Fire: Ecology & Prevention

By

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Proposal

For my senior project I wish to focus on the subject of fire, and cover two specific aspects of it, Ecology and Prevention. I will focus the first half of my project on fire ecology and the positive and negative effects it has on nature. I want to get past the standard view that wildfire’s are always harmful to nature and show how wildfires can actually function to spread diversity and strengthen sustainability in a wildland’s ecosystem.

The second part of my project will cover wildfire prevention. I took a wildfire behavioral class last year and I want to take what I learned from that class and apply it to a mock wildfire situation at Swanton Pacific Ranch (Cal Poly’s property in Santa Cruz County). With this mock fire situation I would like to show how firefighters would go about attacking the fire, from setting up camp to identifying the safety zones. I will use G.I.S. to map the land and identify the elements important to combating a wildfire. I will identify the most dangerous zones, the flattest and clearest land to set up camp, perennial water sources, and types and degree of fuel loading per area. After that is accomplished I plan to address better tactics to prevent and defend against wild fire.
Annotated Bibliography

Bushfire CRC. 2006. The stay and defend your property or go early policy. The AFAC position and the Bushfire CRC’s current research. Online article retrieved from www.bushfirecrc.com/publications/downloads/bcrcfirenote7staygo.pdf. This article discusses previous cases of residents who prefer to stay and defend their property against the forcible evacuation. This article will not be of much use to my paper.

Carrier, J, Henry, J, & Wood, T. (1989). Summer of fire. Salt Lake City, UT: Gibbs-Smith Publisher. This book is a closer examination of the fires of Yellowstone National Park and surrounding cities in 1988. This Book has a more in depth look at all the aspects of the Yellowstone fire including, evacuation, Tactics, staging areas, animal protection, etc. I would mostly use this book for its brilliant and up close photos of the scenery, fire, and firefighters.

Chandler, c, Cheney, p, Thomas, p, Trabaud, l, & Williams, d. (1983). Fire in forestry. Forest fire behavior and effects. New York, NY: Wiley-Interscience Publication. This book was put together from two decades of research on the behavior and control of forest fires. The team who conducted the research has over a century’s experience of wild land firefighting. This book examines the role fire plays in the dynamics of the forest ecosystem, and the use of fire in forestland management. I think this book will help in the beginning part of my project (fire ecology) in helping to understand the role fire has on various types of ecosystems, also the ways in which fire can be used to help manage lands and let ecosystems flourish.

Cohen, J.D. 2000. Preventing disaster. Home ignitability in the urban-urban interface. Journal of Forestry. 2000. This article cites the hazards associated with living close to the natural environment. For those who live in high-forested areas such as in Lake Tahoe, this article identifies some of the fire risks and ways of preventing them. I might use this source in the fire prevention part of my project but it would be a minimal amount of info used because another source is basically the same as this one.

increasing amount of fires per year. This book will be helpful for
the second part of my project because it talks a lot about the
need for change in current fire fighting policy and gives advise
for future fire-prevention systems.

Backhuys Publishers. This book takes an in depth look in certain
large fires around the world. The book gives a detailed
examination of fire, including how it operates starts and even
ways of predicting fire occurrence. Also in this book are two case
studies on the post-fire ecosystem recovery and management of
the California fires of 1993, and the restoration of burned lands
in eastern Spain. The importance of this book for my project lies
within the two case studies.

Morrison, Micah. (1993). Fire in paradise. The Yellowstone fires and
Publishing. This book covers the dangerous series of fires that
attacked Yellowstone national park in 1988. The author describes
in great detail the battle against the ferocious fires that
threatened Yellowstone and surrounding areas. This book also
brings up the debate over the “let-burn” method presented by
environmentalists verse those that support the aggressive quick
direct combat on fire. The beginning of this book will be
interesting but not very helpful towards my overall project,
however when the author touches on the “let-burn” method verse
the quick attack method I believe I will get valuable information
on strategies on wild land firefighting.

Jumping fire. A smokejumper’s memoir of fighting wildfire.
Orlando, FL: Mariner Books. This is a novel about firefighting and
the major fire that happened on Mt. McKinley. The authors
discuss a method of wild land fire fighting by way of
smokejumpers; a team who parachutes into the heart of the fire
to set up the initial attack. The only thing this novel really has to
offer is the background of smokejumpers, which started in the
1940’s as a way to combat fire.

CRC Press. This book is primarily an overview of the geography,
history, ecology, and silviculture of various types of forests all
over the world. The author conducts minor case studies of
different forests throughout the world including: Conifer forests
of the north to Pine forests of the south, Broadleaf forests of
southern wetlands to tropical forests of Hawaii, South Florida and
Puerto Rico, and so on. I think this book will not be of much use
to me, I think I might gain a basic understanding of forest ecology but that's about it. I would need a more generalized study of forest ecology than what this book has to offer.

Wild land Fire. 2004). Emerging issues in wild land fire protection. Wild land fire management section of the national fire protection association. Quincy, MA. I believe this source is a senior project that was put in the wrong section of the library and has no author, however this article has much information on urban-urban fire. Urban-urban fire is a case in which a wildfire spreads to an urban area/structure. This article will help me in the fire protection section in my project, reviewing safety precautions that should be taken around urban structures close to wild land.

Outline
Section One: Fire Ecology

I. Understanding Wild Fire:
   a. Components of Fire: Fire Triangle; Heat, Fuel, and Oxygen
   b. Forest Fuels and Fuel Moisture
   c. Heat Transfer and Fire Intensity
   d. Fuel Consumption and Burning Patterns; Ground Fires, Surface Fires, and Crown Fires.
   e. Forest Fire Weather
   f. Wild land Fire Behavior

2. Ecological Effects of Wild Fire (Majority Of Section One)
   a. Effects on Soil, Water, and Air
   b. Effects on Wildlife
   c. Effects on Vegetation
   d. Fire as a Natural Process
   e. Ecological Adaptations to Fire

3. Sociological Effects of Wild Fire
   a. Public Perceptions of Wild Fire
   b. “Smokey Bear” Campaign
   c. Wild Land/Urban Interface

4. Fire Management Policy
   a. Management Goals
   b. National Fire Management
   c. Managing Fire USE
   d. Ecosystem Maintenance and Planning
   e. Economics of Fire Management
   f. Policy Determinants, Formulation, and Solutions

Section two – Fire Prevention

5. Wild Land Fire Suppression
   a. Suppression Methods
   b. Eliminating the “Fire Triangle”
   c. Initial Attack Strategies
d. Fire Behavior Planning including Incident Command System  
e. Tactics  
g. Use of Water and Chemicals: Including Foams, Gels and Retardants  
h. Air Operations including:  
   - Detection Aircraft  
   - Air Tankers  
   - Helicopter Use  
   - Smoke Jumpers  

6. Forest Fire Equipment  
   a. Personal Protective Equipment  
   b. Hand Tools  
   c. Firing Tools: Including Explosives  
   d. Mechanized Equipment: Including Plows, Bull Dozers and Various Lightweight Machines  
   e. Water Handling Equipment: Including Backpack Pumps, Different Types of Hoses, Different Types of Fire Engines  

7. Pre-suppression Tactics Fire Education  
   a. Fire Law Enforcement  
   b. Fire Preventing Engineering  
   c. Pre suppression Planning: Mapping and Past Records  
   d. Behavioral Prediction: Forecasts and Fire Seasons  

Part One: Wildland Fire Ecology
Understanding Fire

In order to understand the effects of fire on an ecosystem, we must first understand the basic principles of fire itself. A fire requires three simple components to ignite and sustain burning; fire needs Heat, Fuel, and Oxygen. These three components make up what is called the “fire triangle”. Fire is transferred from one fuel source to another in three means of heat transfer: conduction, convection, and radiation. However, a forth method of heat transfer not commonly mentioned is spotting. That is, “the physical removal of burning material and its deposition in unignited fuels meters or kilometers away. In many forest fires, this is the predominant mechanism of fire spread” (Chandler 20). Fire intensity is another subject needing understanding. Fire burns at different levels of intensity depending on fuel types and the amount of fuel loading in a given area. The lighter fuels such as grasses will burn extremely fast but not as intense as a solid oak tree that will burn slow but extremely intense. For example, in the process of building a campfire, smaller pieces of kindling are utilized to get the larger logs going, once those begin to slowly burn a greater amount of heat is radiated. With a basic knowledge of fire we can further investigate how fire behaves in the wild.

Wildland fire behavior acts differently than urban structural fire because more elements are involved. The most important element is topography. Because so many things affect wild fires, understanding all of the elements is a key factor in being able to suppress it. There are three environmental factors that play on wildland fire behavior: fuels, weather, and topography. In wildfire terminology fuel is defined as any substance or composite mixture susceptible to ignition and
combustion (Chandler 1983). There are many ways to describe a fuel, such as fuel type, fuel moisture, size and shape, fuel loading, horizontal continuity and vertical arrangement. Fuel types can be divided in two categories, light (grasses, leaves, twigs, and shrubs) and heavy (tree trunks, limbs, logs, and stumps). The amount of water in a fuel (expressed as a percentage of the oven-dry weight of that fuel) is called fuel moisture (Teie 2005). Fuel loading is the quantity of fuels in an area, usually expressed as tons per acre. Horizontal continuity describes whether the fuel loading is uniform or patchy, and vertical arrangement describes whether the fire is burning on the ground (best called underground fire), surface, or aerial fires.

“Ground fuels are all combustible materials lying beneath the surface including deep duff, roots, rotten buried logs, and other organic material. Surface fuels are all materials lying on or immediately above the ground including needles or leaves, grass, downed logs, stumps, large limbs and low shrubs. Aerial fuels are all green and dead materials located in the upper forest canopy including tree branches and crowns, snags, moss, and high shrubs” (Wildland Fire).

Weather affects wildland fire behavior dramatically because any change in the weather will cause a change in how the fire behaves. The most important weather factor is wind. Wind increases oxygen to the fire, which creates a rise in the level of intensity and it could change the direction and rate of spread of a fire. Wind also drives convective heat into adjacent fuels preheating them, and it also can dry out fuels, making them easier to ignite (Wildland Fire).
The third and final factor affecting wildland fire behavior is topography.

There are five elements of topography that affect how fire behaves the most: aspect, slope, position of fire, shape of country, and elevation (Teie 2005). An aspect is the direction that the slope faces and may determine which types of fuels will be on either side of the slope, whether they are light or heavy fuels. Slope is the steepness of the topography; steeper slopes cause the fire to spread faster because of convection and radiant heat pre-heating up-slope fuels. The position of the fire on a slope can help predict the rate of fire spread, fires that start on the top of a slope will spread much slower than fire that starts on the bottom. The shape of the country or terrain can act as a box canyon having a chimney effect, which will make the fire burn intensively as it creeps uphill. If the shape of the country is narrow, fire spotting can easily jump across the canyon and ignite the other side, or the radiant heat off one side of the canyon will pre-heat the other side making it easily combustible. Also the shape of the country has dramatic affects on wind direction and wind intensity. The final element of topography is elevation, which will determine which types of fuels will be present at different levels of elevation. Also, different elevations will have different levels of fuel moisture because of varying precipitation and temperature. Refer to Figure 1 for better understanding of how topography affects wildland fire behavior (Wildland Fire).
Fire has been a natural shaper of landscapes long before our ancestors even laid eyes upon the earth and its natural beauties. Evidence of free-burning fire has been found in petrified wood and in coal deposits formed as early as the Paleozoic era (Chandler 293). Fire has a major affect on the ecology of nature ranging from the...
soil that lies beneath, the air that floats above, and everything that falls in between. Fire has the power to influence an entire ecosystem. “Wherever climate permits the growth of plants, lightning provides the match that will sooner or later set them afire” (Chandler 293). Knowledge and understanding of wild fires can provide a basis for fire control (Brown 45). Studying the relationship of fire and an ecosystem is beneficial in both private and public forest policy; it also can be a guide in overall land-management. It is important to understand the interactions between fire and an ecosystem, a new appreciation of fire ecology within the last half century have given researchers better land management knowledge. Historical and current wildfire data can be used in several ways, with some being; serving as a guide for scheduling prescribed burning activities to stimulate natural fire occurrences, a base for land management planning and silvicultural prescriptions, and an aid in documenting the effects of past fires and past fire exclusion policies (Pyne 172). We will begin our exploration of the ecological effects of wildfire starting with the effects on soil, water, and air followed by a close look at the effects on wildlife and vegetation. Then we will end the exploration by focusing on nature’s way of battling back against wildfire with adaptation and the evolution.

**Soils**

The effects of fire on the chemical and physical properties of forest soils will vary from nil to profound depending on the type of soil, the moisture content of the soil, the intensity and duration of the fire, and the timing and intensity of post fire precipitation (Chandler 171). In heavy mineral soils, heat transfer will take place
through conduction and vapor transport downward from the exposed surface whereas potent organic soils can actually support combustion. Underground fires or fires in the soil are very hard to extinguish and can sometimes burn for several months even up to years. Soil moisture content plays a role in heat and thermal conductivity and will determine how fast and how much heat will be conducted downward through the soil. Higher moisture content requires more heat to increase the temperature of a saturated soil. The moisture content of the soil litter and duff layers (decomposed upper layer matter and lower fermentation layer) can be more important than the mineral soil itself in means of fire control. If the moisture content is high enough that the surface litter will burn but the lower layers of duff will not, the soil temperature, even at the surface, remains below 100 °C and there are virtually no effects of fire on the soil chemistry or physics (Chandler 172).

Wildfires can be rated according to severity based on the reduction of the upper layers of litter and the amount of mineral soil that is exposed. Fire rarely consumes the duff layer completely, and almost always some remains to protect the soil against other environment factors; The heat of a fire may temporally make this duff layer somewhat more impermeable but with time the duff layer rebuilds itself (Pyne 191). The overall effects of fire on soil will vary depending on certain properties such as the fuel type, soil type, fire intensity, fire frequency, and timing.

**Hydrology**

Forest fires can affect hydrologic processes indirectly but profoundly by altering the physical and chemical properties of the soil, converting organic ground
cover to soluble ash, and modifying the microclimate through removal of overhead foliage (Chandler 184). Before we can get into the effects of fire on hydrology we first need a basic understanding of hydrological process. When rain falls in the wild, particularly the forest, the foliage and small twigs of trees intercept raindrops. Once the foliage becomes saturated the excess water runs down the surface of the tree (twigs, branches, stem) or can fall straight to the surface. During its time on the tree the water is subject to evaporation. The litter and duff then absorb the un-evaporated water that fell to the ground. Once the litter and duff become saturated the water will filter its way down into the mineral soil. On reaching the mineral soil, some of the water will be absorbed in the capillaries and some will filter down even further into the water table. If the rate of water supply at the surface is greater than the infiltration rate, the unabsorbed water will flow across the surface under the force of gravity (Chandler 185). Forest fires can affect all these processes of interception and evaporation having an affect on the amount and quality of water reaching the watershed. A forest fire will decrease the interception due to the removal of the aerial foliage after a fire. Theoretically, this would result in increased soil moisture and available water. “However, in actuality the opening up of the forest floor to increased insolation and wind increases evaporation to a much greater extent than can be compensated for by decreased interception...” (Chandler 185).

A fire that removes the surface litter and duff will have a much greater impact than just the removal of the canopy. In general, a forest fire reduces the amount of rainfall intercepted and reduces the rate at which it will filter into the
soil, mostly because the rainfall will be able to directly penetrate the soil because there will be no surface debris to slow it down. All of this will add up to increase soil erosion and lead to greater water run off (Pyne196). Soil erosion and water run off can have dangerous consequences including flooding and landslides. Due to a forest fire, water run off will also influence waterways downstream. The first couple storms that follow a forest fire will alter streams chemistry because of the added sedimentation being carried into the stream by the run off. “The added sedimentation to a stream will not usually be sufficiently concentrated to pose a health hazard to humans or animals, but it may contribute to the eutrophication or algal blooms under marginal conditions” (Chandler189). Another effect of a fire on stream quality is an increased water temperature that can occur when streamside vegetation is burned, exposing the stream to more direct sunlight. The rising temperature of the water can drastically alter the water habitat for many biotas. Although fire does not affect water directly, the indirect effect can be major and lead to long-term ecological changes.

Smoke

Where there is fire there is smoke; forest fire smoke is more than a nuisance. Smoke can reduce visibility along roadways, shut down airports, and cause serious loss of tourist revenue to resorts (Chandler 198). Air pollutants emitted from forest fires are harmful to human health and welfare; therefore efficient smoke management is of vital importance. Two products of complete combustion during fires are carbon dioxide (CO2) and water (H2O) that generally make up over 90
percent of the total emissions from wildland fire. Under ideal conditions complete combustion of one ton of forest fuels requires 3.5 tons of air and yields 1.84 tons of CO$_2$ and 0.54 tons of water. Under wildland conditions, however, inefficient combustion produces varying yields. Neither carbon dioxide nor water vapor are considered air pollutants in the usual sense, even though carbon dioxide is considered a greenhouse gas and the water vapor will sometimes condense into liquid droplets and form visible white smoke near the fire (Reinhardt 2000).

Carbon monoxide (CO) is a dangerous chemical compound and another product of wildland fires. Its negative effect on human health depends on the duration of exposure, CO concentration, and level of physical activity during the exposure. Generally, dilution occurs rapidly enough that carbon monoxide will not be a problem for local citizens unless a large fire occurs and inversion conditions trap the carbon monoxide near rural communities. Carbon monoxide is always a concern for wildland firefighters however, both on the fire line at prescribed fires and wildfires, and at fire camps (Reinhardt and Ottmar 2000, Reinhardt and others 2000).

**Wildlife**

Fire in the natural environment has a profound effect on wildlife. Fire has many influences on wildlife, from direct to indirect effects as well as immediate and long-term effects to a habitat. The direct effects of fire on animals are their reactions when a fire is present. Usually if a species is mobile and movements are not restricted, casual movement away from fire is commonly observed (Pyne 190).
Some smaller mammals and less active species prefer in-place survival such as nesting several feet underground. Survival is high because soil is an excellent insulator that protects the species from the heat and flames. In most cases with in-place survival, suffocation is the greatest cause of mortality not the high temperatures. Bird mortality is usually low because the ability of flight makes for an easy escape, however ground-nesting birds will often get trapped in the flames. Larger mobile animals can take temporary shelter in unburned or already burned areas. The reaction of animals, both short and long term, to fire depends on habitat attachment, mobility, ability to find shelter, and sensitivity to smoke and heat (Chandler 208). Short-term, indirect effects on the animals include sudden and drastic modification of habitat structure and microclimate and, depending on the species and fire intensity, the effects can be either positive or negative (Pyne 191). A high-intensity fire can create inhospitable habitats because the large amounts of cover are reduced, greatly increasing the surface temperatures. In less intense fires, a more diverse environment results, providing favorable cover, food resources, and microclimate (Pyne 191). The greatest effects to the stream fauna would be an increase in sedimentation that could suffocate the fauna and the loss of streamside vegetation would result in an increase of water temperatures. Long-term effects of a fire on animals would be the major modifications of the habitat. Some early plant species would generally increase followed by some larger mammals that would feed off those plants (e.g., deer).

Another effect of fire on wildlife would be the influence of animals on the behavior of fire itself. Animals may indirectly increase or decrease the probability of
fire as well as the intensity of any fire that occurs (Chandler 203). For example, insects can cause severe damage to a forested area by feeding off the habitat; they weaken and thin out trees, leaving many trees dead and dried out, resulting in them being more flammable. Those same dead and dried out trees would eventually break off or fall to the ground increasing the fuel loading tremendously. Larger animals can alter the composition of the land on their search for food when they choose certain plants over others, influencing fire behavior. There are some animals however that can help reduce fire potential. Studies show that livestock grazing breaks up potential fuel and establishes trails through the forest which can be used as firebreaks (Chandler 204).

**Vegetation**

The single largest ecological effect of fire would be its influences on vegetation. Fire is such an ancient, universal phenomenon that it has played an important part in creating many of the vegetative communities and many of the global landscapes (Chandler 255). Lightning, volcanic eruptions, spontaneous combustions, and sparks produced by rockslides are all natural causes of fires all over the world. Fire has always been a naturally occurring factor of plant succession and modification creating bio-diversity in many different habitats and ecosystems. The continued action of fire has led to the evolution of a great number of fire-adapted communities, some of which now actually depend on fire for their maintenance and survival. However, man’s appearance on the scene disturbed this balance of nature. Humans used and abused fire for agriculture, religious, and
personal needs. This, in combination with cutting, grazing and farming activities, followed by the abandonment of many areas, has shaped much of the plant life that exists today (Chandler 255). The following statements provide some general knowledge on the effects of fire on vegetation (Pyne 189-190):

1. Fire may trigger the release of seeds in some species (e.g. lodge pole pine and jack pine).
2. Fire may stimulate the flowering and fruiting of many shrubs and herbs.
3. Fire alters seedbeds by removing litter and humus and creating bare soil. This influences the germination and survival of many forest species (e.g., ponderosa pine, Douglas-fir, and giant sequoia).
4. Fire stimulates vegetative reproduction of many woody and herbaceous species when the over story is reduced. Sprouting from root collars (e.g., oaks, maples, redwood, alders) and root suckering (e.g., aspen) is common.
5. Fire temporarily reduces competition for moisture, nutrients, and light, thereby selectively favoring some species.
6. Fire may selectively eliminate part of a plant community.
7. Fire frequency (i.e., return interval) influences community composition and the succession stage and controls over story age for vegetation types experiencing crown fires.
8. Fire frequency regulates susceptibility of forests to blow downs.
10. Fires deep in organic soils can create a basin topography that, in the wet season, furnishes feeding sites for animals and in the dry season, may become a refuge for many species and source areas for future colonization.

The final ecological effects of fire addressed are the natural adaptations that combat the harsh conditions that a fire may bring. One plant species in particular whose adaptation and evolutionary traits allow it to survive even through a fire will also be examined. An adaptive trait is defined as an aspect of the development pattern, which facilitates the survival and/or reproduction of its carrier in a certain succession of environments, in our case: fire (Chandler 146). Some tree bark has evolved to gain thickness, carry greater moisture content, have increased heat capacity, lowered combustion properties, etc. thus protecting the internal layers of the tree. Some species buds can be protected in layers of succulent nonflammable foliage. This can happen by them being deep within branch axils or in heartwood pockets on the main stem. Another way is the plant locating them on the underground roots where sprouting is chemically induced after fire or other injury to the aboveground plant parts (Chandler 147). Some plants have minimized their fuel by reducing the volume of small diameter stems and leaves or needles, by developing thicker, fleshy photosynthetic and reproductive organs, or by reducing competitive herbaceous and shrub vegetation (Pyne 180). Some plants require fire for the germination of future offspring. Many woody species produce seeds that are dormant when released and can remain dormant for several years. These dormant seeds typically have restrictive seed cases or coats that physically inhibit the seed itself from breaking free and germinating. The heat output from a fire is sufficient to
crack open the seed case and release the inner seed. Post fire seedling numbers consequently can be unordinary high (Pyne 180). Refer to figure 3 below of an example of prolific post fire germination in a temperate hardwood forest near Ham Lake Minnesota:

**Figure 2** (Dvorak)

In most plants and trees normal seedling height growth is generally linear with time, but with the long leaf pine, it has adapted to fire to prolong its life. Long leaf pine seedlings cease height growth soon after establishment, forming what is referred to as a “grass stage” (Pyne 184). During this prolonged grass stage, photosynthetic energy is differentially allocated to the root system, building a strong foundation. When the next low-intensity surface fire occurs, the terminal bud, which is close to the ground, is protected from the heat damage because the foliage is high in moisture content and there is little oxygen in the densely packed needles. After the fire, carbohydrates stored in the root system are mobilized for high growth and the terminal bud is lifted high enough into the air to be protected from the heat of the next surface fire. During this inter fire period, the bark thickens, insulating the
cambium and affording protection to the plant (Pyne 182). The figures below show each stage of this process. Figure 4a displays the plant in its “grass stage” where the energy is directed to the root system instead of height growth. The next figure (4b) shows the post fire adaption to rapidly direct the energy to the height growth carrying the terminal buds out of reach from a future surface fire. Figure 4c is a picture of a mature long leaf pine having thicker and fire protectant bark. In addition, the tree has a habit of dropping its lower limbs preventing ladder fuels from reaching the crown.

**Figure 3-a** (“Wolly pine needle aphids stress transplants”)
Figure 3-b ("Long Leaf Pine")

Figure 3-c ("Ponderosa Pine Trees")
Cultural Perceptions of Wild Fires

This section will cover some of the sociological perceptions on wild fires and examine the wildland-urban interface. Wildland-urban interface is the term referred to the residents and communities built in, around, or in close proximity to the wildland. Two general perceptions of wildland fire deal with opposing views of the let burn policies, and the aggressive immediate suppression actions. After a basic understanding of wildfire, the viewpoints on both sides have good value.

Wildfire risk managers often start with the assumption that wildfire is an important hazard that demands mitigation. However, a review of literature reveals that wildfire has generally not been high on the list of concerns for the public, nor has it attracted much attention from those charged with protecting the public against a wide range of hazards that modern people face (Daniel, Terry, Matthew Carroll, and Cassandra Moseley 55). Wildfires as a natural hazard may not be the source of major fatalities, usually only numbering in the hundreds per year, with most of those being firefighters and not the general public. But it is the indirect effects of wildfires that people are unaware of that cause problems for the public down the road. These include: flooding, landslides, loss of timber, affected waterways, etc. In fact most people are completely unaware of the effects of wildfires because they are taught is that wildfires are a danger. This general idea was implemented because of community prevention programs including the “Smokey the Bear” campaigns. That campaign was one of the most effective interventions dealing with influencing broad public awareness of wildfire risks. It promoted public cooperation in reducing wildfire potential with its motto, “Only
You can prevent forest fires.” It was so effective, in fact, that subsequent interventions to promote public awareness and acceptance of the positive value of fire in forest ecosystems may be attenuated in their effectiveness (Daniel, Terry, Matthew Carroll, and Cassandra Moseley 144).

**Wildland-Urban Interface**

For those who choose to reside in natural forested areas, they are at an increased risk to be affected by fire. Over recent years, more and more people are moving into wildland areas, and fires having catastrophic impacts are becoming increasingly common. To reduce the potential for damage to human communities, wildland-urban interface (WUI) residents have been encouraged to perform mitigation or firesafing measures around their homes and communities (Martin, Wade, Carol Raish, and Brian Kent 23). Most homeowners however have yet to take the initiative to adopt such firesafing measures. This reluctance may be due to lack of knowledge of firesafing and lack of finances. The knowledge is out there, many wildland fire stations and insurance companies have put of flyers and pamphlets in wildland communities giving tips on how to make your residence more fire safe. Many times fire fighters and nature will be blamed for the loss of property during a wildfire, by the residents and homeowners, but all to often, a little preparation and firesafing of their land could have prevented serious damages. Fire has been a natural phenomenon throughout time and those who choose to reside in the wildland should take appropriate prevention measures. Some general firesafing information will be covered later on in the pre-suppression tactics section.
Wildland Fire Management

Managing wildfires is a social creation—in America, a social compact among the people and the institutions, it builds on certain principles common to fire management everywhere. “But it also builds on special circumstances of environment, history, and cultural mores that make for national strategies and unique traditions” (Pyne 309). Fire management includes multiple aspects including economics of managing fire, fire use itself, establishing policy determinates, and ecosystem planning. Because wildfires can affect many different elements, multiple agencies and communities are interested in the policies of fire management. The challenge of managing wildland fire in the United States has dramatically increased in complexity and magnitude over the decades. Large wildfires now threaten millions of both public and private acres, particularly where vegetation patterns have been altered by development, land-use practices, and aggressive fire suppression (USFS).

Protection of human life is the first priority in wildland fire management. Once firefighters are committed to an incident, they are the number one priority. Property and resource values are the second priority, with management decisions based on values to be protected (USFS). Because wildland fire respects no boundaries, uniform policies and programs are essential, as well as strengthening cooperators’ relationships. The Departments of the Interior and Agriculture, together with tribal and state governments and other jurisdictions, are responsible for the protection and management of natural resources on public lands. And, as
firefighting resources become increasingly scarce, it is more important than ever to strengthen cooperative relationships (USFS). Structural fire protection in the wildland-urban interface is the responsibility of tribal, state, and local governments. The role of federal agencies in the wildland/urban interface includes wildland firefighting, hazard fuels reduction, cooperative prevention and education, and technical assistance (Pyne 312).

Using fire itself as a tool is also part of the fire management process. Wildland fire management decisions and resource management decisions go hand in hand and are based on approved Fire Management and land and resource management plans. Fire managers also have the ability to choose from the full spectrum of fire management options, from prompt suppression to allowing fire to function in its natural ecological role (USFS). Fighting fire with fire is an essential method to fire suppression; it is commonly used in backfiring (discussed in the next section). Owing to fire as a natural process in the environment it can be used to help rebuild, maintain and promote growth in many ecosystems. Burning can improve seedbed conditions for regeneration. Fire is an efficient tool for improving food and cover conditions for certain wildlife species. The use of fire by the landowner serves a variety of purposes, which may be placed in two general categories. The first is to reduce the severity of the fire control problem; the second is to facilitate some phase of management of wildland resources (Brown 596).

Although the use of fire in wildland management has many valuable uses, the burning of extensive wildland areas has remained a controversial issue. Conflicts in
wildland use itself also make the use of fire controversial. Burning that may improve pasture for cattle or browse for deer or the water yield for irrigation may accelerate soil erosion or be destructive of timber and recreation values (Brown 559). As mentioned earlier the atmospheric effects of fire have concerned many people, who often oppose controlled fire use because of their fear of air pollution. The lack of knowledge and manpower to control the prescribed fire causes a great concern that the fire might be able to escape the control of the operators. Another concern is the liability to damage suits as a strong inhibiting factor where mixed ownership occurs and some of the owners oppose use of managed fire. Such liability becomes real whenever a set fire crosses the property line of such an owner, even if the damage causes by the fire itself may be nominal (Brown 559).

**Part Two: Prevention & Suppression Methods**

**Wildland Fire Suppression**

Wildland firefighting is extremely dangerous but with knowledge of fire behavior and efficient suppression skills, the dangers can be greatly reduced. There are many methods of fighting a wildfire, and almost every time, multiple suppression methods and tactics are utilized in combination with one another. Planning during the event of a fire is controlled by a method, called the Incident Command System which is a system is organized to control everything from financing the operation to the actual tactics of attack. Some of the dangers of fighting fire can be reduced by taking appropriate safety measures which include: knowing where escape routes and safety zones are, paying attention to fireline hazards, and
proper use of personal protective equipment (covered in next section), and good communication. Another helpful resource in wildland fire fighting is “air operations” which is the use of aircraft to fight fires. Also the technology of using chemical agents, such as fire retardants (foams, gels, powders) to fight fires has been a powerful tool in reducing fire spread. The efforts needed to control a fire grow simultaneously with the degree of difficulty the fire is to suppress. At worst, a fire is capable of defeating every method of control yet devised; firefighting success may yield only to certain fire-fighting techniques (Brown 358).

Fire behavior varies with fuels, weather, topography and other factors of the local environment. For this reason, no two-fire suppression jobs are exactly alike, and how to control a particular fire cannot be detailed in advance (Brown 358). Suppressing a fire requires strategies (overall plans and actions to control a fire) and tactics (the techniques used to accomplish the strategy). In the strategy side of suppressing a fire, the initial size-up is important, this can provide insight on how the fire is behaving. The next step is the decision of taking offensive action (confining and controlling the fire by constructing a fireline) or by taking defensive action (used when the fire behavior does not favor an offensive approach or the dangers of an offensive approach are too high). For both of these strategies there are separate techniques and methods used to combat the fire.

A direct attack is a method applied directly on the flaming edge of a fire, this is usually done is lighter fuels where fire behavior is relatively controllable. The direct attack of “flanking” uses an anchor point (usually a road) and will work
around the fire to barricade it. Another direct attack method is the “tandem” attack; this method is a modified flanking attack that involves two or more fire engines or apparatuses. The lead engine takes heat out of the fire and the second engine is used to follow up, picking up hotspots and securing the line (Teie 215). The other method of attack is an indirect attack. This method is used when a direct attack is not possible or practical. In this method, “ground” is selected to gain the greatest advantage in suppression and control.

Basically the goal of all fire fighting is to eliminate one essential component of the fire combustion triangle. This can be done by either removing the fuels, removing the oxygen, or by reducing the temperature of the burning fuels. Typically, removing fuels is the most common method used in conventional forest fire fighting (Brown 359). This is usually done by creating a fire line that barricades the actual fire. In a successful “fire line” method, the actual fire itself should continue to burn until it reaches the fire line where there would be no more fuels left to burn. The fire would have nowhere to go and eventually burn out. There are several other ways to break the other sides or element of the fire triangle to suppress a fire. The use of water, retardants, and even dirt can be used to smother the fire eliminating heat and oxygen. Water is a very powerful tool; one volume of water will cool three hundred volumes of burning fuel. If used properly a little water goes a long way (Teie 169). There is another way of fighting fire that may seem ironic but can have very effective results, this method of fighting fire with fire is know as “prescribed burning”.
Prescribed Burning

All burning techniques are based on one or more characteristics of fire behavior to accomplish the purpose intended with the least amount of danger. Prescribed fires can be used to approximate the natural vegetative disturbance of periodic fire occurrence (USFS). However, using prescribed fire techniques as a suppression method during a fire will be emphasized. Generally there are four types prescribed burning techniques, which are, backfire burns, flank-fire burns, chevron burns, and head-fire burns. Another popular burning technique is the “center firing” method. This method consists of firing in such a way that a strong convection column is created at or near the center of the area to be burned (Brown 580). There are many more techniques of prescribed burning than the five mentioned above and each has their own unique style or a combination of one another.

“Backfiring” is often used as the term that covers all four types of prescribed burning to fight fire with fire. Backfiring or back burning is typically done by setting a line of fire along a natural or artificial firebreak and permitting it to spread against the wind or down a moderate slope (Brown 574). This technique is used most commonly on flat lands where the rate of fire spread is high or when burning under hazardous conditions as in steep slopes or dangerous terrain. The “flank-fire” method is set along a line parallel to the wind and allowed to spread at right angles to it. After a burned safety strip has been established along a firebreak, new fires or lines of fire in level terrain are set along short parallel lines into the wind (Brown 575). Where “backfiring” and “flank-firing” methods are used on level surfaces, the
“chevron burn” technique, which is basically a modified backfiring technique, is utilized in uneven terrain with ridges and valleys. It consists of establishing the line of fire in a crescent or V-shaped pattern. In general, the “chevron burn” with its V-shape mimics a natural wildfire with a strong head fire, giving stability to the backing fire to help maintain its desired direction (Brown 575). Then there is the “head-fire” burn, which sets fire to run with the wind or an upslope area. It is the reverse of the back-burn technique, though the head fire is seldom permitted to run freely for any considerable distance in a prescribed burning project (Brown 576). An advantage of this method is that no interior firebreaks are needed. During an actual wildfire, the backfiring techniques described above would be used in combination with one another to increase efficiency of wildfire suppression. The figure below illustrates the first four methods mentioned above.
Figure 4 (Brown 557)

A. Backburn

B. Flank fire burn

C. Chevron burn

D. Head fire burn

- Solid line: Roads
- Dashed line: Firebreaks

Small stream
**Incident Command System**

Organization during a fire is extremely important, and the development of the Incident Command System (ICS) in wildland fire fighting has proven to be very useful. The Incident Command System is an “all risk” operating system that can be adapted to fit any type and size of incident (Teie 323). The system can be expanded or contracted to fit any situational changes. ICS has five basic organizational functions: Command, Operations, Logistics, Planning, and Finance/Administration. The incident commander (IC) oversees all the levels of organization and assumes command of the incident. Typically the IC has three levels directly under him to coordinate with the rest of the organizational components. Under the IC should be an information officer (reports new information directly to the IC), a safety officer (ensuring appropriate safety measures are taken), and a liaison officer (who will liaise between the IC and the other components). The ICS Planning level develops the Incident Action Plan for each operational period; keep track of the status of all assigned resources; and tracks the fire (Teie 334). Logistics is responsible for all the services and supporting needs of an incident, including obtaining and maintaining essential personnel, facilities, equipment, and supplies (Teie 335). The Finance/Administration section of the ICS is responsible for monitoring incident related costs, and administering any necessary procurement contracts (Teie 336). The last section of the ICS is Operations, which, is responsible for the implementation of the incident’s action plan and air operations branch.
Air Operations

The use of aircraft in wildland fire is extremely efficient and reduces the dangers to the firefighters on the ground. Aircraft are able to drop mass amounts of water or retardants on a given area and reduce or suppress fire in a fraction of the time that it would require on foot. There are many different types of firefighting aircraft. There are air crane helicopters, dropping tankers (water and retardant), detection planes, transporters, etc. Some of the aircrafts tankers can carry up to fifteen thousand gallons of water and drop it at a desired location. Also, the refilling of water on some aircraft is extremely fast and efficient. The fire helicopters that drop water from a bucket/tarp apparatus can easily refill simply by submerging the apparatus in a water source. Another method for helicopters is by a hose suction system. A heavy duty hose can pull thousands of water up into their water tank and then release the water back down the hose as needed. Some massive air tankers can refill their water tank by flying close to a water source (usually lake) and scoop the water up without ever completely landing. Sometimes the best way is to go back to base and refill with water or retardant. The figures below show some of the fire aircraft.
**Figure 5** ("Air Tanker Dropping Fire-Retardant")

**Figure 6** ("Fire Crane Helicopter.")
Wildland Fire Safety

Safety is always first when it comes to fighting wildland fires. If a firefighter becomes injured or hurt, then they are no longer a useful tool in suppressing a fire and become a liability for others. Wildland firefighters need to maintain good health and be physically fit, their job is very demanding and stressful on the body. During a fire, firefighters are often required to work sixteen hour days, for weeks at a time.

Proper maintenance of a firefighters personal protective equipment (discussed in next section) and knowledge of how to use it are vital to survival. Each firefighter is trained on a standard set of guidelines for safety, negligence of any one of the guidelines could result in death. There are also guidelines that should help indicate “watch out” situations where safety may be compromised. These “watch out” situations should raise a warning flag whenever they are seen. The safety guidelines are known as the “Ten Standard Wildland Firefighting Safety Orders” (Teie 15). The following lists are the ten safety orders that must be followed and the ten situational “watch outs”. These orders are found in the book Firefighter’s Handbook on Wildland Firefighting: Strategy, Tactics, and Safety by William C. Teie.

TEN STANDARD WILDLAND FIREFIGHTING SAFETY ORDERS

1. Keep informed on fire weather conditions and forecasts.
2. Know what your fire is doing at all times.
3. Base all actions on current and expected behavior of the fire.
4. Identify escape routes and safety zones and make them known.
5. Post lookouts when there is possible danger.

7. Maintain prompt communication with your forces, your supervisor, and adjoining forces.

8. Give clear instructions and be sure they are understood.

9. Maintain control of your forces at all times.

10. Fight fire aggressively, having provided for safety first.

SITUATIONS THAT SHOUT, "WATCH OUT!"

1. Fire not scouted and sized-up.

2. In country not seen in daylight.

3. Safety zones and escape routes not identified.

4. Unfamiliar with weather and local factors influencing fire behavior.

5. Uninformed on strategy, tactics, and hazards.

6. Instructions and assignments not clear.

7. No communication link with crewmembers or supervisor.

8. Constructing line without a safe anchor point.

9. Building fireline downhill with fire below.

10. Attempting frontal assault on fire.

11. Unburned fuel between you and the fire.

12. Cannot see main fire; not in contact with someone who can.

13. On a hillside where rolling material can ignite fuel below.


15. Wind increases and/or changes directions.
16. Getting frequent spot fires across fireline

17. Terrain and fuels make escape to safety zones difficult.

18. Taking a nap near the fireline.

**Wildland Firefighting Equipment**

All firefighting tools and equipment serve the main function in the aid of breaking up the fire triangle, or eliminating one of the elements to suppress the fire. There are all sorts of equipment that can be used, ranging from a simple shovel to an air tanker dropping thousands of gallons of water as mentioned earlier. The methods of extinguishing a fire depend on the performance of a firefighter and his effectiveness. Both are indispensible. Mechanized equipment may replace a firefighter in actually doing the physical work, but the machines require a man’s direction and control in performing tasks. Firefighters do however need the aid of equipment to effectively do their job. All firefighting tools can be classified according to which functions they adhere, either by reducing the heat, eliminating oxygen, or removing the fuels. The most efficient tools are the ones that can serve more than one function. Digging and scrapping tools employed in building a fire line are devoted almost entirely to removing fuels from exposure to kindling temperatures (Brown 398). Equipment used to apply water to a fire carries a dual functioning role, it eliminates oxygen and can reduce the heat output of the burning fuel. Backfiring equipment is used as another function to remove fuel from an area by pre-burning fuels from the path of the main fire. All of the equipment mention thus
far is important. However, the most important equipment to a firefighter is his/her
Personal Protective Equipment (PPE).

Personal Protective Equipment

The PPE worn by wildland firefighters is designed to get the most work
efficiency out of a firefighter while still providing him/her adequate safety and
protection. The PPE is made up of flame-resistant shirts and trousers, a helmet,
goggles, shroud, web gear, gloves, heavy leather boots (at least nine inches tall),
head lamp, hearing protection, drinking water, fire shelter, cotton socks, and a
second layer of cotton undergarments (Teie 7). The flame resistant shirts and
trousers are usually made of Nomex and Kevlar, Nomex is a common material used
in many fireproof materials. The helmet, goggles, and shroud function to protect
your head and face when working. Dead branches (snags) can be fatal if they fall a
head when not protected by a helmet. The goggles help keep the debris and heat
away from the eyes while the shroud functions to keep the heat off the neck, face,
and ears. Gloves should be made of leather, fit well and be long enough so that a gap
does not exist between the shirtsleeve and the glove (Teie 9). Hearing protection is
important to have when working around loud equipment. As far as the second layer
of cotton undergarments go, experience has shown that a single layer of protective
clothing is not enough if a firefighter is exposed to extreme heat (Teie 7).
Firefighting gear is designed not to burn or melt, but it can and does transfer heat to
the skin. The solution is to wear a second layer of protective clothing.
One of the most important pieces of equipment of the PPE is the fire shelter, which can be a life safer when trapped in the line of fire and not being able to escape to a safety zone. The device was developed so that a firefighter can wrap it around his/her body, then fall flat on the floor with the open side facing the ground. This allows the firefighter to be in direct contact with the cool ground. One very important step before deploying the safety shelter is to make sure the ground where the shelter is located is cleared down to mineral soil that cannot be burned. Also the more mineral soil or un-burnable ground around the shelter is desired because it will help reduce heat radiation from penetrating the shelter. Knowledge and practice with the fire shelter is required training before a firefighter is allowed to work. The practice can be a matter of life or death. The figures below show an example of the complete PPE and a up close look at a fire shelter.
Figure 9 ("New Generation Fire Shelter." & "Fire Shelter.")

Tools

All fire equipment, whether powered or hand operated, is subject to the same basic criteria of suitability for the job (Brown 398). Because the firefighting endeavor varies, there is a need for a variety of tools for success. Having the right tool for the right job can make all the difference. There are basic variables to consider when choosing the right tool. They are: effectiveness, efficiency of productivity, versatility, portability, durability, simplicity, maintenance and replace ability, standardization, and economy. “No organization can operate on the basis that cost is of no consideration, nor can it afford to be without efficient equipment. In the long run, equipment must pay off in savings in suppression costs and in reduced damage” (Brown 401). During wildfires, large amounts of equipment belonging to several different agencies are gathered together for use by all firefighters, so standardization of tools is highly desirable. Most of the tools get serviced and repaired during the off hours of the night so minimum maintenance of
the tools used is essential. A tool or machine should be simple to use, easy to operate, and have the fewest parts possible because most firefighting is done under emergency conditions by men that may have limited equipment experience (Brown 400). The tools used during a fire need to be durable. Often times the strategy and plan to control a fire depends on the limited amount of tools. The portability of tools needs to be easy enough so that it does not tire out a firefighter before he/she even reaches the fire. Many times firefighters are required to haul their equipment into areas with difficult access. Versatility of a tool must be taken seriously when selecting which tools to bring along for the job. A machine or hand tool may be very effective and efficient but sharply limited in the number of tasks it can perform (Brown 399). Efficiency goes hand in hand with effectiveness and is often the deciding factor when selecting a tool. Simply the equipment chosen should provide maximum productivity for the desired job. Below is a list of the most common types of hand tools, powered machinery, smothering tools (used for mop up), and firing devices (used for prescribed burning) and their purpose or desired use; Information provided by Firefighter’s Handbook On Wildland Firefighting: Strategy, Tactics, and Safety by William C. Teie.

1. Axe – For cutting purposes (can even be used for breaking up hard soils).
2. Pulaski – Used for cutting and grubbing (good for constructing trenches).
3. Brush Hook – Used for cutting small diameter wood material such as brush.
4. Shovel – Used for scrapping, digging, cutting, trenching, smothering, raking, shielding and various other needs (extremely versatile).
5. McLeod – Most widely recognized tools on the fireline, Has multiple uses similar to the shovel (very effective tool for scrapping and raking).

6. Combi – Used for digging, scrapping, and cutting.

7. Fire rake/broom – Good for fireline construction and mop up purposes.

8. Handsaw – Used for cutting wood to reduce fuels in an area.

9. Chainsaw – Same use as a handsaw (quicker but also more dangerous).

10. Gunnysack – Old fashion but still effective, used for mop up.

11. Backpack Pumps - Used to extinguish flames by direct attack with water (can be very strenuous to carry for long periods of time).

12. Drip Torch – Handheld firing device (used primarily for backfiring).

13. Fusee – Also used as a firing device (resembles a common road flare)

14. Flare Guns – A long range firing device.


**Wildland Firefighting Vehicles**

A fire engine company is the most versatile element in the fire service (Teie 238). Engines can carry personnel, water, hoses, and other fire fighting tools to the scene of a fire. Fire engines come in many different sizes, shapes, colors, and have tanks that can hold water ranging from seven hundred fifty gallons to fifty gallons. However, not all engines can or are built to handle wildfires. Wildland fire engines are usually smaller and more versatile than the ones in city/suburban neighborhoods. Most of them are four-wheel drive, do not carry ladders like city fire engines do, and do not pump water as much or as fast as city engines (mostly
because water is usually scarce in the wildland and a high gallon per minute pump is not necessary). There are many varieties of wildland fire engines and they often perform specific duties suited to the area that they service. For example a wildland type six engine is a pickup truck that carries minor supplies and a small water tank. In some areas this type of engine is the most efficient. A commonly used wildland fire engine by Cal Fire is the type three engine. It carries five hundred gallons of water, 1 ½ inch to 1 inch hoses, and four crew members (Refer to figure below for a picture of a type three engine). One method of using an engine to fight fire is called “mobile attack” which is a fast and efficient method of controlling wildland fires, however, this attack can only be used in light fuels (grasses and scattered brush) and when topography permits maneuvering the engine across it. In a mobile attack, the engine drives along the edge of a fire and a firefighter walks just ahead of the engine, using a hose connected to the engine to extinguish the fire as they move (Teie 240). Another type of machine that helps in fighting wildland fires is a bulldozer. The bulldozer is extremely efficient in building a fireline and is a lot safer that building a fireline by hand. It however, like engines, can only be used when the topography allows it to traverse.

**Figure 10** (“Mobile Equipment”)
Pre-Fire Suppression Methods

Being prepared for a wild fire is just as important as actually being able to suppress the fire. In fact when appropriate measures are taken before an event occurs, time, energy, cost, and dangers can be greatly reduced. There are many parts to pre-fire suppression methods including: fire education, fire law enforcement, prevention engineering, planning (mapping, past records), and knowledge on behavioral prediction (Teie).

Education

Fire education programs play a major role in preventing fire. The “Smokey the Bear” campaign mentioned earlier has had the greatest educational effect about wild fires and the dangers that come with it. With its motto “Only You Can Make A Difference” it urges people to take preventative measures. The campaign provides great ideas of how people can help to prevent catastrophic wild fires. Simple tips such as: never leave a campfire unattended, build campfires away from low hanging branches/steep slopes/and dry grass, never throw a lit cigarette out the window of a vehicle. Community fire prevention programs in the wildland-urban interface are beneficial and can train people at the basic level on how to help if a fire breaks out.

Law Enforcement

One major way of preventing forest fires is the use of law enforcement by fire marshals, park rangers, and policemen alike. Patroling around campgrounds and other wildland areas can help reduce fire negligence and increase the alert time if a
fire does break out. Also the enforcement of building codes to meet fire safety requirements can help protect the property if a fire breaks out in the wildland-urban interface areas. On the topic of buildings, new fireproof technology and materials are being developed by engineers to reduce the impact of fire.

**Wildland Firefighter’s Role**

For the firefighter side of pre-suppression tactics, knowledge of wildfire and being able to predict its behavior can reduce the time, energy, and dangers of the fire. Being able to know where the fire is going to move will not only cut down the difficulties to fight the fire but save lives. Proper training can help save the lives of the courageous firefighters who show no fear in the face of flames. Wildland firefighters are in exceptionally good shape, knowledgeable of fire behavior, and are very effective with the tools used to combat the wildfire. Fire fighters will often start a controlled prescribed fired in high-risk fire areas to help prevent a natural caused fire from have a catastrophic effect. Prescribed fires not only reduce the chance of a major fire from occurring, they reduce the efforts needed to control that fire. This happens because prescribed fires create firebreaks in areas preventing a fire from “jumping” to the other side or becoming uncontrollable. The figure below shows an example of a firefighter using a drip torch to light a prescribed fire.

**Figure 11** ("Drip Torch in Backfiring Use.")


