Fire Management Study Unit

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Fire Management

Overview

For the past 400 million years, Earth has had the capacity to burn. Fire is a natural event in most forest ecosystems. Lightning ignited fires in prehistoric times that helped stimulate life by catalyzing Earth's earliest organic compounds. Entire plant communities have adapted to and now depend on the fire process. Fire's influence causes certain types of vegetation to thrive and regenerate in the fire dependent ecosystem.

Fire can have both positive and negative effects on the environment. Understanding this catalyst is important in managing fire to promote forest health, protect natural resources and achieve sustainability of ecosystems.

Fire Behavior

Objectives

Understand the process of combustion.
Identify methods of heat transfer.
Describe how a fire starts, spreads and burns.
Describe how weather and topography affect fires.
Recognize nature's danger signals.

Combustion

The manner in which a spark flames into life, flares up, spreads, fades and eventually dies is all in accordance with natural laws. Fire is a chemical reaction sometimes called rapid oxidation. When a substance is affected by enough heat a flammable gas is released. Then, in the presence of enough oxygen and continued heat, a flame (combustion) occurs. With a continuous supply of heat furnished by the combustion itself, air to supply oxygen, and fuel to burn, a fire will exist. Fires need *heat*, *fuel*, and *oxygen* to burn. These three elements are known as the "fire triangle". Remove any one of these three elements in the fire triangle and the fire will go out.

Reasonably accurate predictions can be made on what will happen given certain conditions of fuel, topography and weather during the process of combustion. These are discussed in this unit.

Heat Transfer

Heat must move from one molecule of fuel to another for combustion to continue. This heat is transferred by three processes of movement called ***radiation, convection*** and ***conduction.***

Radiation is waves or rays that move away from the source of heat. For example, the sun radiates heat to the earth's surface and causes it to grow warmer. During the cool of night, part of that heat radiates away from the earth into the cooler air. The transfer of heat by radiation varies inversely (increases or decreases when the other proportion increases or decreases) as the square of the distance from the heat source. For example, a camper is comfortable at 68 degrees Fahrenheit (68° F.) two feet from the campfire. The second camper cannot receive the same amount of radiated heat at a distance of four feet away unless the fire is made four times as hot. The third camper at a distance of six feet away will not receive a comfortable amount of heat (68° F.) unless the fire is made nine times as hot. However, nine times the heat to make the third camper comfortable will ignite the clothing of the camper nearest the fire.

Convection is the way heat moves in heated air masses. Air absorbs heat, expands, becomes drier and lighter than the surrounding cooler air and rises. Think of convection as a smoke column with hot gases and embers that dry and ignite other fuels.

Conduction is the way heat moves through solid objects to the air which touches it much like electricity. Most forest fuels like wood are poor conductors of heat. That is why a burning log must be turned over to allow heat from the underside to radiate into the air or why a smoldering fire must be chopped out of a log or tree.

Start and Spread of Wildland Fire

Weather, fuel and ***topography*** are the three principal environmental elements that affect wildland fire behavior. Each of these elements have certain conditions and characteristics that determine the intensity of the fire and how fast or slow a fire will spread. Weather is difficult to understand because it is constantly changing. However, because it has tremendous influence on fire, a basic knowledge and ability to make field observations of weather is important in fire management.

Weather

The main forces that "create" weather are solar energy (heat from the sun), the force of gravity and the phenomenon that all elements seek a state of balance or equilibrium. *Temperature, wind, relative humidity*, and *precipitation* are the main weather factors that affect the start and spread of wildland fire.

Temperature is the measurement of warmth or coldness. The main source of heat for outside air is solar energy from the sun. Fuel (any combustible material) and ground temperatures receive and reflect radiation from the sun. The surface air temperatures rise or cool as contact is made with the fuels and the ground. Fuels in the sun will be easier to ignite than fuels in the shade because of temperature differences which can be as much as 50° F. between open sunlit areas and dense shade. Wood ignites between 400° and 700° F. Woody fuels will burst into flame at approximately 540° F. provided enough oxygen is present. The sun can only heat a surface to around 160° F. which is far below the possibility of spontaneous combustion. However, this heat will boost fuel combustion a hundred degrees or more before the igniting spark is applied.

Wind is the movement of air. The average person thinks of wind as the horizontal movement of air that can be felt, but convection winds carry air upward. Wind is one of the most important influences on fire behavior. Wind increases the supply of oxygen, influences the direction the fire will spread, dries fuels, carries sparks ahead of the main fire and moves air heated by convection to downwind fuels. Air movement is unceasingly stimulated by several major forces over the earth. First, there are vast heated areas of the earth's surface that produce rising air currents which return to earth in cooler regions. Then, there is the gravitational effect of the turning earth on these tremendous currents. Seasonal changes alter the pattern of wind movement because the hot and cold regions of the earth are shifted. Wind and all weather with it are then modified by water bodies, land masses and lesser local elements on a smaller scale. Wind can be compressed under pressure, expanded and contracted with heat and cold, made moist or dry and may pause, then gust with violence in any direction.

It is estimated that one pound of fuel requires 200 cubic feet of air during combustion. Wind makes more oxygen available to the fire which increases the rate of fuel consumption. Winds may cause fires to jump prepared or natural barriers or send a fire through tree tops when there is little understory heat or fuel. Over areas such as plains or long, wide valleys, prevailing wind direction can be easily predicted throughout the year, but in rough topography, wind currents are thrown into confusion as vegetation, large rocks, mountains or hills create drag upon wind movements.

Winds change direction or intensity throughout the day and night with temperature fluctuations and local topography. Large bodies of water such as oceans and lakes, usually cause winds to blow inland as the sun warms the land then outward when the land cools more rapidly than the water. Winds will blow upward when mountain slopes warm under the sunshine and down slope as the surface cools at night.

Relative humidity is the relationship between the moisture vapor in the air now and the total it could hold at its present temperature. Air passes over surfaces picking up water vapor until it becomes saturated and precipitates moisture. When it has reached this point, the air has a relative humidity of 100 percent. Warm air can hold more moisture than cold air. When the relative humidity descends below 30 percent, conditions are more favorable for wildfire because the air can absorb more moisture from fuels. The less moisture in the fuel, the less time is required for heat to bring about combustion. Light fuels such as grass, dead leaves and pine straw lose moisture quickly with changes in humidity. Heavy fuels such as limbs, logs and tree trunks dry out more slowly.

Precipitation is the liquid or solid moisture that falls from the atmosphere. Fuel moisture is affected by the amount and duration of precipitation. Light fuels are affected more quickly than heavy fuels since they gain and lose moisture usually within one hour. Heavy fuels are not affected as much since they gain or lose moisture more slowly. Green living leaves gain and lose moisture according to the transpiration habits of their species, so it is not unusual to see "green" trees burning in a wildfire.

A large amount of precipitation in a short time will not raise the fuel moisture as much as lesser rainfall over a longer period of time where the fuels can absorb more moisture before it runs off. Moisture in fuel will not burn. It must be converted to steam by heat and driven away before combustion will take place.

Large fires can make their own weather. Large convection updrafts cause air currents along the ground toward the fire and sometimes cause down drafts beyond the fire perimeter. Smoke clouds may shade the sun and alter the temporary radiation of solar heat toward and away from the earth.

Fuel

Fuel is any combustible material. Wildland fuels are basically live and/or dead plant material. These vary from one area of the country to another with the ecosystem. Fuels are important to study in fire management because they are the one component of the fire triangle humans can influence the most. Wildland fuels are grouped into four major types based on the primary fuel that carries the fire. These are *grass, shrubs, timber litter* and *logging slash.*

Grass is found in most ecosystems, but it is more dominant as a fuel in desert and range areas. It can become prevalent after a fire in forested areas. Fires in grass spread rapidly but burn out quickly.

Shrubs are also found throughout most areas. Palmetto and gallberry are highly flammable shrubs in the southeastern United States. As you go westward, sagebrush and chaparral are the highly ignitable shrubs.

Timber litter is leaves, pine needles, small twigs and limbs you find on the forest floor especially in mountainous areas.

Logging slash is the debris left after timber harvesting or silviculture operations such as pruning, thinning or shrub cutting. It includes broken understory trees or shrubs, stumps, bark, branches, chunks or logs.

Regardless of the type of fuel, fire behavior is dependent on characteristics such as *fuel* *moisture, size and shape, fuel loading, horizontal continuity* and *vertical arrangement.* We have discussed the role weather plays in *fuel moisture*. Different species have different moisture holding capacity. Dry fuels, will of course, ignite and burn more easily than the same fuels when they are wet. As fuel moisture increases, the amount of heat required to ignite and burn that fuel also increases.

The *size and shape* of fuels also determine their ability to burn. *Light fuels* which have a diameter of one-half inch or less, dry out quickly, ignite quickly as they are surrounded by plenty of oxygen, burn quickly and are easily extinguished. Light fuels include grasses, shrubs, leaves, twigs, and pine needles. *Heavy fuels* are larger such as limbs, logs and tree trunks which dry out more slowly, heat more slowly and usually have bark or some protective mechanism to prevent moisture loss.

Fuel loading refers to the quantity of fuels in an ecosystem. However, this does not necessarily mean the fire will burn with great intensity. There are many factors that affect the availability of fuel for combustion, such as the size and shape, fuel moisture, the arrangement of moisture and the proximity of fuel particles to one another in respect to the free movement of oxygen around the particles. Hemlock needles on the ground will be less flammable than pine needles or oak leaves at the same place and time because the finer needles are too compact to allow enough oxygen for rapid combustion.

Horizontal continuity is the way fuels are spread over an area. Uniform fuels are the same type that form a network connecting each other to provide a continuous path for a fire to spread. Patchy fuels are distributed unevenly over the area with breaks or barriers such as rock outcroppings, bare mineral soil or less flammable species.

Vertical arrangement is the way fuels are spread vertically over an area. This arrangement includes *ground fuels, surface fuels* and *aerial fuels*. *Ground fuels* are the combustible materials arranged vertically in the ground such as tree roots, deep duff or thick peat. Ground fires burn the organic and combustible fuel beneath the surface such as a peat fire.

Surface fuels are combustible materials lying immediately above the ground including grass, shrubs, timber litter and logging slash. Surface fires burn this fuel.

Aerial fuels are the green and dead materials located in the upper canopy including tree branches and crowns, snags, hanging moss and vines and tall shrubs. Crown fires burn through the tops of trees or shrubs and can progress with or independent of a surface fire.

Topography

The lay of the land is the most stable of the three environmental elements and easier to predict its influence on weather and fuel. Topographic factors that affect the start and spread of wildland fire are *aspect, slope, shape of the area, elevation*, and *barriers*.

Aspect is the exposure of a slope to the sun. It usually determines the amount of heating the land gets from the sun. North of the equator the sun's rays shine most directly upon the south and southwest slopes. Southeast and western slopes receive about the same amount of heating and northern slopes receive the least exposure. This starts a chain of reactions that result in differences in soil and vegetation regardless of the parent soil material. Southern slopes generally have light fuels, higher temperatures, lower humidity, lower fuel moisture and are most critical in terms for the start and spread of fire. Northern slopes have heavier fuels, higher humidity, cooler temperatures and higher fuel moisture.

Slope is the degree of incline of a hillside. Fires burn faster uphill than downhill because the fuels above the fire are brought into closer contact with upward moving flames. The steeper the slope, the faster the fire burns. Convective and radiant heat help the fuel catch on fire easily. A fire near the bottom of a slope will spread more rapidly during daytime conditions than a fire near the top of the slope because it has a greater uphill run. Burning material also can roll downhill and ignite fuel below the main fire.

Shape of the country influences the direction, intensity, and rate the fire will spread. Canyons, ridges and saddles are topographic shapes that influence weather especially wind direction.

<u>Box canyons</u> have steep walls and a generally flat floor. Air will be drawn in from the canyon bottom much like a wood burning stove or fireplace creating strong up slope drafts (the chimney effect) and rapid spread of fire. This can result in extreme fire behavior and be very dangerous.

<u>Narrow canyons</u> also have steep walls with a narrow floor that can best be described as “V” shaped. Wind direction will normally follow the direction of the canyon and fire can easily spread to fuels on the opposite side by radiation and spotting. Wind eddies and strong up slope air movement can be expected at sharp bends in a canyon.

<u>Wide canyons</u> have the same characteristics as box and narrow canyons except the floor is much wider so there is less danger of fire spotting across to a different slope. The prevailing wind will not be deflected by sharp up or down drafts. There will also be strong differences between fire conditions on the north and south aspects of a wide canyon.

<u>Ridges</u> are the long narrow edges or the crest of a hill. Fires burning along lateral ridges may change direction when they reach a point where the ridge drops off into a canyon. This is caused by the flow of air coming from the canyon. Sometimes a whirling or eddying fire may result around the point of a ridge.

<u>Saddles</u> are the ridges connecting two higher elevations such as a mountain pass. Wind is channeled through narrow or constricted areas and spreads out on the leeward or downwind side with eddying action.

Elevation or the height above sea level plays a large role in both the amount of fuel available and the condition of the fuel. Fuels at lower elevation dry out earlier in the year than fuels at higher elevations due to higher temperatures. At extremely higher elevations there may be no fuel. Elevation also affects the amount of precipitation received, winds and its relationship to the surrounding terrain.

Barriers are natural and man-made obstructions to the spread of fire. Natural barriers include rivers, lakes, rock slides, some fuels whose moisture content or other characteristics prevent them from burning as well as other fuels in the area. Man-made barriers include roads, highways reservoirs and the fireline built to control the fire.

Nature's danger signals

Ability to recognize the signs warning of potential dangerous conditions is very important in fire management. Turbulent air movements near the ground create a serious hazard to life and property as well as difficulty in controlling fire. It is important to be able to determine wind direction. Wind direction is the direction the wind is blowing *from,* i.e. a north wind means the wind is blowing from the north. Ability to identify the types of clouds in the area also helps to determine developing weather conditions that usually bring strong winds. These weather conditions are:

High and low pressure systems are strong general winds that are usually influenced and modified in the lower atmosphere by terrain. These systems may also have gradient winds that occur 1,500 feet above mean terrain height. They flow parallel to the isobars or contours and have a speed such that the pressure gradient and centrifugal forces of the area are in balance.

Cold fronts in the northern hemisphere have southeasterly to southwesterly winds *ahead* of the front and westerly to northwesterly winds *behind* the front with cooler air. These winds are generally 10 - 20 miles per hour for 12 to 24 hours. A cold front is the boundary line between a cooler air mass which replaces a warmer air mass. The heavier cold air may cause the warm air to be lifted. If the lifted air contains enough moisture, cloudiness, precipitation, and even thunderstorms may result. If both air masses are dry, there may be no cloud formation.

Foehn winds pronounced "fern". Foehn winds are a type of general wind that occurs when stable, high pressure air is forced across and down the lee slopes of a mountain range. The descending air is warmed and dried as it passes due to compression. These winds are known by local names such as Santa Anna and Mono of California, East wind of the Pacific Northwest and Chinook on the east side of the Rockies.

Thunderstorms are violent local storms produced by cumulonimbus clouds accompanied by thunder, lighting, strong gusty winds and sometimes hail. They seldom last over three hours for any one storm. A tall, building cumulus cloud is an indicator that a cumulonimbus cloud is forming. The cloud resembles cauliflower and has a dark flat base. The top is usually anvil shaped and is well above the freezing level. The direction of thunderstorm movement is generally the direction the anvil shaped top is pointing. Down draft winds from thunderstorms spread radically in all directions when they hit the ground but they are always away from the thunderstorm. Velocities can be as high as 60 miles per hour. Surface winds will be the strongest in the direction the thunderstorm is moving. Lightning is caused by the equalizing of positive and negative electricity at the upper and lower limits of the cloud. Sometimes lightning flashes from cloud to cloud which helps dissipate the electrical tensions and sometimes it strikes earth often igniting fires.

Whirlwinds, dust devils and mirages are indicators of unstable air. Wildland fires burn hotter and with more intensity when the air is unstable. There is usually good mixing of air with up-ward motion when the air is unstable. Smoke will rise straight up and often to great heights; cumulus type clouds will form; visibility is usually good and gusty winds are present. Dust devils are small whirlwinds that form usually around mid day when the sun has heated the surface air to the point the air expansion is out of balance with the density of the air above the ground. When conditions are right for dust devils to form, a wildfire “blow-up” can occur over a smoldering fire and the whirling air can spread flames in its path. Dust devils can range from 10 feet to over 100 feet in diameter with heights from 10 feet to 4,000 feet. Wind speeds are often up to 50 miles per hour. The same unstable air conditions that produce dust devils can produce lake mirages.

These “lakes of water” illusions disappear as one approaches or changes the observation point. The illusion is caused by the bending of light rays through layers of air of different density The lake mirage is probably the reflected sky. The presence of whirlwinds, dust devils and mirages are extremely dangerous to firefighters.

Inversions take place under stable air conditions. They are easy to recognize because they trap smoke, impurities, and gases resulting in poor visibility especially in valleys. An inversion is a layer in the atmosphere where the temperature increases with altitude. Smoke and other impurities will rise only until their temperature equals that of the surrounding air, then will flatten out and spread horizontally. The rupture of the inversion boundary under pressure spells trouble for fire management.

The *thermal belt* is also stable air associated with mountainous slopes. This belt is the area with the least variation in daytime temperatures, the highest average temperatures and lowest average relative humidity. They are usually found on the mid-portions of slopes. Within the thermal belt, wildland fires can remain active throughout the night.

In a wildland fire, keep an eye on the smoke column. This will give you an idea of the direction the fire will spread, location of spot fires and changes in fire intensity. Danger signals to watch for are small groups of trees or brush beginning to torch, simultaneous fires starting or smoldering fires picking up in intensity. Also be aware of firewhirls developing inside the main fire and fires in the treetops.

A basic knowledge of fire behavior is essential in both wildland fires and prescribed fires to insure human safety and to determine suppression methods.

Different Types of Fires

Objectives

1. Identify the basic types of fire.
2. Identify fire characteristics that determine damage.
3. Recognize toxic fires.
4. Analyze effects of fire on wildlife, water quality, soil and air.

Types of Fire

There are different types of fires, each with its own characteristic behavior, often requiring different fire fighting techniques. These are segregated mainly by the types of fuels which have similar burning tendencies. These are *ground fires, surface fires, crown fires* and *spot fires.*

Ground fires burn below the earth's surface in layers of organic material such as peat, tree roots or deep duff. These fires are slow smoldering, have little or no flame and little smoke.

Although these fires are rare, it is difficult to control them once they get started.

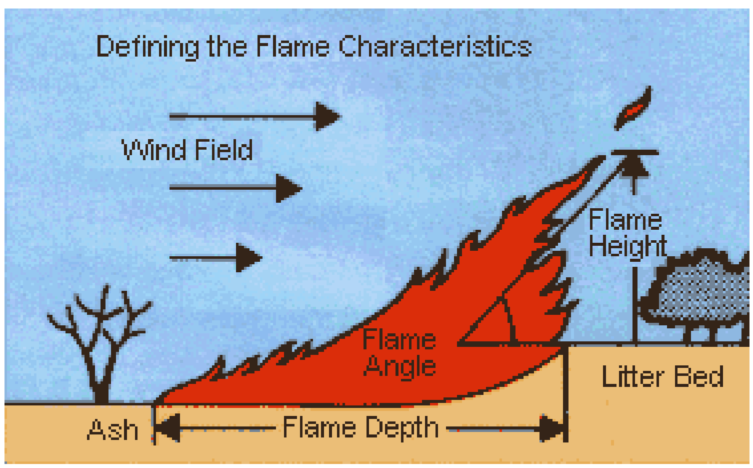
Surface fires burn lower levels of vegetation such as grass, timber litter, understory shrubs, and logging slash. Often in dry weather or high wind conditions, these are considered flashy fuels as they are easily ignited and consumed quickly.

Crown fires burn through the tops of trees. They are particularly dangerous because they are unpredictable. They may burn at the same rate as the surface fire below or may race through the crown ahead of the surface fire depending on topography, wind, moisture, and species. Tree tops can also be considered flashy fuels.

Spot fires are started by wind carrying burning bark and leaves ahead of the main fire igniting other areas. This is an indicator of unstable weather conditions and requires special fire fighting operations.

Fire Characteristics

Flame height, depth, angle and *scorch height* are characteristics that determine the degree of damage a fire will do. Add *intensity, the season of the year* and *frequency of fire occurrence* and you have an even better tool to determine environmental impact.



Flame height is measured vertically from ground level. This measurement does not take into account short, upward flashes of flame.

Scorch height is the height at which leaves are killed by the heat of the fire. The scorch height increases faster than flame height due to increased heat intensity.

Flame depth is the width of the zone within which continuous flaming occurs behind the fire edge. The depth of the fire is an important factor in the survival of the larger animals caught in a fire. Research suggests that in severe fires, some animals will double back onto already burned ground if the flame height and depth is not too great.

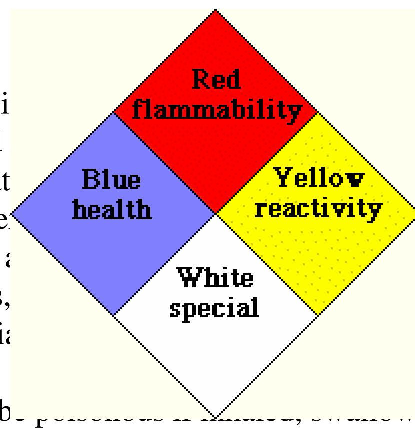
Flame angle is measured from the horizontal in front of the fire. A vertical flame is 90 degrees while a leaning flame has an angle of less than 90 degrees. A fire burning up a steep hill is particularly dangerous as it pre-dries and heats the fuel before the flames actually reach it.

Intensity is the rate at which energy is released (measured in kilowatts) while the fire is burning. The intensity is proportional to the amount of fuel available. Fire intensity quadruples each time the amount of fire fuel doubles. A prescribed fire may have a flame height of 2 feet and a low intensity of about 300 kw while a wildfire can have an intensity between 2,000 kw per meter and up. Ability to control a fire is greatly reduced when the intensity is above 3,000 kw per meter.

Frequency is the average number of years between fires. Records of fires are kept with such details as climatic conditions, how the fire started and the amount of destruction. This gives an indication of fuel build-up on the forest floor and how often fire occurs in a region.

Season of the year often determines amount of moisture in vegetation and forest floor litter. For most of the United States more moisture is present in the spring and less in the fall.

Toxic Fires



Technology has brought many changes i [illegible] growing number of
hazardous materials that may catch fire and [illegible] ods and precautions.
Hazardous materials are defined as any mat [illegible] s that may produce
serious health, fire or explosive danger. Eve [illegible] nd rural areas con-
tains some hazardous materials. Examples a [illegible] lothing, home and
office furnishings, cleaning supplies, paints, [illegible] torage and transpor-
tation of large amounts of hazardous materi [illegible] case of fire.

Toxic materials are substances that can b [illegible] ed, absorbed, or introduced into the body through cuts or breaks in the skin. Often hazardous materials produce toxic fumes in the presence of heat or fire. An international identification system has been developed to recognize the presence of hazardous material and the danger it poses. These are identified by a standard diamond symbol with colored background and numerical ratings. **Blue** indicates a *health hazard*; **red,** a *fire hazard,* **yellow** is *reactivity hazard* and **white** indicates *additional information is needed to identify the hazard.*

The diamond-shaped symbol will also have a number from 1 to 4 which indicates the degree of hazard. These are:

4 = Severe Hazard

3 = Serious Hazard

2 = Moderate Hazard

1 = Slight Hazard

0 = Minimal Hazard

All hazardous materials are required to be labeled with descriptive placards. You see these on pesticide containers, gasoline, railroad cars, ships and trucking vehicles carrying these materials. Hazardous materials are further identified by marking systems developed by the country's military or the most widely used *United Nations Classification System*. This system divides hazardous materials into nine categories or classes. The class number will appear at the bottom of the diamond-shaped placard. Accompanying the background color, and class number is a four-digit identification number which must be used with the *Emergency Response Guidebook* to further identify the product and degree of hazard it poses.

The U.N. System divides hazardous materials into the following classes:

Class 1	Explosives
Class 2	Gases
Class 3	Flammable Liquids
Class 4	Flammable Solids
Class 5	Oxidizers
Class 6	Poisons and Infectious Substances
Class 7	Radioactive Substances
Class 8	Corrosives
Class 9	Other Hazardous materials not otherwise identified

The red placard indicates the material presents a flammable hazard. The "3" indicates the class of hazard is a flammable liquid and the 4-digit number 1090 must be "looked up" in the *Emergency Response Guidebook* to identify the flammable chemical, its dangers and how to handle it.

In this case, the *Emergency Response Guidebook* identifies 1090 as Acetone. Acetone has still another code (127) which one must look up for more information. Chemicals assigned code 127 should be approached with the knowledge given in the *Emergency Response Guidebook* and printed here as an example.

POTENTIAL HAZARD

FIRE OR EXPLOSION
Highly Flammable: Will be easily ignited by heat, sparks or flames.
Vapors may form explosive mixtures with air.
Vapors may travel to source of ignition and flash back.
Most vapors are heavier than air. They will spread along ground and collect in low or confined areas (sewers, basements, tanks).
Vapor explosion hazard indoors, outdoors or in sewers.
Some may polymerize (P) explosively when heated or involved in a fire.
Runoff to sewer may create fire or explosion hazard.
Containers may explode when heated.
Many liquids are lighter than water.
HEALTH
Inhalation or contact with material may irritate or burn skin and eyes.
Fire may produce irritating, corrosive and/or toxic gases.
Vapors may cause dizziness or suffocation
Runoff from fire control may cause pollution.

PUBLIC SAFETY

Call Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.
Isolate spill or leak area immediately for at least 25 to 60 meters (80 to 160 feet) in all directions.
Keep unauthorized personnel away.
Stay upwind.
Keep out of low areas.
Ventilate closed spaces before entering.
PROTECTIVE CLOTHING
Wear positive pressure self-contained breathing apparatus (SCBA)
Structural firefighters' protective clothing will only provide limited protection.
EVACUATION
Large Spill
Consider initial downwind evacuation for at least 300 meters (1000feet).
Fire
* If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (l/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.
FIRE
CAUTION: All these products have a very low flash point: Use of water spray when fighting fire may be inefficient.
Small Fires
Dry chemical, CO_2, water spray or alcohol-resistant foam

Large Fires
Water spray, fog or alcohol-resistant foam.
Do not use straight streams.
Move containers from fire area if you can do it without risk.
Fire Involving Tanks or Car/Trailer Loads
Fight fire from a maximum distance or use unmanned hose holders or monitor nozzles.
Cool containers with flooding quantities of water until well after fire is out.
Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank
Always stay away from the ends of tanks.
For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
SPILL OR LEAK
ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
All equipment used when handling the product must be grounded
Do not touch or walk through spilled material.
Stop leak if you can do it without risk.
Prevent entry into waterways, sewers, basements or confined areas.
A vapor suppressing foam may be used to reduce vapors.
Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers.
Use clean non-sparking tools to collect absorbed material.

Large Spills
Dike far ahead of liquid spill for later disposal.
Water spray may reduce vapor; but may not prevent ignition in closed spaces.
FIRST AID
Move victim to fresh air. Call emergency medical care.
Apply artificial respiration if victim is not breathing.
Administer oxygen if breathing is difficult.
Remove and isolate contaminated clothing and shoes.
In case of contact with substance, immediately flush skin or eyes with running water for at lest 20 minutes.
Wash skin with soap and water.
Keep victim warm and quiet.
Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

Recognizing the warning placard is the first safety measure in identifying the potential for a hazardous material fire. There are over six million unique substances listed by the Chemical Abstract Services of which 75% are listed in hazardous material literature. Many of them are known by different names. The *Emergency Response Guidebook* lists about 2,400 chemicals and classes of chemicals with the same type of information described in the *acetone* example so it is impossible for one to learn all the hazards, and exactly what to do without referring to the *Guidebook*.

While some toxic fires do produce warning signs such as unusually dark or light smoke, odors, etc. others do not. One must NEVER rely on sight, smell, taste, or touch to detect the presence of leaking or spilled hazardous materials. If these materials are there they propose a potential hazard. The location of significant quantities of hazardous materials and the type of materials stored, transported or manufactured in an area should be reported to the fire department annually. Fires threatening or burning hazardous materials should be immediately reported to the appropriate authorities who are trained and equipped to handle such fires.

Certain plants growing in the forest also produce toxic fires. The oils in Poison Oak, Ivy and Sumac are carried in higher concentrations when burned in smoke. These not only can cause annoying skin rashes and irritations, but can be fatal if the smoke is inhaled into the lungs. Learn to recognize these plants. They are part of the forest ecosystem and burn along with forest floor litter and the trees. Take precautions not to inhale smoke from any fire.

Effects of Fire

Wildlife is affected by the type of fire and type of vegetation being burned. Fire, where heavy fuels exist, tends to burn intensely and kill more animals, especially invertebrates and micro-organisms. Generally, vertebrates are rarely killed in fires, but when a deer, rabbit, squirrel or other animal dies in a fire, it usually has little effect on the population of its species. Wildfires that burn hotter also tend to kill more vegetation including overstory trees. Fires are more damaging to wildlife if they occur during nesting and denning season when young animals have a harder time avoiding intense heat and smoke.

Fire releases minerals into the soil which stimulates plant growth. Wildlife, in turn, benefit from additional minerals when they eat the new plant growth or the charcoal and ash. Some rabbits and white-tailed deer have been observed eating the charred bark or ash after a fire. Wildlife with flexible habitats and diets thrive while those who eat foods found only in mature or old-growth conditions, decrease. Burning helps remove the heavy litter layer on the forest floor making seeds more accessible to wildlife. It also creates an opening for dusting used by species such as bobwhite quail, wild turkey, and ruffed grouse.

The diversity of vegetation tends to increase when an area is burned. Burned areas often "green-up" faster in the spring thus providing early food and cover for many species of wildlife. Forbs and legumes such as beggarweed, partridge pea, and butterfly pea are quickly established after a fire. They provide nutritious, succulent forage (both vegetative and reproductive (fruit) tissues are consumed) for a variety of wildlife. Seed production is stimulated. Roaming animals such as deer and bear will find new pathways for moving to and from water, breeding areas and summer/winter ranges by following the burn pattern.

Invertebrates and their eggs are often killed by flames and heat. Flying insects are attracted to heat, smoke and to dead or damaged trees. Populations of certain species of insects may increase during and after a fire. Wildfire destroys the sap that keeps bark insects away. These insects soon move into a burned forest followed by woodpeckers and other birds who nest in cavities.

Fire can have negative effects on aquatic life. Leaf packs are the source of energy for stream food chains. When a fire burns streamside vegetation, it reduces the amount of leaves that eventually reach the stream. This results in a reduction of the amount of aquatic life the stream can support. The loss of streamside vegetation removes the "buffer" that prevents eroding sediments from entering the stream. These sediments can reduce productivity for phytoplankton, reduce the size of fish spawning beds and resting places as sediment fills up pools, and can smother fish and aquatic insect eggs. Smothering prevents oxygenated water from reaching the egg surface and kills newly emerged fish fry by covering the gills with fine materials.

Burning streamside vegetation also raises stream temperatures by removing overhanging canopy allowing more sunlight to penetrate the water surface. It can also increase turbidity (a measurement of the amount of suspended particles in water such as silt, clay, phytoplankton, zooplankton and organic matter). Increased turbidity causes fish to have trouble seeing their food and may crush or dislodge eggs. Higher stream temperatures will decrease oxygen content and increase incidence of fish disease and kill or drive away fish species that require cooler water temperatures. Less mobile insects may also die when water temperatures increase. Nutrient loading will proliferate algae production resulting in a more diverse population of insect larvae which is beneficial to fish if toxic levels are not reached.

Water quality responses to fire involve turbidity and sediment. Sediment is the soil that gets in the water of the stream and then settles in the stream bed. Concentrations of various nutrients often increase after a fire. Some of these such as nitrogen often exceed drinking standards for short periods of time. Streams usually return to pre-fire levels of these nutrients quickly. Concentrations of a particular nutrient are usually reduced as the stream mixes with tributaries and groundwater flow.

The effect of a fire on water quality is often unpredictable as a number of factors come into play. Site differences in topography, soil characteristics and moisture content, variation in fuel moisture and fuel loads, density of vegetation, microclimates associated with a given slope, aspect and topographic position, and variations in weather patterns before, during and after a fire effect turbidity and sedimentation. As a general rule, the volume of water in a stream increases after a fire due to a reduction in plant cover.

A reduction in plant cover increases the susceptibility of nutrients to erosional losses. Nutrient uptake by plants is then reduced, which further increases the potential for nutrient loss by leaching.

Soils change as a result of fire whether the fire is a prescribed burn or a wildfire. When forests burn, the form, distribution and amount of elements or nutrients in the forest ecosystem change. Nutrients are continually cycled within and among the various organic components of the soil. When burn temperatures reach 100^{o} C., fungi and bacteria are lost. Nitrogen loss begins to occur at 200^{o} C., sulfur at 375^{o} C and phosphorus and potassium at 774^{o} C. Severe or stand replacing fires may burn the duff and the top layer of soil so that only ash remains on the surface and the mineral soil is "cooked" and discolored by a chemical change. Other elements such as calcium and manganese are vaporized at temperatures that reach more than 1000 degrees C.

Moist, thick duff will protect the soil from heating by fire. If the litter layer is thin, dry or partially burned the underlying soil can be heated substantially. The degree of heating depends on the type of fuel, intensity of the fire, the thickness, packing and moisture content of the litter layer and the properties of the soil itself such as water content, texture, and organic matter present. Destruction of micro-organisms in the soil may account for the increased plant growth after a fire as competition for nutrients is reduced but they quickly recover.

Nitrogen fixing plants also grow prolifically after a fire and may restore lost nitrogen. Nitrogen becomes available when it is cycled through soil organisms, oxidized by fire, precipitated or added in the form of nitrogen fertilizer. Bacteria also recover quickly as the conditions for their growth and reproduction are favored by the decreased soil acidity, optimal temperature, moisture and nutrient-rich ash.

Air quality is affected by fire. Smoke can reduce visibility on roads and airports as well as in the forest itself. Over 90 percent of forest smoke is water vapor and carbon dioxide. The major problem with smoke is the small particles that can't be seen with the naked eye. These particles can be inhaled into the lungs and compound any respiratory problem. Smoke can irritate the eyes, nose, and throat, and make breathing difficult. It can also spoil fresh paint jobs and laundry hung outside to dry for at least two miles downwind.

Fire Suppression

Objectives

Determine when to suppress a fire.
Know how fires are detected.
Know the causes of fire.
Understand how fires are suppressed in Georgia.
Know fire safety standards.
Understand interagency cooperation.

Fire Policy

Determining when to suppress a fire depends on the resource management goals and potential destruction of resources and property. At the turn of the 20th century, all fires were fought because fire was perceived as an enemy. Today we know all fires are not bad. Wildfires are always suppressed especially when threatening human life and property. Fire “under prescription”, on the other hand, is allowed to burn within the limits defined in a fire plan. In some areas and with some agencies, this would include lightning caused fires where it has been determined that such fire would be beneficial to the ecosystem. This includes congressionally designated wildernesses.

Increased development in and around forests presents challenges to resource management and protection of human lives and property. House design, building material, site topography, landscaping, road design, accessibility for emergency vehicles, and availability of water are factors that should be considered when building a home in a wooded area. These factors greatly affect suppression efforts not only for defending homes but in controlling and conducting prescribed burns to achieve ecological objectives.

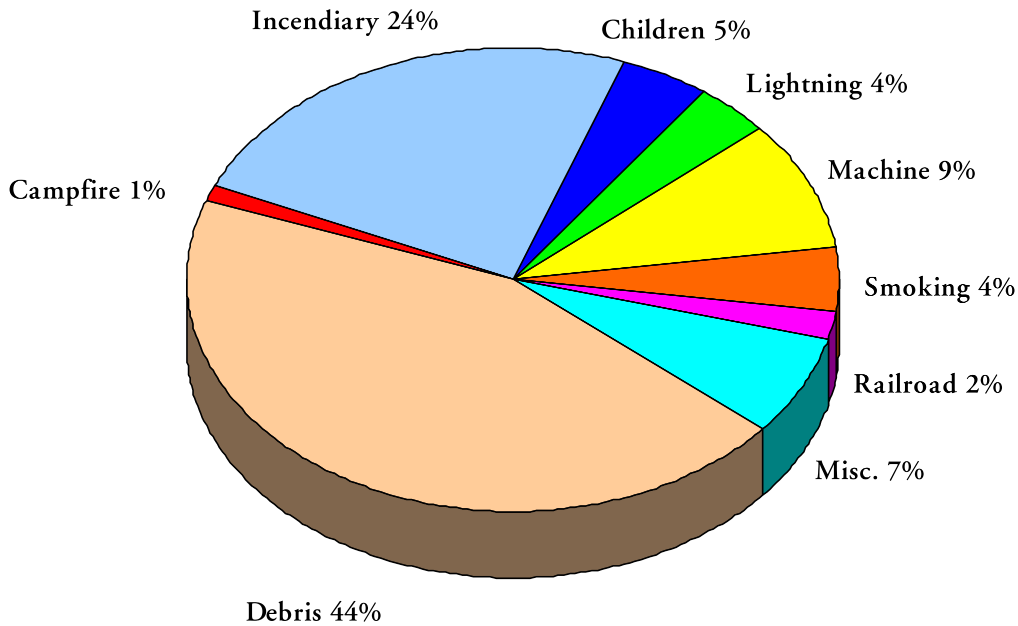
Fire detection is the key to effective forest protection. Most forest fires are reported by local citizens. Other fires are detected by air patrol and fire towers. Air patrols and fire towers are used sparingly until dry, windy conditions warrant increased detection efforts. Fire season refers to the time of year when most forest fires occur. Most forest fires in Georgia occur during the dry and windy months of February-April and October - November. In some years, hot, dry weather and high winds can change the season and make it earlier, later or longer.

Causes

There are two basic causes of wildfires. One is *natural* (lightning) and the other is *people*.

Natural fires are often started by lightning. Lightning accompanies thunderstorms and is a short-lived, bright flash of light produced by electrical discharges as powerful as 100 million volts. Of the three types of lightning recognized —— *cloud-to-ground*, *cloud-to-cloud*, and *cloud-to-air* —— the form most likely to generate fires on the ground is ***cloud-to-ground.*** Cloud-to-ground lightning occurs when the electrical charge travels between a negatively charged cloud base and the positively charged ground. When a lightning bolt strikes, the electrical energy changes into heat. Temperatures in the path of a lightning bolt can reach as high as 50,000 degrees Fahrenheit (28,000 degrees Celsius), five times hotter than the surface of the sun.

The color of lightning indicates the content of the surrounding air. The flash will appear *red* if rain is in the cloud, *blue* if hail is present and *yellow* if a significant amount of dust is in the



atmosphere. *White* lightning indicates an absence of moisture in the air and as a result is more likely to generate a ground fire. Not all lightning strikes start fires. It must combine with local weather and vegetation to produce fire.

Humans are responsible for most wildland fires most of which are avoidable. These fires stem from activities and actions both intentional and accidental. The following is a list of the causes of wildfires from human origin.

Debris Burning is a fire set for burning brush or debris such as land clearing, yard waste, weeds, grass, trash, garbage, etc. Debris burning requires a burning permit and should be done only with control in mind and safety practiced. **Note: Burning garbage in Georgia is illegal.**

Incendiary is the name given to a fire caused by anyone willfully setting fire to vegetation or property not owned or controlled by him and without consent of the owner or his agent. Known as arson, this is a felony crime and punishable by fines, imprisonment, or both.

Smoking causes fires either by a smoker's match, lighter, or by burning tobacco in any form.

Campfires started for cooking, heating, providing light or mood may cause wildfires if left unattended, improperly built or inappropriately fueled.

Machine use is the category of fire caused by mechanical equipment or its operation.

Children who are 12 years of age or younger may play with matches, experiment, or accidentally start fires.

Railroads are the source of fires caused by equipment or personnel engaged in the construction, maintenance, or operation of this common carrier mode of transportation.

Miscellaneous is the category of fires caused by specific means that cannot be properly classified under any of the other causal categories. Examples of causes are fireworks, structure fires, powerlines, and spontaneous combustion.

Causes of Forest Fires in Georgia (Fiscal Years 1989-1998)

Suppression

The heart of the fire fighting team is the firefighter with a tractor/plow unit. This consists of a crawler tractor and accompanying fire plow. As the crawler moves through the woods, the plow removes the forest fuels by creating a firebreak of bare ground four to six feet in width. The size of the firebreak could increase depending upon the size of the fire. Because different regions of the state have different fuels, weather, and topography, tractor/plow units may be large or small, depending on the need.

Ground crews equipped with hand tools such as shovels, chainsaws, and pulaskis (combination of ax and mattock) are used to create fire breaks where terrain is steep, hard-to-reach, or inaccessible to heavy equipment. Roads, bodies of water, rock outcroppings and bare soil areas are incorporated as part of the fire break when possible.

Air patrol is used to help with fire fighting. The pilot can radio information to fire fighters on the ground about how to get to the fire, fire behavior, and lay of the land. A pilot saved the lives of several firefighters in North Georgia by advising them that they were completely surrounded by fire. They used their tractor and plow to create a safety zone by the time the fire reached them. Airplanes and helicopters are also used to dispense water and fire retardant (a combination of chemicals and water).

Fire personnel are available 24 hours a day, 7 days a week, 365 days a year. Local, state and federal dispatchers are available to take fire calls around the clock. Usually, people call their local fire department and their dispatchers contact the agency responsible for the fire's suppression. An elaborate radio communication system allows fire personnel to talk to each other, to air patrol, towers, and other fire suppression agencies. Once dispatched to a fire, firefighters can evaluate and report the fire's progress and request additional support if needed.

Agents of the Georgia Forestry Commission have the right to go on any land to suppress, control, or prevent forest fires without being held liable for trespassing.

Fire Safety

Fighting fire is an inherently dangerous occupation. Certain guidelines have been established to insure the safety of fire personnel These are known as the *10 Standard Fire Orders:*

FIRE ORDERS

Fight fire aggressively but provide for safety first.
Initiate all action based on current and expected fire behavior.
Recognize current weather conditions and obtain forecasts.
Ensure instructions are given and understood.

Obtain current information on fire status.
Remain in communication with crew members, your supervisor and adjoining forces.
Determine safety zones and escape routes.
Establish lookouts in potentially hazardous situations.
Retain control at all times.
Stay alert, keep calm, think clearly, act decisively.

In addition, a checklist of *situations* that signal possible dangers are:

SITUATIONS

1.. Fire not scouted and sized up
2. In an area or 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 crew members/supervisors.
8. Constructing line without 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 anyone who can
13. On a hillside where rolling material can ignite fuel below
14. Weather is getting hotter and drier
15. Wind increases and/or changes direction

16. Getting frequent spot fires across line
17. Terrain and fuels make escape to safety zones difficult
18. Taking a nap near the fireline

Interagency Cooperation

There was a time in Georgia when forest fires were fought by forest rangers and house fires were fought by firemen. Rarely did a forest fire threaten a house, because there were not many houses. It was during this time that families lived close together, in groups. Houses were built in clearings and the dirt yards were swept clean daily, removing any debris that might carry fire or become habitat for unwanted animals.

Today the landscape is covered with houses. The popular trend is to build in and around the much loved forest. But there is fire in the forest and forest rangers meet much too often with firemen as both forest and houses burn together. These situations are very intense and complicated requiring full cooperation from all involved. Interagency Cooperation is the term used to describe how many agencies work together to protect public health and property.

The Georgia Forestry Commission is responsible for suppression of forest fires in the State of Georgia and the USDA Forest Service is responsible for suppression on the National Forests. This does not mean however, that the agencies necessarily do the job alone. Both rural and city fire departments are charged to protect their community. Private companies that grow timber, so that we can have paper and wood products, must also protect their valuable forests. In addition to the US Forest Service, federal land managers such as the U. S. Fish and Wildlife Service, National Park Service, Bureau of Land Management and Bureau of Indian Affairs are also charged to manage fires on nationally owned lands. All of these agencies may work together to suppress a fire. If a fire threatens safety on a roadway, the Department of Transportation, Georgia State Patrol, and county Sheriff may help to direct traffic. The worst forest fires may even require help from the military. If the governor declares a state of emergency, all resources are required to work together to protect life and property. Agencies like the Salvation Army and the Red Cross may provide food and shelter for firefighters and for displaced citizens. An organization called the Georgia Emergency Management Agency is tasked with coordination of all of the above agencies whenever the job gets too big and too complicated for local government to handle and the Federal Emergency Management Agency helps with disasters that overwhelm the states.

The fire job remains in control of the agency having primary jurisdiction. The fire officer will use all of the above resources, through a process called Interagency Cooperation, to get the job done. Interagency cooperation starts before a fire occurs. Fire personnel meet with the fire department chiefs to get acquainted with everyone that helps when a forest fire occurs. They get together often and talk about all of the jobs to be done to suppress a fire and to protect the public. When the fire does occur, everyone has a job to do, and the pieces of the fire suppression job fall together like a jigsaw puzzle.

There are national standards that have been developed to standardize interagency cooperation across the entire United States. Called the NIIMS, National Interagency Incident Management System, the system integrates common communication terminology, training, fire fighting qualifications, informational publications, and supporting technology, to insure that the cooperation we have been talking about can work nearly anywhere for any type of problem. We are talking mainly about fire, but a hurricane, tornado, flood, hazardous material spill, or other type incident may require the same type of interagency cooperation. The backbone of NIIMS is the *Incident Command System*.

The Incident Command System provides an organizational chart of all of the jobs that may become necessary to suppress a fire. For instance, every fire must have a qualified Incident Commander. This could be the forest ranger driving a tractor/plow unit on a small forest fire, a fireman with a fire truck on a grass fire, or the head of an entire agency on a large forest fire. If the incident is small, the organizational structure is small. As a fire increases in size and complexity, the Incident Commander may need support such as someone to provide meals and repair equipment (logistics), someone to plan for needed resources (planning), someone to be in charge of the ground forces (operations) and someone to keep up with expenses and personnel work time (finance and administration).

INCIDENT COMMAND SYSTEM

INCIDENT COMMANDER

PLANNING OPERATIONS LOGISTICS FINANCE/ADMINISTRATION

Interagency cooperation plays an important role in filling all of these positions. The Georgia Forestry Commission may provide the incident commander and the other positions may come from the fire department, forest industry, federal agencies, etc.

The most important part of the Incident Command System that deals with interagency cooperation is the concept of Unified Command. A fire may have become so large that it crosses jurisdictional boundaries. If the fire is burning on the National Forest and on private property both inside the city limits and in the county, several agencies have major responsibilities. Each agency may have different policies and various goals to achieve. You might think that everyone would agree that the fire should be suppressed immediately at all costs. But some agencies may decide that the fire is beneficial or that the suppression method chosen would do more harm than good. How can the incident be organized to meet the needs of so many different people? Unified Command places representatives from each jurisdiction on a panel to discuss how to best handle the incident for all involved. This panel sets priorities like protection of life first, protection of property second, protection of natural resources third, until all the different agencies involved are somewhat satisfied. This way, everyone affected by the fire has some input into how the incident is handled.

You might say that all this organization could result in confusion and indecision. The trick is for everyone to work together all the time, not just when an emergency occurs. That way we all know what to expect from one another and who can best perform which jobs. Interagency cooperation is like teamwork. Practice makes perfect.

Agencies may work together on worthwhile projects like fire prevention and education about natural resources. This type work keeps interagency cooperation alive and ready for serious fire suppression work.

Interagency cooperation brings much needed manpower and equipment to the fire scene. A highly trained and coordinated team of people can work smarter than one person alone.

Fire Prevention

Objectives:

1. Know the history of Smokey Bear.
2. Know how fire prevention is organized in Georgia and the fire danger ratings.
3. Understand the burning permit system in Georgia.
4. Describe management objectives of prescribed burning.
5. Know what factors to consider when prescribed burning.
6. Understand the various burning methods for prescribed burning.
7. Analyze the effects of prescribed burning on other natural resources.

History

Fire can be friend or foe depending on whether it is under control or out of control. It has earned a reputation as a dangerous and notorious adversary when out of control. One of the most destructive fires in the United States occurred on October 8, 1871, in Peshtigo, Wisconsin. When it was over, millions of forest acres had burned and 1500 people had lost their lives. National Fire Prevention Week, occurring in the United States during the second week of October, continues today in commemorating the 1500 people who lost their lives during this fire.

Currently an estimated 30-32 million acres of forest land burn out of control each year worldwide.

Smokey Bear is the national symbol for forest fire prevention. How this came to be is an interesting story. During the l9th and early 20th centuries burning of the woods was done routinely to control insects, enhance grazing for farm animals, and clear land. Often these fires got out of control, burning much more than had been intended. Trains also ignited forest fires as did hunters and careless campers. An effort was needed to encourage people to be careful with fire in the forest. Before the United States entered World War II, the Japanese launched incendiary balloons from ships off the California coasts igniting prime timberland. The forest fire prevention message grew into a necessity with this threat and World War II. Timber was a primary commodity for battleships, gunstocks, airplane propellers, packing crates and hundreds of products in support of the military and war effort. The War also took the firefighters into the military so few men were left to suppress wildfires. Fearing that an enemy attack could destroy our forest resources at a time when wood products were vitally needed resulted in the organization of the Cooperative Forest Fire Prevention (CFFP) Program in 1942 by the USDA Forest Service. The Forest Service asked the War Advertising Council for assistance in conveying the message to citizens to help the war effort by doing what they could to prevent forest fires. The Council produced an appealing poster featuring Walt Disney’s “Bambi” character asking, “Please, Mister, DON'T BE CARELESS." The Council found that an animal of the forest was the best messenger to promote the prevention of accidental forest fires, but Bambi was already spoken for by Disney.

Harry Rossoll, an illustrator with the USDA Forest Service in Atlanta, Georgia first drew Smokey Bear in the early 40's for the "Smokey Says" column that appeared in the Atlanta Journal and the Atlanta Constitution. Harry's Smokey, however had a stout, severe look that was not adopted as the symbol. In 1944, noted animal illustrator, Albert Staehle, was given a description by the Forest Service and the Council from which to paint a forest fire prevention bear. In the 1945 campaign, the public was introduced to Smokey Bear with a poster depicting Smokey pouring water on a campfire with the caption, "SMOKEY SAYS – Care <u>will</u> prevent 9 out of 10 forest fires". Smokey's signature slogan, "Remember… Only YOU can prevent forest fires," was seen and heard for the first time in 1947. Rudy Wendelin, a USDA Forest Service illustrator with the Washington, D.C. headquarters, refined Smokey into the rounded nose, blue-jean wearing cartoon character we know today.

After World War II, the War Advertising Council dropped the word War from its name and became simply the Advertising Council. Smokey's campaign broadened to appeal to children as well as adults. In 1952, Congress passed Public Law 359, or the "Smokey Bear Act", to guard against the misuse of this fire prevention symbol. During the same year a licensing program was started which continues to this day to control the manufacturing and sale of items using the Smokey Bear symbol. Royalty proceeds are collected by the Forest Service and returned to the CFFP Program for use in furthering the forest fire prevention message.

A significant chapter in Smokey Bear's history occurred in 1950 when a bear cub was found clinging to a tree after a wildfire destroyed over 17,000 acres of the Lincoln National Forest in Capitan, New Mexico. Taken in and cared for by local forest fire fighters and veterinarians, the recovery of the burned cub was monitored by the American public. The cub became a living counterpart to the CFFP's fire prevention symbol that had evolved six years earlier.

The Smokey Bear of New Mexico died in 1976 at the National Zoo in Washington, D.C. and was returned to Capitan for burial. When the second Smokey died in 1990, the living symbol was laid to rest.

New challenges are making Smokey's task increasingly difficult. Although Smokey's mission has always been to educate people in what they can do to prevent *accidental* forest fires, some feel the message leaves no room for using fire as a tool in ecosystem management. Increasing numbers of people are living in the wildland-urban interface where accidental forest fires can spread to nearby residences. Demand for our dwindling natural resources continues to grow as does the population. Obviously the need to prevent accidental wildfire will be greater than ever, and Smokey helps to remind us, "REMEMBER… Only YOU can prevent forest fires!"

Fire Prevention in Georgia

Georgia is the largest state east of the Mississippi River, with a total land area of 37 million acres. Sixty-five percent, or 24 million acres, is forested. Forestry is Georgia's number one industry contributing close to 20 billion dollars to the economy as of 1998. Protection of the forest from destruction by wildfire is still a primary thrust of the Georgia Forestry Commission, USDA Forest Service and the forest industry.

State headquarters for the Commission is located at the Forestry Center in Macon, Georgia. The State Forester, J. Frederick Allen, is Director of the Commission and supervises a staff that includes the Chief of Forest Protection. There are 12 forest protection districts across the state with approximately 13 counties in each district. Forest rangers working for the chief ranger, suppress the fires with crawler/plow units. All newly hired fire control personnel are required to attend a four week training period at the Georgia Forestry Academy and graduate with a minimum score of 70 on each of the weekly exams.

The Georgia Forestry Commission also administers the Rural Fire Defense (RFD) Program. Initiated in 1968, the RFD program equips, trains, and assists rural communities for fire control. In return, the Commission is provided with a back-up force of personnel and equipment for emergency forest fire use.

Money to fund forest protection in Georgia comes from county and state governments. Each county government pays four cents per forested acre in its boundary and the State pays the remainder of the cost. This money is used to pay salaries, provide funds for operating costs, purchase equipment and for maintaining offices and shops.

Fire Rating

The Georgia Forestry Commission's daily agenda depends heavily on the weather forecast. Fire behavior is directly related to weather conditions making it important for forest rangers to know the daily weather forecast. The Commission employs a forestry meteorologist at the headquarters in Macon. He produces a forecast twice a day that helps the rangers plan ahead for fires. Not only is the normal forecast produced for each district, but a set of fire danger ratings is given to indicate how severe a fire might burn on a given day. Fire danger ratings are on a scale from class 1 to class 5. *Class 1* is a low danger of fire, *Class 2 and 3* is a moderate danger, and *Class 4 or 5* indicates a high danger of fire where any fires ignited are likely to escape control. The forest rangers can provide weather conditions when you call for a burning permit and are available to help with outdoor burning by being present at the burn with a tractor/plow unit. This is done on a first-come, first-served basis.

Over the years, careless debris burning has been the leading cause of wildfires accounting for 40% of the total fires. Nearly every one in Georgia eventually has something that they want to burn. Too many people, though, do not take the proper precautions to control their fires.

Wood arson is the second leading cause of forest fires. This accounts for one in every four of Georgia's forest fires. Arson is considered a felony crime. The Commission has several investigators who are trained to determine the cause of forest fires and conduct investigations if necessary.

Burning Permit

The "Forest Fire Protection Act" of 1942, referred to as the permit system, has been a valuable fire prevention tool. This law requires that notification be given to the county ranger prior to starting a fire. It has helped in promoting safe burning and in the understanding and perception of prescribed burning as a forest management tool.

Permits are given by the forest ranger from the county in which the burn will occur. A permit number corresponding to a permanent record at the office will be issued if weather conditions are right for burning. Your request for a permit could be denied if it is determined that smoke from the fire will cause a problem or obstruction of highway visibility, or the fire rating is high. In 1998, the Governor of Georgia declared by Executive Order the *Voluntary Ozone Action Plan* for the counties of Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Henry, Paulding, and Rockdale. Implemented from May 1 through September 30, the policy is an effort to be in compliance with the Clean Air Standards for Atlanta. It requests that such activities as re-fueling of vehicles and lawn maintenance be done after 6:00 P.M. The issuance of burning permits is restricted in these counties during this time frame.

A permit is good from dawn to dusk on the day the permit is issued. The applicant must specify the burn location, the size of area to be burned, and what is being burned.
Debris to be burned must originate from the area being burned. Burning garbage and dimensional lumber (treated wood) is not allowed. The permit provided by the county forest ranger is in addition to any notice, permit or requirement for burning by a local county or municipality law, ordinance, or resolution. There is no charge for permits issued by Georgia Forestry Commission.

Prescribed Burning

Prescribed burning is "the controlled application of fire to wildland fuels in either a natural or modified state, under specified environmental conditions which allow the fire to be confined to a predetermined area and at the same time produce the intensity required to attain planned resource management objectives." The phrases prescribed burning and controlled burning are often used incorrectly. The difference consists in the need for a written prescription.

With a prescribed fire, a written burning plan is prepared by a knowledgeable person for each area to be burned. The plan is completed before the burning begins. It serves as a checklist to insure that some aspect or potential impact of the fire has not been overlooked. Controlled burning, such as a campfire or debris burning, is a systematic prearranged burn which is confined to a specifically designated area. It does not require a written prescription but may require a permit.

Our understanding of fire's role in the ecosystem continues to grow. With the success of fire prevention and its exclusion from the forest, natural fire cycles have been disrupted in ecosystems dependent upon or adaptive to fire disturbances. Increased tree densities, understory growth, and accumulation of flammable forest fuel have led to larger and more severe wildfires. The Yellowstone fires of 1988 are considered by some as a high profile example of such a wildfire. Since the 1980s, large wildfires in dead and dying forests have accelerated the rate of forest mortality. Susceptibility of trees to insects and disease has increased and many fire dependent species are threatened with extinction due to the exclusion of fire in their ecosystem. Many forest managers have come to recognize how essential fire is in certain forest ecosystems.

Longleaf pine once covered nearly 70 million acres of the southeastern coastal plain of the United States. Today, less than 5 million acres of this southern pine type remain Longleaf pine forests are among the most fire dependent forest types in the world. Most original longleaf forests were regularly burned on a natural frequency of 2-7 years ignited by lightning. The suppression of wildland fires in longleaf stands is thought by many to have seriously affected the integrity and health of this ecosystem.

During the past several decades, prescribed burning has become an accepted forest management practice for southeastern pine woods. When foresters first used this tool in the 1940s it was viewed as a means to an end and not as a natural part of the ecosystem. Commercially valuable pine stands were competing with encroaching hardwood species and prescribed fire was used to control this encroachment.

Today the sustainability of a forest is measured by forest productivity, diversity, resiliency and the maintenance of ecological processes over large land areas. As it turns out one of the best ways to fight fire is with fire.

Management Objectives

Foresters and land managers may use prescribed burning for numerous reasons including one or more of the following:

Fuel Reduction. One of the most important reasons for prescribed burning is to reduce naturally occurring fuels within the forest area. Reduction of forest fuel build-up reduces the risk of intense, uncontrollable wildfires that threaten life, property, and economic timber losses. It is one of the most cost effective elements of any fire prevention program when compared to suppression and damage costs. Complete coverage is not necessary when prescribed fire is used to reduce fuel accumulation. The objective is to break up fuel continuity. This can usually be achieved satisfactorily by burning about 75% of the area. Unburned patches continue to provide cover and food for wildlife.

Southern pine stands of the Coastal Plain can accumulate a dangerous level of combustible fuel over a five to six year period. Plantations are often burned for the first time when they are 15 to 20 feet tall. Subsequent burns usually occur on a three to five year cycle, but each area to be burned must be evaluated individually based on factors such as stand size, species composition, drought years, amount and arrangement of fuels.
Cool, damp conditions with some wind and closely spaced ignition spots are a must to avoid crown damage. Fuel reduction burns are usually conducted in the winter.

Insect and Disease Control. Prescribed burning helps control the fungal infection, brown spot needle rust, in longleaf pine seedlings. Longleaf pine is a tree species that has adapted to allow fire to be utilized at an early stage in its life. Once fire consumes the diseased needles on young pines, the seedlings can continue to store carbohydrates in their roots which aids with growth acceleration. Prescribed burning also helps to control insects such as the white pine cone beetle (Conophthorus coniperda) . Problems from the fungal disease, Fomes annosus root rot, seem to be reduced where prescribed fire has been used.

Maintenance of native species in fire-adapted ecosystems. Certain natural systems are dependent upon periodic fire for maintenance of their biological diversity. Many plants have structural adaptations, specialized tissues, or reproductive features that favor a fire-dominated ecosystem. Fire is essential for the longleaf-bluestem forest ecosystem occurring from Mississippi to east Texas and for the longleaf-slash, pine-wire, grass-saw palmetto ecosystems found in south Georgia and much of Florida. Without fire in these ecosystems, shade tolerant species invade the sites, displace the grasses and surpass the growth of pines. Plants, such as orchids and pitcher plants, are benefited by fire. The interval between fires as well as the fire intensity need to be understood for each species before a fire can be prescribed to benefit that species.

Wildlife Management. Where loblolly, shortleaf, longleaf, or slash pine is the primary overstory species, prescribed burning is highly recommended for habitat management. A mosaic of burned and unburned areas tend to maximize “edge effect” which promotes a large and varied wildlife population. Fruit and seed production is stimulated. Yield and quality increases occur in herbage, legumes and browse. Openings are created for feeding, travel and dusting.

Game species that benefit from the effects of prescribed burning are deer, quail, dove and turkey. Endangered species include the Florida panther, gopher tortoise, indigo snake and the red-cockaded woodpecker.

Site Preparation. Prescribed fire is useful for the regeneration of planted southern pine by controlling competing vegetation until seedlings become established, hastening the return of nutrients to the soil for use by the young trees, improving visibility of tree planting hazards such as stumps and allowing easier access and movement by planting crews. With natural regeneration, any burning should be done several weeks PRIOR to seed fall.

Disposal of logging debris. Unmerchantable debris leftover from logging is an impediment to both people and planting equipment. Broadcast burning is preferable to windrow, or pileup, burning due to smoke management problems and the potential for site degradation. If overstory pines are left as seed trees, more care is needed during burning to insure their protection.

Factors To Consider When Prescribed Burning

As with wildland fire, *weather, fuel and topography* are factors to be considered with prescribed fire.

The weather forecast for the day of the burn, the following night and a 2-day outlook is necessary for a successful prescribed burn. Weather observations should be made at the prescribed burn site immediately before, during and after the burn. Four sources for weather information are: National Weather Service, State Forestry Agencies, Local Observations, and Private Weather Forecasting Services. The best source of information is generally the local office of your State forestry agency.

Weather changes by the minute and these changes can directly affect fire behavior. Wind is recognized as the most important variable to be considered when using prescribed fire. A steady wind, both in direction and speed, is desired. Winds vary with the density of the stand and crown heights. Speed should be a minimum of 3-miles per hour and a maximum of 8-10 miles per hour under normal conditions assuming other weather factors are favorable.

Winds from the northwest and northeast, are preferred. These winds usually coincide with other favorable weather factors. Easterly winds are generally unreliable. Proper burning is possible, however, with wind from any direction provided it is steady and other factors are favorable. Any sudden change in wind direction is undesirable.

Relative humidity greatly affects fuel moisture and fuel moisture affects the prescribed burn. Preferred relative humidity for prescribed burning varies from 30% to 50%. When humidity is 25% or lower, prescribed burning is dangerous. When humidity is greater than 60% the burn may not be hot enough to accomplish the desired result.

Low relative humidity means dry fuels and high relative humidity means damp fuels. The preferred range of actual fuel moisture is from five to ten percent. Burning when fuel moisture is below 5% may result in serious damage to young growth, overstory, and even soil. When fuel moisture is high, fires tend to burn slowly and irregularly and are often incomplete.

Be familiar with the area you are burning beforehand. Know what roads are in the area and their status of use. Roads are essential in planning travel routes to and around a fire and can be utilized as control lines in some cases. Be familiar with cross country barriers such as creeks, swamps, and cliffs. Know the location of steep slopes, ridges, and water sources that will affect the behavior of the fire as well as suppression tactics. Know the best access to any and all area of land being burned and where to establish control lines and fire barriers. Know where areas of excess fuel buildup are and be prepared to handle any increase in heat intensity. Always be alert to the fact that a change in topography can cause a change in the behavior of fire.

Burning Methods and Applications

Three types of fires are used for prescribed burning. Based on behavior and spread, fires either move against the wind (*backing fire*), at right angles to the wind (*flanking fire*), or with the wind (*heading fire*). Each one is used only after an adequate fuel free zone is established at the downwind boundary of the area to be burned. Fire lines should be carefully planned and plowed before the fire, but not so far in advance that freshly fallen debris poses a hazard.

Backing fires, or backfires, are set on the windward side of a control line. These fires burn into the wind at rates of one to three chains per hour (one chain= 66 feet). These are the easiest, safest and least intense types of fires to use as long as windspeed and direction are steady. When a large area is to be burned, interior lines are often plowed at 5 to 15 chain intervals and additional backfires set along them. Backfires are often used to reduce heavy rough. This fire type is also used in young stands with a minimum basal diameter of three inches and when the air temperature is below 45 degrees.

In-stand winds of 1 to 3 mph are desirable with backing fires. These conditions prevent heat from rising directly into tree crowns and helps dissipate the smoke. The cost of using backfires is relatively high because of additional interior plow lines and an extended burning period due to the slower movement of the fire.

Flanking fires are set by treating an area with lines of fire set directly into the wind. The lines spread perpendicular, or at right angles, to the wind. Land slope has an effect on the rate of spread similar to that of wind. Fire intensity with this kind of fire is intermediate. It is best used in medium-to-large sawtimber. This fire type requires considerable knowledge of fire behavior, expert crew coordination and timing, and effective radio communication. Wind direction must be steady. Fuel loading should be light to medium (less than 8 tons per acre) and a downwind base line should always be secured first.

Heading fires, also known as headfire or strip-heading fire, run with the wind into a prepared firebreak. A series of lines of fire are set 1 to 3 chain lengths apart to prevent a high energy fire level. This distance can vary depending on several variables. A backing fire is generally used to secure the base line while the remainder of the strip area is treated with a headfire requiring fewer interior plow lines. Headfires permit quick ignition and burnout needing just enough wind to give direction, generally 1-2 mph in-stand. Winter use is best (below 60 degrees Fahrenheit) to help avoid crown scorch where lines of fires burn together and fire intensity tends to increase.

This type of fire is used in medium-to-large sawtimber and for annual plantation maintenance after initial fuel reduction has been accomplished. Cost is lower than the other two fire types because fewer interior plow lines are required and fire progress is rapid.

Smoke Management

When using fire there will be smoke emissions into the surrounding air. In addition to air quality concerns during burning, smoke can also decrease visibility on roads and in the surrounding environment. This is a primary concern with respect to prescribed burning.

For smoke management, the most important tool of prescribed burners is the forecasted weather information. These forecasts are needed to project the trajectory and dispersion rate of the smoke. Burning at night is often discouraged because the wind often dies down and the smoke tends to stay near the ground and accumulate in hollows. Burning fuels with low moisture content, scattered rather than piled debris, and using backfires where possible are practices that tend to minimize smoke.

The amount of smoke generated depends on weather conditions, type of fire used, amount and type of fuel being burned, its moisture content and the size of the area being burned. Minimizing adverse environmental effects, especially near populated areas, hospitals, and airports should always be of primary concern to the burner. If information is incorrect or conditions become dangerous the burn must be discontinued.

Environmental Effects of Prescribed Burning

Effects on Vegetation

Survival and susceptibility of vegetation from prescribed burning is dependent on a combination of factors such as fire intensity, length of exposure to high temperatures, plant characteristics such as bark thickness and stem diameter, temperature of the air at the time of burn, season of the year, and the interval between prescribed fires.

Hardwood trees are more susceptible to fire injury than are pines. Prescribed fire is generally not used in the management of hardwoods once a stand is established. Pines such as the longleaf are *fire-dependent* species and depend upon fire as part of their ecosystem survival. *Fire-tolerant* species are able to withstand fire but are not dependent upon it for survival. Pine trees three inches or more in ground diameter have bark thick enough to protect the stems from damage by most prescribed burns. Cambial damage can occur if the duff around the root collar smolders for an extended period of time. This kind of damage is more likely in mature, previously unburned trees where a deep organic layer has accumulated. As a rule, plants are more easily damaged by fire when they are actively growing.

Streamside (riparian) vegetation is excluded from prescribed burns to protect associated plant and animal habitat and water quality. A control line should be put in to protect this kind of vegetation during a prescribed burn if an adequate buffer zone is not present.

Effects On Wildlife

Fire effects on wildlife are complex. They are often indirect, affecting habitat more than individuals. Fire is beneficial to some species and detrimental to others. Many species are attracted to the presence of fire due to the availability of prey. The major effects to wildlife from prescribed burning pertain to animal habitat: food, cover, and water. Burning can improve habitat for species such as quail, deer, turkey, birds and other animals by increasing food production and availability and by diversifying cover choices.

The deleterious effects of prescribed burn on wildlife include destruction of nesting sites and killing of wildlife from being trapped. Fortunately, prescribed burns can be planned at times when nests are not being used, and by allowing ample escape routes for wildlife by avoiding the practice of ring firing – lighting all sides of a burn area. Most plants and animals living in a fire dependent ecosystem are well equipped to deal with fire. Small mammals and reptiles burrow underground, while larger mammals and birds simply flee the area until the fire has moved past.

The endangered red-cockaded woodpecker presents a special challenge in a habitat historically maintained by fire. By using short flame lengths and raking the fuel away from the cavity trees, the likelihood of igniting the dried resin that flows from the nest cavity toward the ground is decreased.

There are studies showing prescribed burning adjacent to trout streams changes the ph making streams less acidic thus enhancing the aquatic insects and food for trout. An improperly done burn however, can cause sedimentation to streams and rivers if erosion from the site occurs.

Effects On Water

In the South a properly planned prescribed burn will not adversely affect the quality or quantity of water. Increase surface runoff, sedimentation and ash accumulation in water sources will occur, though, as well as leaching of minerals into the ground water if burns are not properly conducted.

Effects On Air

Smoke consists of small particles of ash and partly consumed fuel and liquid droplets. Gases such as carbon monoxide, carbon dioxide, hydrocarbons, oxides of nitrogen and sulfur are other combustion products in smoke depending on the amount and type of fuel being burned and the rate of fire spread as determined by timing and type of firing technique used. The greatest problem associated with prescribed burning, though, is visibility. Atmospheric stability and windspeed are the main factors determining the rate of smoke dispersal. Weather and smoke management forecasts are available from local weather stations and fire management units. These factors must be considered before a burn takes place. The burner could be held liable if accidents occur as a result of the smoke from a prescribed burn.

Effects On Soil

How fires affect surface runoff and soil erosion is a major concern of the forest manager. Little danger of this exists in the Lower and Middle Coastal Plain sites in Georgia when part of the forest floor is left intact after burning. In the Upper Coastal Plain and Piedmont some soil movement is possible due to the steeper topography. In these areas and the mountains, burning should not be done if exposure of highly erosive soils is likely. In the mountains burning should be completed by mid-September to allow herbaceous plants time to seed in and provide a winter ground cover.

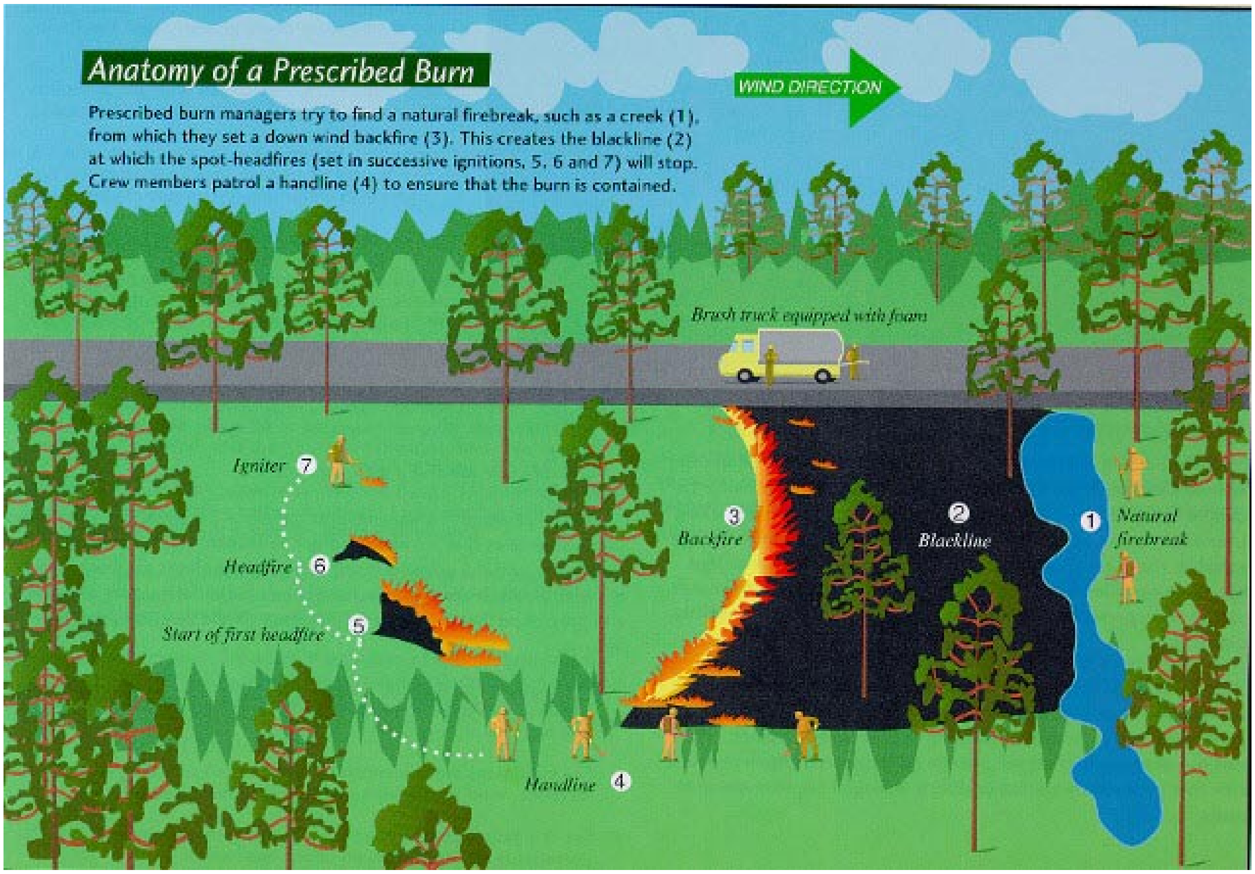
At the time of burning, soil should be wet or damp to ensure that an organic layer will remain and the microenvironment of the forest floor remains viable.

Effects on Human Health and Welfare

Drift smoke from prescribed burning is more often than not more of an inconvenience than a health problem. High smoke concentrations can pose particular risk to people with respiratory illnesses and the elderly. Fire management personnel exposed to high concentrations of smoke often suffer eye and respiratory irritations and need to be aware of continued exposure to carbon monoxide gases that could result in impaired alertness and judgment. On a prescribed fire this is virtually non-existent.

One group of compounds carried in smoke that can have an immediate effect on individuals is those found in poison ivy and poison oak. Breathing smoke with these compounds in them can cause severe reactions in people, especially anyone allergic to these plants.

Conclusion


Anatomy of a Prescribed Burn
Prescribed burn managers try to find a natural firebreak, such as a creek (1), from which they set a down wind backfire (3). This creates the blackline (2) at which the spot-headfires (set in successive ignitions, 5, 6 and 7) will stop. Crew members patrol a handline (4) to ensure that the burn is contained.
WIND DIRECTION
Brush truck equipped with foam
Igniter 7
Headfire 6
Start of first headfire 5
3 Backfire
2 Blackline
1 Natural firebreak
Handline 4