money into preventing a disaster typically costs less, over time, than trying to stop it once it happens. Wildfires are like any other disaster in this respect. In the case of a wildfire, the primary method of preventing disastrous fires is reducing the amount of fuel available to the fire. This is because fuel is the easiest leg of the fire triangle to control; both oxygen and temperature are impractical to reduce long-term.

3.2.1. Thinning

Thinning is perhaps the most common method of reducing fire hazards in a wildland-urban interface region. By reducing the number of trees in an area, the amount of fuel available to a wildfires is reduced. However, leftover materials such as stumps and unusably small branches must also be removed in order for this to be effective. Thinning is a primary focus of the Healthy Forests Initiative [31].

3.2.2. Prescribed Fires

In forests which are not very close to human presences, some fires may be prescribed in order to reduce the fuel buildup in order to reduce the damage of a later wildfire, and also to improve the health of the forest ecosystem. This is risky, as it may result in an out-of-control fire if conditions are not carefully considered before starting the fire, as in the Cerro Grande Fire. However, when successful, this is typically about 95% less expensive than suppression, and requires less time and manpower than manually thinning the equivalent area [32].

3.2.3. Building Maintenance

James Paxton commented that about half the houses that were burned in the Rodeo-Chediski fire could have been saved if the owners had performed a single weekend's worth of work around the house [33]. This maintenance can include things as simple as clearing leaves

from gutters. More complex tasks involve ensuring an adequate water supply and ensuring that roofs remain fire resistant [34].

3.2.4. Simulations

Simulations can be applied to more than just a fire that is already burning. A simulation of the terrain, vegetation, and climate can assist land managers with determining where thinning and prescribed fires would be most useful in preventing future wildfires. Simulations can also be used in determining where signs should be placed and patrols run [30].

4. Technical Solutions

Obviously, the technology in use for fighting fires can have a significant impact on how quickly a fire can be suppressed. A firefighter with a large water hose and an adequate water source can handle a significantly larger fire than can a firefighter armed only with a bucket. Likewise, a homeowner with a chainsaw and a planning map can more effectively reduce the fire hazard of his property than one with only a hand axe. This section examines possible improvements that can be made in the technologies currently in use for fighting wildfires, ranging from larger tankers to better modeling technology.

4.1. Prediction and Modeling

One of the areas in which technology is improving our capability to handle living with fires is in predicting and modeling fires, smoke, weather, and fuel buildups, and "initial attack and suppression allocation modeling", or modeling that will assist fire managers in planning how to begin to put a wildfire out [35]. Research is being conducted in this field at institutions as prestigious as Las Alamos National Laboratories [36].

4.2. Fire-resistant Construction

Another area of research prescribed by the National Fire Plan is improving "Methods for reducing the vulnerability of homes and community infrastructure" [35]. This may include research into fire-resistant building materials as well as fire-resistant landscaping, both suggested as tools by Firewise [34]. Also, this may include research into the most effective ways to prevent wildfires from entering towns.

4.3. Fuel Reduction

Additionally, methods for reducing the fuel available for wildfires are being actively researched. One specific tool is "harvesting and utilizing small diameter materials", traditionally

regarded as worthless by lumber companies. This also involves investigating the "effectiveness of thinning and prescribed fire" [35]. Presumably this will result in more effective applications of thinning and prescribed fire to specific situations.

5. Societal Solutions

In additional to the technical aspects of controlling wildfires, there are several ways in which society can influence wildfires. One of these is by providing greater funding for the organizations which suppress and prevent wildfires. Another is educating the public to reduce the number of accidental fires and decrease the fire hazard on private property. Finally, landowners could be required to reduce the fire hazard on their property.

5.1. Funding

Many firefighting organizations are funded by government money. For instance, the Bureau of Land Management, Department of the Interior, US Fish and Wildlife Service, Bureau of Indian Affairs, US Forest Service, and National Park Service are all national government agencies involved in wildfire management [16].

The Forest Service budget for 2004 includes $1.5 billion for Wildland Fire Management. Of this amount, $604 million is intended to pay for wildfire suppression. An additional $30.4 million has been provided for cooperative fire protection, and another $3 million for fire research. [18]

The Bureau of Land Management 2004 Budget Justifications provided more detailed information about what the money provided to the Department of the Interior and the Department of Agriculture should be used for. Out of a total of $2.27 million, $800 thousand, or about 35%, is budgeted for fire suppression operations. Another $418 thousand, or 18%, is budgeted for hazardous fuel reduction. The third large piece of the budget is wildland fire preparedness, with $892 thousand, or 39% [19]. This money "funds the non-emergency and

predictable aspects of the Departments wildland fire program", which includes fire science research, personnel, maintenance, equipment, and planning [20].

Overall, the federal government is budgeting almost $700 million for wildland fire management, according to the Bureau of Land Management 2004 Budget Justifications. Out of this, $283 million is to go to wildland fire preparedness. This budget includes $195 million intended for suppression operations (36). Burned area rehabilitation is to be given $24.5 million (43). Another $186 million is intended for hazardous fuel reductions, of which about 60% will focus on the wildland-urban interface (49).

Additional money and other resources are provided by state, local, and private sources. For example, recipients of Rural Fire Assistance grants are required to contribute at least 10% of the funding or equivalent services (59).

Since the majority of funding to suppress wildfires is paid by the federal government, some people wonder whether all taxpayers should have to pay for the losses of homeowners who don't make an effort to protect themselves [22]. This is resulting in an increased emphasis on alternative means of protecting homeowners in fire-prone regions, such as teaching them how to decrease the hazard to their own house and requiring their neighbors to do likewise.

5.2. Education

Education can also have a major impact on wildfire hazards. One aspect of education is reducing the number of human-caused fires, which is what the Smokey Bear campaign focuses on. Another is improving the fire safety of private land, which is promoted by organizations such as FireWise.

Figure 1 - Smokey Bear with Fire Danger Sign [37]

While human-caused fires are not the entire problem, about 50% fewer fires would occur each year if all human-caused fires were prevented [6]. Much of the Smokey Bear campaign is focused on children in school, with educational materials freely available. Another major facet is the TV commercials produced to educate campers [23]. The other major facet of Smokey Bear's public appearances is in signs, such as the fire danger level signs posted outside ranger stations, similar to that shown in Fig. 1, and trailhead signs reminding visitors to be careful about their fires.

FireWise advocates homeowner action to reduce the threat of wildfires to their homes [17]. Their suggestions range from the seemingly obvious, such as clearing the ground of debris, to the drastic, such as maintaining at least a 30' safety perimeter containing only carefully managed plant life. In general, however, their suggestions echo the work done by public agencies in fire prevention (see Section 3.2), although preventative measures such as controlled burning are inappropriate to inhabited areas.

Similar ideas are contained in numerous Forest Service pamphlets and publications, such as NFES#92075, "It Could Happen to You," and "'It Can't happen to My Home!' Are You Sure?". However, the mere availability of pamphlets may be insufficient to motivate

homeowners to make the effort to create a defensible space around their homes. Firewise takes the information and motivation to the people with workshops and evaluation and assistance programs [24].

5.3.Legislation

In addition to educating private landowners about what they can do to reduce the fire hazard of their property, governments or insurance companies can apply pressure to ensure that they reduce the hazard on their property. Some requirements in this direction exist, and more are being introduced.

Insurers are moving towards requiring homeowners to protect their houses from wildfire, although this progress is slow. Paul Kovacs asserts that "wildfire losses remain moderate for the industry", although they may still become involved in education, and encourage safer house design through prices [25].

Government on various levels is also moving towards requiring homeowners to make their property fire safe. Ventura County's vegetation control legislation was cited in a recent report to the Secretary of Homeland Security as an excellent example of government control resulting in reduced fire damage [28].

Another way in which legislation can help to control the danger of fires is by restricting development in areas at high risk for wildfires [31]. Development in these regions is increasing the fire danger by increasing the properties at risk from normal fires.

However, successfully implementing legislation or insurance requirements to increase fire safety requires that the legislators or insurers who control these requirements understand the threat that they are mitigating, and how what they are requiring will help. Also, land- and homeowners will accept these requirements more readily if they understand the issues at stake.

Thus, legislative or insurance based attempts to mitigate the wildfire hazard depend upon successful education.

6. Comparisons

Technological and societal solutions target different aspects of the problem of living in fire-prone areas. Since both types of solution can be expensive to implement, it seems reasonable to question which will be more effective in the long term. This section attempts to summarize the advantages and disadvantages of each.

Technological solutions take advantage of the American tradition of technological innovation and creative use. However, technology cannot easily contain problems which have a social source for very long, and most of the reasons for the increase in fire hazard is grounded in social influences. Part of the problem is the growing population in fire-prone areas, and part is that residents simply do not protect their own property; the spokesman for the Rodeo-Chediski fire, James Paxton, claimed that about half the houses that were lost in that fire could have been saved if the residents had performed a single weekend's maintenance that spring [33]. The evidence of recent large fires suggests that current technology cannot successfully protect the development that is already present in fire-prone areas, so it will likely not be able to cope with even greater development.

Societal solutions, in contrast, attempt to modify the behaviors which are increasing the problem. This will probably result in greater effectiveness in the long term, as residents take greater responsibility for their own safety. However, in the short-term, technological advances are useful to protect the human populations in fire-prone areas while they learn to protect themselves. Even if every person living or working in high-risk areas could be educated instantly, time would still be needed to implement the methods for wildfire prevention, causing suppression to continue to be needed.

In summary, technology is still necessary to deal with the immediate dangers of wildfires. Society may be able to reduce the need for it in the future, although it may still be needed occasionally. However, if residents can be taught to implement preventative techniques, the total cost for both government and residents should be reduced.

7. Conclusions

The issue of wildfires in the southwestern United States is a serious problem, and growing. Increasingly, large wildfires that burn through the forests of the region threaten towns and private homes because the population of these areas is growing. Technological solutions alone are inadequate to handle this problem. Thus, some combination of societal solutions must also be applied.

Education should be, and appears that it is, the primary focus of fire prevention strategies. Until ordinary citizens understand what the dangers of wildfire are and how to reduce them responsibly, laws and insurance requirements forcing homeowners to keep their property in defensible condition will be seen as draconian. Additionally, since taxpayers in other regions could understandably grumble about paying for wildfire damages, much prevention must be performed utilizing local resources. Local taxpayers as well might grumble about the costs of wildfire prevention unless they understand what they are contributing to. Thus, citizens must be educated before further measures can be undertaken. Finally, educated homeowners may take care of their own property, taking appropriate measures to protect it from wildfires; this eases the burden of protection on firefighters and reduces the likelihood that the structures will be destroyed in a wildfire.

Overall, it appears that the United States is taking the best approach to reducing wildfire damage that it can under current conditions. Despite emphasizing education and prevention programs, the government is maintaining its force of firefighters to handle the wildfires that will continue to threaten towns. Increased restrictions on property management in fire-prone regions are being considered and tested on a local level in some places. Research is being funded to increase understanding of how to manage fires and how to efficiently reduce the hazard that

wildfires pose to human structures. While it is unlikely that this issue will be entirely eliminated, it seems that this methodology is likely to reduce the damage caused by wildfires.

8. References

[1] D. C. Morton., et al. "Assessing the Environmental, Social, and Economic Impacts of Wildfire". May 2003. [02/19/2004] <http://research.yale.edu/gisf/assets/pdf/ppf/wildfire_report.pdf>.

[2] B. Kent, et al. "Social and Economic Issues of the Hayman Fire". [02/19/2004] <http://www.fs.fed.us/rm/pubs/rmrs_gtr114/rmrs_gtr114_6.pdf>.

[3] "Ponderosa Pine Forests of the Colorado Plateau". 2002. [12/02/2003] <http://www.cpluhna.nau.edu/Biota/ponderosa_forest.htm>.

[4] S. Nix . "Cramer Fire Death Report". 8/12/2003 [03/17/2004] <http://forestry.about.com/b/a/017322.htm>.

[5] USDA Fire and Aviation Management Briefing Report. 8/20/2003 [02/19/2004] <http://www.iccsafe.org/news/pdf/030904usda-fire.pdf>

[6] Southwest Area Fires & Acres (By State). [03/17/2004] < http://www.fs.fed.us/r3/fire/swapredictive/swaintel/ytd_historical/annual_1992-present_avg-by-state.htm>.

[7] "Insurers To Be Reimbursed for Cerro Grande Fire Claims". 8/9/2001 [03/17/2004] < http://www.insurancejournal.com/news/west/2001/08/09/15449.htm>

[8] New Mexico Quickfacts from the Census Bureau [3/19/2004] <http://quickfacts.census.gov/qfd/states/35000.html>

[9] NRCS Colorado Hayman Fire Update [3/21/2004] <http://www.co.nrcs.usda.gov/technical/features/colorado-wild-fires/2002/NRCS-EWP/Technical-Assistance-Proposals/damage-hayman-fire-Aug-8-02.htm>

[10] RMRS Public Affairs: Hayman Cost: $237.8 million [3/21/2004] <http://www.fs.fed.us/rm/main/pa/newsclips/03_09/0926_hayman.html>

[11] NCRS Colorado Coal Seam Fire Update [3/21/2004] <http://www.co.nrcs.usda.gov/technical/features/colorado-wild-fires/2002/NRCS-EWP/Technical-Assistance-Proposals/damage-coal-seam-fire.htm>

[12] Rocky Mountain Insurance Information [3/21/2004] <http://www.rmiia.org/News_Releases/Coal_Seam_Estimates_2002.htm>

[13] Scott Able Fire Coverage. 3/19/2004 [3/21/2004] <http://www.cloudcroft.com/special.htm>

[14] Wildland Fire Terminology. [3/21/2004]
<http://www.fs.fed.us/r3/fire/swainfo/southwest/swa-terms.htm#w>

[15] Fire Plan – Glossary. [3/21/2004]
<http://www.fire.ca.gov/FireEmergencyResponse/FirePlan/glossary.html>

[16] Southwest Area – Wildland Fire Operations Website. [3/24/2004]
<http://www.fs.fed.us/r3/fire/>

[17] "About Firewise". [3/30/2004]. <http://firewise.org/about.htm>

[18] USDA Forest Service 2004 Budget Information. [4/7/04].
<http://www.fs.fed.us/budget_2004/appropriation.shtml>

[19] Bureau of Land Management 2004 Budget Justifications. p. IV-7. [4/2/2004].
<http://www.blm.gov/budget/2004just/wildlandfire.pdf>

[20] Bureau of Land Management 2004 Budget Justifications. p. IV-24.

[21] Smokey's Resources. [4/7/04]. <http://www.smokeybear.com/resources.asp>

[22] Ring, Ray. "Who should pay when houses burn?". *High Country News*. Vol. 35 No. 10. May 26, 2003.

[23] TV Commercial Viewer. [4/7/04]. <http://www.smokeybear.com/commercial.asp>

[24] Firewise Events. [4/7/04]. <http://www.firewise.org/events.html>

[25] Kovac, Paul. "Wildfires and Insurance". ICLR Research Paper Series No. 11. p. 10.
<http://dels.nas.edu/dr/docs/kovacs.pdf>

[26] Timothy Duck, Todd Esque, Timothy Hughes. "Fighting Wildfire in Desert Tortoise Habitat: Considerations for Land Managers." [4/14/04].
<http://azwww.az.blm.gov/dt/TORTFIRE.HTML>

[27] "Types of Crews". [4/16/04] <http://www.nationalfiretraining.net/misc/pp/292,60,Types of Crews>

[28] "Suppression". [4/16/04]
<http://www.nationalfiretraining.net/misc/pp/292,221,Suppression Methods for Breaking the Fire Triangle>

[29] "The California Fires Coordination Group". 2/13/04. p. 49. [4/21/04].
<http://www.fema.gov/pdf/library/draft_cfcg_report_0204.pdf>

[30] "Risk Assessment and Mitigation Strategies Overview". [4/21/04]. <http://www.nifc.blm.gov/nsdu/fire_planning/rams/Overview.pdf>

[31] "wildland fire in the Greater Yellowstone Ecosystem". [4/21/04]. <http://www.greateryellowstone.org/lands/wildland-fires/fires.html>

[32] "Fighting Fire with Fire: Keeping Forests Healthy and Protecting Air Quality". United States Environmental Protection Agency, Office of Air Quality Planning and Standards. February 1999. EPA-452/F-99-001. Available at <http://www.westar.org/Docs/Fire/FIREFITE.pdf>

[33] Interview with James Paxton. 6/1/03.

[34] Firewise Checklists. [4/21/04]. <http://www.firewise.org/pubs/checklists/fwlistsz.pdf>

[35] "Fire Science and Technology Development". [4/22/04]. <http://www.fireplan.gov/reports/364-372-en.pdf>

[36] "the Delphi Project, Wildfire, Las Alamos National Laboratory". [4/22/04]. <http://www.lanl.gov/delphi/projects/wildfire-rams.shtml>

[37] "Salmon-Challis NF Fire Links". [4/27/04]. <http://www.fs.fed.us/r4/sc/fire/links.htm>