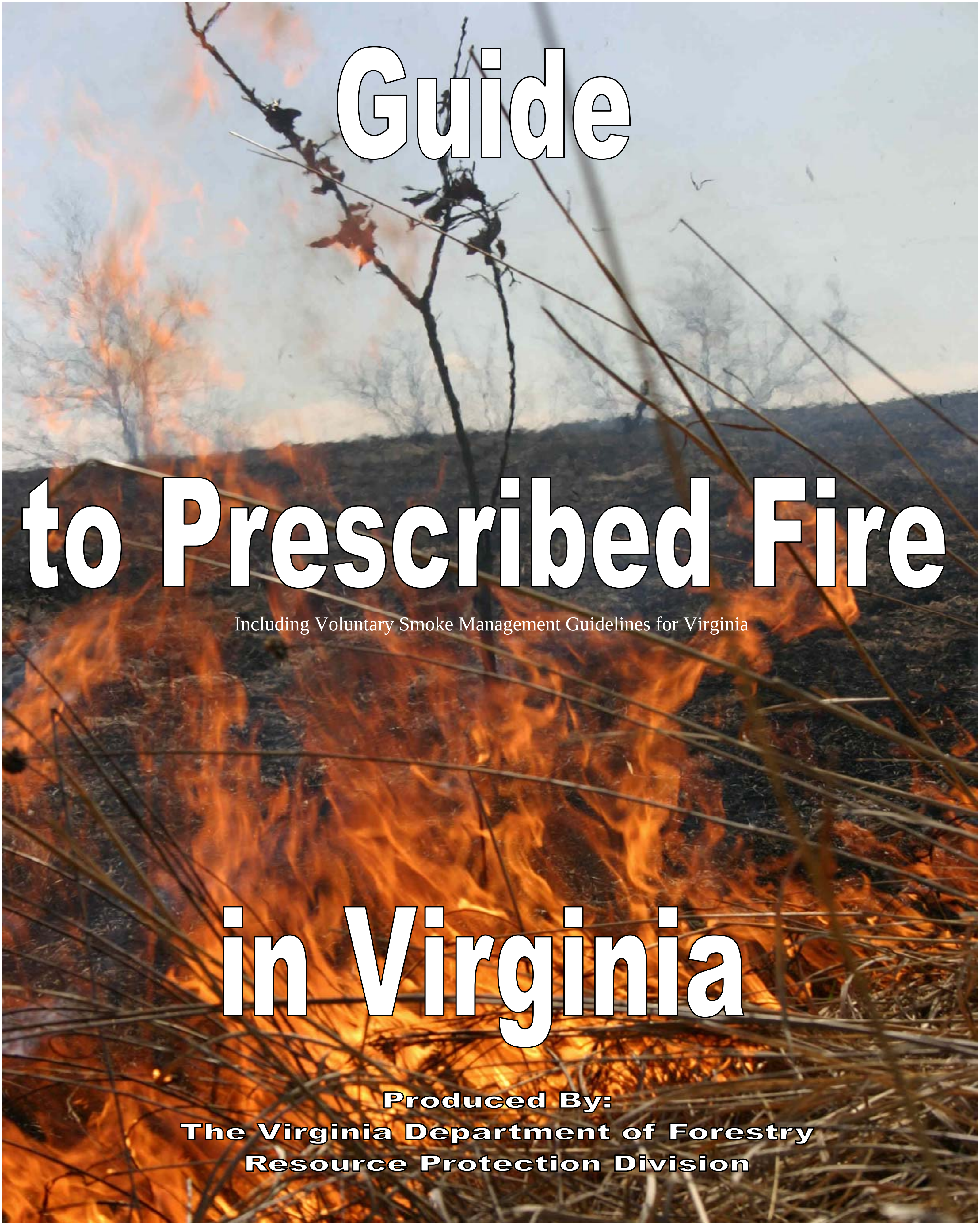

# Guide to Prescribed Fire in Virginia

Including Voluntary Smoke Management Guidelines for Virginia

**Produced By:**
**The Virginia Department of Forestry**
**Resource Protection Division**

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# Introduction

This publication provides guidelines for planning and managing smoke from prescribed fires to:

Minimize ambient air quality impairment.
Prevent smoke from being carried to, or accumulating in, areas sensitive to smoke.
Recommend burning guidelines to supplement the regulations established by the State Air Pollution Control Board.

This guide applies to all prescribed fires, and is not limited to any one agency or region. Prescribed fire stewardship emphasizes the immediate safety aspects of personnel conducting the burn; the health, safety, and property of others that may be directly affected by the fire, and the potential for off-site effects of smoke on public health and visibility. We emphasize, however that the prescribed fire manager cannot merely comply with standards and regulations. They must exercise professional and moral judgment in carrying out their duties,
The use of prescribed fire as a resource management tool has long been regarded as indispensable. In order to lessen the impact of smoke generated from prescribed burning on public health and welfare, the Virginia Department of Forestry has developed voluntary smoke management guidelines. Application of these guidelines will minimize concentrations of smoke in sensitive areas and assist in maintaining air quality standards.

Promotional emphasis on fire prevention has created a misconception that all fire is bad. Various southern ecosystems depend on fire as do many silvicultural recommendations. Fire can be both good and bad depending on when, where, and how it occurs. With proper training and planning, prescribed burn managers will know the when, where, and the how to use fire to benefit the resources. How well we manage smoke from prescribed fires will determine our future use of this valuable and indispensable resource management tool.

The general public has a great influence over how we manage the resources of the forest. Some forest regulations are based on public emotion instead of scientific facts. Public relations are an essential part of a prescribed burn. The prescribed fire manager should feel obligated to minimize effects on the nearby residents and be prepared to “sell” his or her job to the general public. The following statements have been taken from an article by Mark Glisson. His article is based on the premise that the public image of the prescribed burner is critical to the success and continuation of prescribed burning. “Image has everything to do with how we are perceived and may have little to do with what we actually are.”
Attitude may be the most individualized of the ingredients of a good public image. Each burner must consciously strive to be friendly and courteous in their public encounters.
The old adage that there is no substitute for experience should be capitalized on. If the public feels that the burner is a professional, that he/she knows his/her stuff, there will be less fear. For government employees, the image of professionalism is ever more critical than for most. The common perception of “typical government employees” who waste taxpayers’ money with incompetence and laziness must be overcome. The demonstration of knowledge and ability is the best method for dispelling myths.
Attention to appearance should be considered essential to projecting a professional image. Particularly if the burner is a member of a uniformed agency, special care should be taken to create in others a positive association between the uniform and those who wear it.

The equipment should be adequate and as modern as possible. It should look good also. Dented and scratched trucks, unpainted equipment, or tools poorly treated all combine to give the impression of haphazard operations. All equipment should be functional and treated with pride.

Be honest with yourself, and remember that whatever the image of the prescribed burner is, it is a direct result of our own success or failure. Never assume that the benefits of burning are understood or that the public is to blame for the image dilemma. The responsibility for improving image is ours alone.


## Acknowledgments

The Resource Protection Division of the Virginia Department of Forestry thanks those who had the foresight to realize that prescribed burning and smoke management would someday become critical to our profession. The first publication on the benefits of prescribed fire and how to plan a burn was published by the then-VA Division of Forestry in the ‘70s. And the first publication in Virginia on smoke management was prepared by Roland B. Geddes, district forester, in March 1981 and was revised by Don T. Morton, assistant chief of fire management, in July 1989. The Virginia Department of Forestry is very fortunate to have had leadership that provided a firm foundation for those of us who followed, and one to build upon. In the late ‘90s Fred X. Turck was tasked with the development of Virginia’s Certification program. In working with our many cooperators, this became a law and reality in 1999. We would also like to thank all those who continue to provide leadership and direction as prescribed burning increases in its use as a valuable forest management tool, and smoke management becomes even more critical.

# Chapter 1 Fire History

A brief history of wildland fire in Virginia

The use of fire in the forests of Virginia has come full circle. Early settlers found Indians using fire in virgin pine stands and adopted the practice themselves to provide better access, improve hunting, and to get rid of brush and timber so they could farm. Annual burning to “freshen up” southern range became a custom. This practice, plus destructive wildfires after logging, left millions of acres of forest land in the south devoid of trees.
The increasing wildfire problem coupled with the need for a fire-free interval of several years to allow the pines to become reestablished led many foresters to advocate the exclusion of all fire from the woods. Others, however, pointed out that fire might have a place in the management of longleaf pine. Fire has been used by professional foresters to reduce hazardous fuels since the turn of the century. The misconceptions and controversy surrounding the deliberate use of fire to achieve resource management objectives have slowly been replaced by facts. As knowledge accumulated, the use of prescribed fire grew.

So, where do we start discussing wildland fire history–with the beginning of the Earth, with the first human use of fire, which may have occurred well over a million years ago, or with the evolution of prescribed fire beginning in the 1930s in the United States? Where we start to tell the story is appropriately defined by those who are listening to our story.
The story of the history of fire is fascinating. It is a story of how fire has shaped the landscape, our human history, our cultural evolution, and the natural and built communities in which we reside. It is a story of building up and burning down, of shaping and reshaping. While natural wildland fire has exerted its own shaping forces, humans using both native wisdom and scientific knowledge of fire ecology and fire management have also shaped fire regimes.
As we tell the story of fire to illustrate the science of wildland fire management, we also need to tell stories that promote coexistence with wildland fire. We are reminded each year as the fire season manifests itself that fire has been with us since the beginning of time and will probably be with us throughout time.

North America has a rich wildland fire history illustrating human coexistence with fire, the impacts of fire suppression, and the ravages of wildland fire. The Forest History Society (www.lib.duke.edu/forest/), among others, catalogs such conservation history.

Capt. John Smith commented that in the forests around Jamestown in Virginia:
“A man may gallop a horse amongst these woods any waie, but where the creeks and Rivers shall hinder.” Andrew White, on an expedition along the Potomac in 1633, observed that the forest was: “Not choked with an undergrowth of brambles and bushes, but as if laid out in by hand in a manner so open, that you might freely drive a four horse chariot in the midst of the trees.”
Smith’s and White’s observations of the open nature of eastern forests are typical of those of most other early observers, who commonly spoke of the ease of riding a horse or driving a

wagon under the forest canopy. Reports of such open conditions were widespread in the coastal forests and in the forests west of the Appalachians as well, as far north as Quebec.

Such conditions could only have been created by frequent, low-intensity ground fires, many of which were set by Indians.

In surveying the boundary between the states of North Carolina and Georgia in 1811, Andrew Ellicott wrote that: "The greatest inconvenience we experienced arose from the smoke occasioned by the annual custom of the Indians in burning the woods. Those fires scattered over a vast extent of country made a beautiful and brilliant appearance at night; particularly when ascending the sides of the mountains."

But frequent forest burning did more than reduce the undergrowth and improve the habitat for preferred species. In many cases, it created grasslands in areas where forests otherwise would have existed. Prairies extended into Ohio, western Pennsylvania, and western New York. In Virginia, the Shenandoah Valley—a broad valley located between the Blue Ridge Mountains and the Allegany's—was one vast grass prairie which covered more than 1,000 square miles. Native Americans burned the area annually. R.C. Anderson writes that the eastern prairies and grasslands, "Would mostly have disappeared if it had not been for the nearly annual burning of these grasslands by the North American Indians." In the West, as well, Indian burning also greatly extended the area of grasslands and reduced the area of forest.

The plants and animals that existed at the time of human arrival in the southeastern part of the North American continent were arguably adapted to fire on a relatively frequent interval. Fire occurrences were no doubt more frequent on drier sites and less frequent on wetter sites. The wetter sites tended to grow greater quantities of fuel, which probably resulted in more intense fires but on a lesser frequency. Those plants, which could not survive the passage of a flame front, were relegated to exist in very moist soil conditions. Some plants evolved with a reproductive strategy that allowed them to survive fire, such as serotinous cones.

Agricultural crops and communities of wooden homes were not adapted to the natural cycle of fire. While many Native American groups were relatively nomadic, the new settlers were not. To the new immigrants, flaming fire meant the loss of everything, while Native Americans simply relocated their communities in concert with this natural force.
The new culture in North America, while seeking to control fire, did use fire for land clearing, cleaning areas of snakes, brush and briars, and to enhance wildlife propagation. However, the practices were ill-conceived by today's standards and often resulted in conflagrations, not enhancements.
By the advent of the American Revolutionary War, fire regimes had begun to change. European perspectives of fire were crossing the Allegheny Mountains. Within 100 years, they would reach to the west coast. By the post-Civil War period, the last of interior Florida wildland was being settled, the last open ranges in the Dakotas hosted extensive herds of cattle, and the last great virgin forests were beginning to fall. With the spread of human activities, the booming American population began to spread fire.

Often careless or ignorant use of fire resulted in conflagrations. The Peshtigo, Wisconsin, fire of 1871 left 1,300 dead and more than one million acres charred. Newspaper headlines and government debates flourished. So did wildland fires–many became data points for disaster (e.g., Yacult, Washington burn in 1902; Virginia's Dismal Swamp burn in the 1930s; Oregon's Tillamook burns in the 1930s and '40s).

The creation of the U.S. Forest Service formalized a national approach to wildland protection, which was heavily weighted toward suppression. As the Virginia Forest Service (present day Virginia Department of Forestry) and other federal and state land resource management agencies came into being in the early 1900s (1914 for the VDOF), they followed the U.S. Forest Service's lead. That lead advocated a national perspective of fire eradication.

While the battle was valiant, the battle plan was flawed. Numerous firefighting organizations sprung up at the local levels; fire tool cache boxes were scattered throughout the country, and a national agenda was put into place. The battles were fought from every sector–government organized, varied firefighting hardware was invented or redesigned, and religious leaders in the southeastern United States, where fire was indiscriminately used more so than in other places, preached of the "evils" of setting fires. While not completely suppressed, there was a great reduction in wildland fire.

As early as the 1930s, land managers in the southeastern United States began arguing for the return of more natural fire regimes. Other fire-dependent regimes were equally in need of fire, but had few advocates. While few could argue, then or now, that the suppression and prevention of extreme fire was not appropriate, few were arguing that the focus should be on maintenance of natural fire regimes.

Even our wildlands are now being transformed to accommodate human settlement. It is the wildland/urban interface, which redirects the focus in many areas. Adding to the complexity of fire management and contemporary history is the issue of smoke management. How does smoke impact human health, transportation, agriculture, atmospheric carbon loading, and global warming? The regulatory community now struggles with atmospheric impacts, weighting them against the danger of reducing prescribed fire.

Wildland fire history is critical to telling the story of our ecological history. Without this historical perspective, we are without a baseline perspective to make our story whole. Without a whole story for society to understand, those who seek to manage wildland fire with a Pulaski in one hand, a set of regulations in the other, and a news microphone in front of them, will continue to find the message wanting.

Stephen Pyne's book Fire in America: A Cultural History of Wildland and Rural Fire is probably the most comprehensive historical coverage of wildland fire in North America.

# Chapter 2 Smoke Management Objectives and Regulatory Requirements

**Voluntary Smoke Management Guidelines for Virginia**

**Objectives**

Prescribed fires produce varying quantities of smoke, an elusive by-product which can be a major concern. Therefore, smoke management must be considered in every prescribed fire plan. Awareness of smoke production and transport characteristics will enable us to refine existing smoke management prescriptions.

The key to good smoke management lies in the resource manager's ability to use prescribed fire with minimal smoke impact. This is done by combining favorable meteorological conditions with a variety of prescribed fire techniques designed to keep smoke emissions to a minimum.

Three basic objectives of smoke management are:

1. Avoidance, identify and avoid smoke-sensitive areas;
2. Dilution, disperse and dilute smoke before it reaches smoke-sensitive areas, and
3. Emission Reduction, reduce smoke (emissions) produced from the burn site.

Regulations for Controlled Burning.

Open burning in Virginia is regulated by the State Air Pollution Control Board and the Virginia Department of Forestry. (Synopses of these regulations are included in the Appendix) The State Forester has accepted responsibility for the development, dissemination, and administration of a smoke management program for burning related to forestry programs. Nothing contained in this plan shall be construed as allowing any person to be in violation of any regulations, laws, ordinances, or orders of the Commonwealth of Virginia or other governmental entity having jurisdiction, or to relieve any person from the consequences of damages or injuries which may result from the negligent conduct during any burning operation.

A typical definition of "open-controlled burning" is: Any fire from which the products of combustion are emitted into the atmosphere without passing through a stack or chimney.

The State Air Pollution Control Board has established regulations for the control and abatement of air pollution, which was last revised in 1997. Sections of the regulations that refer to and impact prescribed burning are #9 VAC 5-40-5600, 5610, 5620, 5630, and 5631. Section 9 VAC 5-40-5630, #9 specifically states that open burning is permitted for approved forest management practices provided the following conditions are met:

- The burning shall be at least 1,000 feet from any occupied building unless the occupants have given prior permission, other than a building located on the property on which the burning is conducted and
- The burning shall be attended at all times.

Please refer to the complete text of the "Emission Standards For Open Burning (Rule 440)" available from the Air Pollution Control Board.
In the event that an Air Pollution Health Advisory, Alert, Warning or Emergency is reported from the Department of Air Pollution Control, the Virginia Department of Forestry will suspend its burning operations and recommend to all cooperators that their burning be suspended as well.

Prescribed Fire Managers have a professional, legal, and personal responsibility to assure the success of the smoke management program. They must voluntarily curtail burning if their portion of an air shed is becoming overloaded with smoke or local weather factors are likely to create such problems even though no burning restrictions have been issued.

**My fire**
**My smoke**
**My problem**
**Wherever they go**

## SMOKE MANAGEMENT

Smoke management includes planning, screening and emissions reduction.

This chapter introduces principles of smoke management strategies for prescribed fire.
Smoke management practices include:

- Fuel management;
- Fire prescriptions to reduce available fuel loading or improve combustion efficiency;
- Firing and mop-up techniques to reduce emissions;
- Scheduling to enhance convection or dispersion;
- Scheduling to ensure plume trajectory moves away from sensitive areas. and
- Coordinating burning locations for the best overall result.

### Determining the Need for A Smoke Management Program

Smoke management techniques must be considered by anyone who uses fire as a management tool. Smoke management involves prioritizing individual burns, monitoring fuel conditions, monitoring surface and upper air meteorological parameters, predicting down wind particulate and visibility impacts. The following questions must be considered in developing the smoke management plan.
A. Will smoke from prescribed burning result in public health and safety problems, such as on highways or airports?
B. Are there any other areas that should be considered as smoke sensitive?
C. Will smoke from prescribed burning result in complaints from the public?
D. Can the topography or weather conditions cause poor smoke dispersion? Mountainous terrain and stagnant high pressure systems usually cause the most problems.

E. Are there limitations on the number of days available for prescribed burning because of fire hazard or stagnation problems?
F. Will prescribed burning impact any areas where visibility is an important value?
G. How is the health and safety of the work force being impacted?

## Smoke Management Strategies

Avoidance, dilution, and reduction of emissions are ways to manage smoke from prescribed fires.

### Avoidance
Pollution can often be prevented by scheduling prescribed fires during conditions that make intrusions of smoke into smoke-sensitive areas unlikely. The most obvious way to avoid pollution impacts is to burn when the wind is blowing away from all smoke-sensitive areas. Most fires have an active burning period and a residual period. Wind direction during both periods must be considered. At night, drainage winds can carry smoke toward smoke-sensitive areas. Residual smoke is especially critical at night.

### Dilution
Smoke concentration can be reduced by diluting smoke through a greater volume of air, either by scheduling during good dispersion conditions or burning at slower rates (burning smaller or narrower strips or smaller areas). Caution: Burning at slower rates may mean that burning continues into the late afternoon or evening, when atmospheric conditions become more stable. The time of day at which ignition occurs is also an important consideration because mixing height and transport wind speed are likely to change during the day and night. Generally, a burn early in the day encounters improving ventilation factors; an evening burn encounters deteriorating ventilation factors.

### Emission Reduction
Emission reduction can be an effective control strategy for attaining smoke management objectives.
There are six general categories that encompass all of the techniques to reduce the amount of smoke emissions:

1. Reduce the Area Burned
2. Reduce Fuel Load
3. Reduce Fuel Production
4. Reduce Fuel Consumed
5. Schedule Burning Before New Fuels Appear
6. Increase Combustion Efficiency. Effective firing techniques and proper scheduling can minimize the smoke output per unit area treated. For example, backing fires minimize the inefficient smoldering phase of a prescribed fire.

## Techniques to Minimize Smoke Production and Impacts

Prescribed burning, though necessary for accomplishing certain resource management objectives, can degrade air quality. The practice of prescribed burning carries with it an obligation to eliminate or minimize any adverse environmental effects, including those caused by smoke. The following guidelines will help reduce impacts.

### Why Plan for Smoke Dispersal?

NAAQS – National Ambient Air Quality Standards have been established by the Environmental Protection Agency, EPA, for those compounds which exist in the atmosphere that may cause a human health problem. The standards are expressed in parts per million, PM10, PM25, etc. Historically, prescribed burners have thought that particulate matter, which causes reduction in visibility, was the only problem with wildland fire smoke. While particulate matter is still an important concern, burners must be aware of NAAQS. If NAAQS become a problem, the Virginia Department of Environmental Quality may require stricter regulations and possibly shut down the prescribed burning program in a portion of the state that is in non-attainment.


Class I Air Sheds - were established by the U.S. Congress in the Clean Air Act. They are scenic areas where visibility is critical to the esthetics of an area, such as Grand Canyon National Park.

EPA and other Agencies have been monitoring visibility in national parks and wilderness areas since 1988. In 1999, the U.S. Environmental Protection Agency announced a major effort to improve air quality in national parks and wilderness areas. The Regional Haze Rule calls for state and federal agencies to work together to improve visibility in 156 national parks and wilderness areas such as the Grand Canyon, Yosemite, the Great Smokies and Shenandoah.

The rule requires the states, in coordination with the Environmental Protection Agency, the National Park Service, U.S. Fish and Wildlife Service, the U.S. Forest Service, and other interested parties, to develop and implement air quality protection plans to reduce the pollution that causes visibility impairment. The first State plans for regional haze were due in the 2003-2008 timeframe. Five multi-state regional planning organizations are working together now to develop the technical basis for these plans.

**REGULATED POLLUTANTS (a partial list)**
Wildland fire smoke is primarily water vapor. Burning wildland fuels may produce the following regulated compounds:

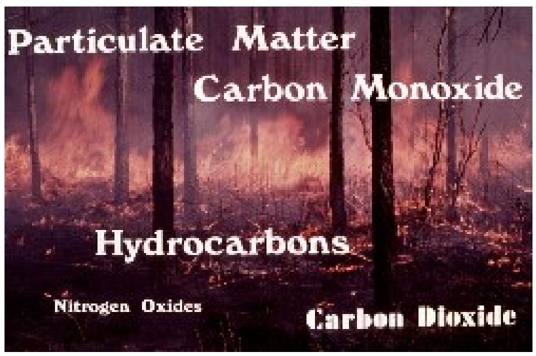
**Particulate Matter** - The main pollutant that can be a problem with forestry smoke. It can affect visibility and could possibly aggravate the breathing of people with respiratory problems.

**Hydrocarbons** - Produced in very small amounts in wildland fires.

**Carbon Monoxide** - Smoke from forestry activities (wildfire and prescribed fire) produces small quantities that are rapidly diluted in the open air.

**Nitrogen Dioxide** - Negligible amounts produced.

**Sulfur Dioxide** - No sulfur dioxide is found in forestry smoke except in rare cases where sulfur is in the ground.




The cumulative effect of all sources of smoke and pollutants in an area may result in problems. Prescribed burners do not operate in isolation. The smoke from a burn may seem inconsequential but may result in saturation or exceed acceptable levels, when combined with other smoke in the area.

**Pre-burn Smoke Management Planning**

The planner and manager should consider smoke factors prior to the burn. Good merchandising of timber can reduce the fuel load and reduce smoke emissions. Felling or raking around snags and removal of 100 and 1,000 hour fuels from the burn area will reduce the fuel load and subsequently reduce smoke emissions. Preventing fire from getting into boggy areas and pocosins where peat and other organic soils may be ignited will prevent residual smoke production that could last for several days.

Burning immediately following a light rain, which wets the humus and part of the duff where the fuel load is heavy, may reduce the amount of fuel consumed and, thus, the smoke produced. Likewise, planning the burn at a time when the 100 and 1,000 hour fuels are too moist to ignite can reduce smoke emission, particularly residual smoke from smolder.

No forestry burning should be done in that portion of Virginia covered by an Air Pollution Health Advisory, Alert, Warning or Emergency issued by the Department of Environmental Quality. All open burning is prohibited when an Air Pollution Alert, Warning, or Emergency has been declared.

All burns, regardless of size, need to follow the recommendations listed on pages 17 and 18, and should be subjected to the screening procedure listed below.

The following procedure, is adapted from the Southern Forestry Smoke Management Guidebook and A Guide For Prescribed Fire in Southern Forests and is used to identify those burns that pose smoke problems for specific sensitive areas.

**Who Should Use Smoke Screening?**

The good old days of grabbing the torch and going are gone. All prescribed burning activity must be carefully preplanned, including planning for smoke dispersal with smoke screening

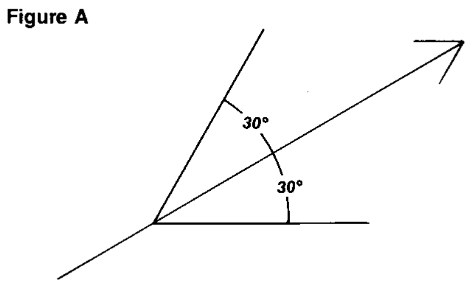
**No Prescribed Fire Should Be Initiated Without First Performing Detailed Smoke Screening**

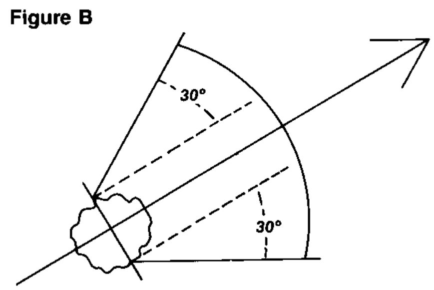
Smoke Screening is the process of reviewing the proposed burn for any impacts that may result from smoke emissions. The burn manager and planner must be aware of the Smoke Sensitive Areas, SSA, in the vicinity of the burn. The planner and manager must also be familiar with the basics of smoke dispersal.

**Smoke Sensitive Areas**

Smoke sensitive areas, SSA, are those places where smoke will cause problems or be a general nuisance to the public. Blocked visibility on highways may result in accidents. Smoke in chicken houses and hog parlors may cause animal fatalities. Smoke at airports can cause air traffic problems. Smoke at hospitals or nursing homes can cause problems, particularly for individuals with respiratory problems. Shuts-ins who depend on supplemental oxygen or who have other respiratory problems can be adversely affected by smoke. Smoke in populated areas can be a general nuisance. Transport winds may carry smoke long distances. Special attention must be paid to critical areas down wind, such as airports, hospitals, areas of non-attainment, and metropolitan areas.

## Smoke dispersal




Smoke disperses at a 30º angle to both sides of a straight line from a point source of smoke. Wind is seldom from a fixed direction but tends to vary. Likewise, we don't burn points, we burn areas, so we must consider the widest points of the source of smoke and consider the 30º drift dispersal from that point. The distance smoke will travel depend on weather factors, topography, and the volume of smoke produced. The volume of smoke produced depends on the volume of fuel that will be converted into smoke and on the speed of ignition.

Two of the strategies of smoke management can be related to each of these dispersal considerations. Avoidance can be addressed with the 30º dispersal knowledge. Dilution can be manipulated by the speed of ignition. The slower the ignition, the more smoke is diluted as it enters the atmosphere.

## Screening Procedure

Step 1
A. Locate the burn on a map. Draw a line representing the center line of the smoke plume (predicted wind direction) for 20 miles.

B. To allow for horizontal dispersion of the smoke, as well as shifts in wind direction, draw two other lines from the fire at an angle of 30 degrees from the center line as shown in the figure.

Step 2
Identify and mark any smoke-sensitive areas within the 30-degree lines plotted. These areas are potential targets for smoke from the burn. (Caution: If wind changes are predicted for the day of the burn or the night following the burn, plot the trajectory of the smoke for the second wind direction and locate any targets within 30 degrees of that line. The person planning the burn should also locate smoke-sensitive targets in any direction that may be affected by an unanticipated wind change.) Examples of sensitive areas are airports, hospitals, nursing homes, interstate or other major high-speed highways, heavily populated areas and Federal Class I air quality areas.

If no potential targets are found within 20 miles, you need only follow the recommendations to reduce smoke impact for all forestry burns found on the next page.
If targets are found, continue this screening system.

Step 3

A. If no targets are found within 10 miles, but are found between 10 and 20 miles, you may burn as prescribed provided the following recommended conditions are met:

1. Afternoon mixing height is 500 meters (1,640 feet) or greater;
2. Afternoon ventilation factor (mixing height in meters x transport wind speed in meters per second) is 2,000 or more;
3. Visibility at burn site should be five miles or more, and
4. The area will be burned over by no later than one hour before sunset.

If these conditions cannot be met, the burn should be postponed.

B. If targets are located within 10 miles, go to Step 4.

Step 4

Special caution should be exercised where targets are found within 10 miles of the burn. All of the minimum conditions listed in Step 3-A should be met. Other concerns, such as the distance to the target, nature of the target, area of the burn, amount and nature of the fuel, fuel moisture, topography, presence of organic soil or a thick, root mat, are only a part of the factors that combine to determine the quantity of smoke produced, its duration and concentration at various distances. Because of the complexity of these factors, a different wind direction for burns with smoke sensitive targets within 10 miles down wind should be considered.

If a different wind direction is not practical, an alternative to burning should be used.

Prescribed Burning Parameters

The reasons for using prescribed fire in Forest Resource Management are many. They include the following:

Reduce hazardous fuels
Prepare sites for seeding and planting
Dispose of logging debris
Improve wildlife habitat
Manage competing vegetation
Control disease
Improve forage for grazing
Enhance appearance
Improve access
Perpetuate fire-dependent species
Manage endangered species

**Prescribed fires aren't always beneficial, however. When conditions are wrong, prescribed fire can severely damage the very resource it was intended to benefit.**

**Recommended Parameters for Prescribed Burning Operations in Virginia**

Your management objectives will dictate how and when fire will be utilized. The tables below lists the recommended parameters for prescribed burning operations in Virginia. These parameters should be followed to help accomplish your objectives and to minimize problems associated with smoke management, fire control, and personnel safety.

Growing Season Burns

| | |
|---|---|
| Temperature | Use caution when temperatures exceed 90 degrees F |
| Relative Humidity | Minimum 25%, Maximum 65% |
| Wind | Not to exceed 15 mph at 20 feet |
| Mixing Height | Needs to exceed 500 meters |
| Cumulative Severity Index | Not to exceed 500 |
| Ventilation Factor | Needs to exceed 2,000 |

Dormant Season Burns

| | |
|---|---|
| Temperature | 60 degrees or below |
| Relative Humidity | Minimum 30%, Maximum 55% |
| Wind | Not to exceed 15 mph at 20 feet |
| Mixing Height | Needs to exceed 500 meters |
| Cumulative Severity Index | Not to exceed 300 |
| Ventilation Factor | Needs to exceed 2,000 |

Site Prep Burns

| | |
|---|---|
| Temperature | Use caution when temperatures exceed 90 degrees F |
| Relative Humidity | Minimum 25%, Maximum 65% |
| Wind | Not to exceed 15 mph at 20 feet |
| Mixing Height | Needs to exceed 500 meters |
| Cumulative Severity Index | Not to exceed 500 |
| Ventilation Factor | Needs to exceed 2,000 |

**Recommendations to Reduce Smoke Impact for All Forestry Burns:**

A. Have a written prescribed burning plan, including a sketch map, prior to conducting the burn.
B. Obtain and use the best available weather forecasts. Use this information to predict fire and smoke behavior. Take wind and humidity measurements at the tract prior to and during the burning operation.
C. Comply with the provisions of the Virginia Air Pollution Control Board Regulations covering open burning and with all Virginia Forest Fire Laws.
D. Burn when atmospheric conditions are good for rapid dispersion of smoke. The atmosphere should be slightly unstable so smoke will rise and dissipate, but not so unstable as to cause a control problem.
E. Highway visibility must be considered. If an unexpected wind change should cause severe visibility reduction on any highway, be prepared to attempt to cut off the burn and to request assistance in traffic control from local law enforcement. Smoke warning signs should be placed on all roads where visibility may be reduced by smoke. Flaggers should be posted where visibility is significantly reduced. On all burns, mop-up along roads should begin as soon after burnout as possible to reduce the impact of residual smoke on visibility. Relative humidity is a critically important parameter for evaluating potential visibility hazard. A relative humidity at or above 70 percent indicates that a given concentration of smoke will restrict visibility more severely than in dry conditions. Relative humidities in the 80s and 90s may be associated with smoke-induced fog formation and visibility hazards, while natural fog often occurs when the relative humidity is in the 90s as well as at 100 percent. Burning within one mile of Interstate highways where fog can occur should be avoided. Fog problems may be greater in the fall months.
F. Virginia Air Pollution Regulations require that permission be obtained from the occupants of all dwellings located within 1,000 feet of the burn.
G. Volunteer Fire Departments (usually the local emergency dispatcher) and other local residents should be notified. This is very important to help prevent adverse public reaction.
H. If doubt exists concerning fire or smoke behavior, light a small test burn.
I. Use backing fires when possible. Backing fires give more complete combustion of fuel and produce less smoke. Even though slower and sometimes more expensive, less pollutants are put in the air and visibility is less restricted. In those cases where a backing fire in scattered logging debris would not give fires of sufficient intensity for adequate planting site preparation, ring or head fires must be used. In those cases, special attention must be paid to any smoke-sensitive targets downwind. Head fires produce more smoke but do not last as long as backing fires. Burning during the middle of the day or early afternoon (time of more unstable conditions) may result in less smoke concentrations at sensitive targets.
J. Minimize residual smoke caused by fuels that may smolder for hours or days after the burn. Care should be taken to keep fires out of piled logging debris at log decks, sawdust piles, chip piles or bark piles. If fire gets in any material that will smolder for days or weeks, an attempt should be made to extinguish the fire as soon as it burns down enough to be practical. Mop-up activities should be directed toward residual smoke control as well as toward preventing the escape of the fire.

K. When drought conditions exist (Cumulative Severity Index over 400), residual smoke can be expected and additional mop-up may be needed to prevent smoke-related problems. Areas with organic soil or a thick root mat should not be burned when the soil or root mat is dry enough to continue to burn for long periods. Termination of burning should be considered if the Cumulative Severity Index reaches the limits listed on Page 15.

L. The burnout phase should be completed no later than one hour before sundown. Predicting smoke drift is more difficult at night. The wind may lessen or die out completely. The smoke and fog may collect in low-lying areas, causing serious problems if highways or residences are in those areas.

M. Aerial ignition is often advantageous to use because more complete combustion is accomplished with a more intense prescribed burn. Additionally, by burning large acreages quickly, smoke is dissipated very rapidly.

**Topography**

**Down drainage smoke is a**
**KILLER !!**

Where does smoke go at night? Down drainage. Why? Because it is cool. Road bridges across drainages are critical places. Smoke on interstates and other highways and by-ways can result in dire consequences, including fatalities and damage in the millions.

Smoke can be trapped if the surrounding mountains are higher than the mixing height.

**The Burn Plan**

The person who is in charge (the Burn Boss) is responsible for the decision to burn!

Likewise, the Burn Boss is responsible for where the smoke goes!

**All burn plans should include plans for smoke.**
**The following smoke-related questions should be addressed in the plan:**

What quantity of emissions will it take to saturate the airshed?
Where will smoke concentrate if it settles under an inversion?
Do special arrangements need to be made to protect populations impacted by these emissions?
How many burning projects will it take cumulatively to exceed acceptable levels within this airshed?
How long will this airshed remain stable and harbor the emissions?

The plan should address pre-burn smoke matters, smoke screening, and monitoring smoke behavior during the burn, mop-up, and post-burn monitoring particularly in down drainage areas at road bridges.

***Minimize Risk***
**Be on the safe side**

**TONS OF FUEL = TONS OF SMOKE**

Distance of Possible Smoke Impact
Example- If you are burning grass and you have excellent dispersion you will impact targets for only ¼ mile out. If your dispersion is very poor, you will impact targets up to 8 miles out. If you have a target 3 miles from your burn you must have as a minimum, fair dispersion.

| Fuel Type or Firing Technique (fuel model) | Distance in Miles by Category Day (Dispersion Index)+ | | | | | |
|---|---|---|---|---|---|---|
| | (7-12) very poor | (13-20) poor | (21-40) fair | (41-60) good | (61-100) very good | (>100) excellent |
| Grass, crop residue, light understory, or -- using backing fire with any fuel type. | 8 | 4 | 2 | 1 | 1/2 | 1/4 |
| Heading fire, spot fires, or <300 ac. | 16 | 12 | 8 | 4 | 2 | 1/4 |
| Heading or spots >300 ac. | do not burn | 20 | 12 | 6 | 3 | 1/2 |
| Scattered logging debris <200 ac. | do not burn | 16 | 8 | 4 | 2 | 1 |
| Scattered logging debris >200 ac. | do not burn | do not burn | 12 | 6 | 4 | 2 |
| Small dry piles. | do not burn | do not burn | 12 | 6 | 4 | 2 |
| Large, wet piles or windrows. | do not burn | do not burn | do not burn | 15 | 10 | 5 |
| Firing should be completed 1 hour before dusk, because dispersion will deteriorate at night--usually to "poor." | | | | | | |

**Mop-up**

Mop-up, eliminating sources of smoldering flame and residual smoke, is critical to prevent down drainage nigh time smoke problems at road crossings.  Mop is accomplished by working through the burned area to extinguish all sources of smolder smoke. Using a shovel and dirt is one method.  Using water from a bladder pack or a mobile unit is another alternative.

Doing it the hard way.


A mobile source of water is an efficient way to mop-up

**Caution!!!** There may be other sources of smoke in the air shed in which you are working. Other prescribed burns, industrial smoke, construction smoke, etc., may all combine downwind to aggravate any potential problem.  Be cautious!!! Do not rely solely on tables or guidelines. Use judgment based on experience on site!  Remember the strategies: Avoidance, Dilution, and Minimization.  Certain situations deserve Special Caution: Residual smoke/smoldering fire, windrows and large dirty piles, night-time burning, large burns, and helicopter burns all require special attention.

**Residual-smolder smoke considerations:**

The same volume of fuel consumed with a smoldering fire will produce roughly five times the amount of smoke as a flaming fire.
Fuels containing waxes (Mountain Laurel, Wax myrtle) produce more smoke.

**To reduce the impact of smolder:**

Reduce volume of fuel (smaller block);
Reduce the fuel size (merchandising);
Burn only dry fuels (weather timing);
Do not burn stumps or snags (pre-burn prep), and
Do not allow dirt in piles (use a root rake when piling, work with the logger)

**Windrows and large piles:**

Windrows are the most polluting woodland fuel burned in Virginia! Don't burn windrows and large piles.

Piles contain a large amount of potential energy, which, when ignited, may form a convection column that may loft fire brands to areas where they are not wanted.
Wet dirty fuels in piles and windrows are a potential source of smolder smoke. Residual smoke from piles may linger for days and drift onto highways and block visibility. Piles when burning may form a convection column that lofts fire brands into neighboring fuels that were not included in the burn plan.

If conditions are not perfect for pile burning, DO NOT push the envelope! It is better to leave a pile unburned than to risk an escape or smoke problem. The few acres gained by pile burning are not worth the risk.

**To reduce the impact of piles:**

- Don't build them;
- Isolate piles and burn under favorable conditions;
- Break up piles and spread material;
- Require logger to spread logging slash;
- Do NOT push windrows;
- Burn with high ventilation;
- Use root rake when piling;
- Burn with low surface wind speed, and
- Complete burnout one hour before sunset.

**Night-time burning:**

Smoke produced will not lift due to atmospheric stability. As smoke cools it will settle into low areas and drift down drainage. This is primarily the reason the Virginia Department of Forestry recommends NOT TO burn at night.

**Large burns:**

300+ acres….1,000+ acres. Large burns produce large quantities of smoke. Consider the total volume of fuel and the potential total volume of smoke.

**To reduce smoke from burning large tracks:**

Break area into smaller blocks;
Burn scattered blocks in any given day;
Burn when atmospheric conditions are favorable;
Give down drainage SSAs special attention;
Check for nearby burns;
Be sure smoke from different blocks does not come together down drainage;
Be conscious of down wind urban areas, and
Increase the DI category day.

**Helicopter burns:**

The rapid ignition of helicopter burns due to the rapidity of ignition may put large volumes of smoke into the atmosphere in a very short period of time.

**To reduce potential smoke problems from helicopter ignition**

Increase DI by one category;
Do not use a helicopter when RH is over 80% or fog is forecast for the night;
Do not use when an inversion is forecast;
Ignite only a few lines on one block then go to another;
Stop ignition early in the day;
Burn only with 3000'+ mixing height, and
Don't depend on forecast – OBSERVE !!!

Caution !!!
Smoke flows down drainage at night!
How far is the nearest urban area, 30, 50 miles?

**Be Smoke Wise**

# Chapter 3 Fire Science

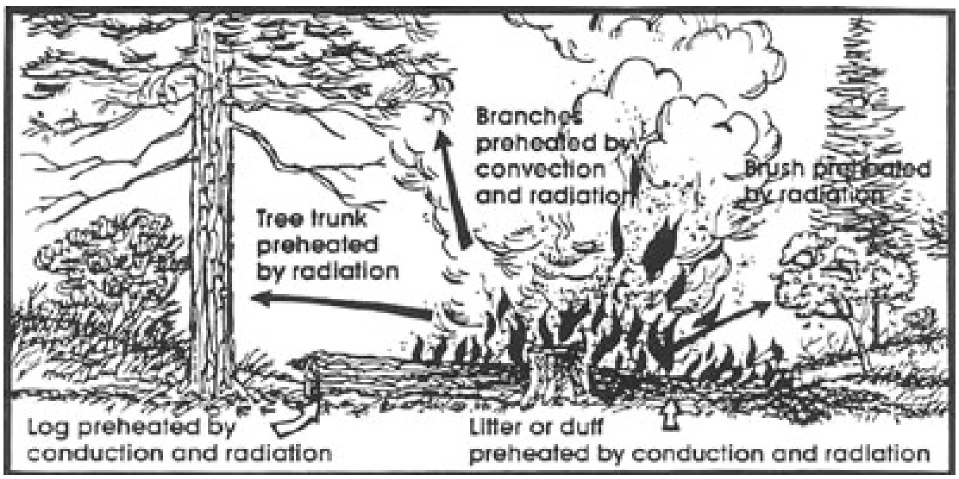
The Fire Triangle


The first step in teaching about wildland fire is to begin with the essentials as illustrated by the fire triangle and its three equal sides, representing heat, fuel, and oxygen; the interaction of the three are required for the creation and maintenance of any fire. When there is not enough heat generated to sustain the process, when the fuel is exhausted, removed, or isolated, or when the oxygen supply is limited, then a side of the triangle is broken and the fire is suppressed. The underlying theme is that wildland fire personnel seek to manage one or more of the three elements in order to suppress an unwanted fire or guide a prescribed fire.

***Heat*** A heat source is responsible for the initial ignition of wildland fires, and heat is also needed to maintain the fire and permit it to spread. In addition, heat is constantly emanating from the fire, warming the surrounding air and preheating fuel in its path.
***Fuel*** The fuel side of the fire triangle refers to both the external and internal properties of the fuel. External properties refer to the type and the characteristics of the fuel material. Internal properties of fuel address aspects of fuel chemistry. Types of fuel include living vegetation, dead vegetation, (duff, twigs, needles, standing dead snags, leaves, and moss), organic subsurface material (peat and coal). Fuel can be defined as any combustible material.
***Oxygen*** The third side of the fire triangle represents oxygen. Air contains about 21% oxygen; most fires require air with at least 16% oxygen content to burn under most conditions. Oxygen supports the chemical processes that occur during a wildland fire. When fuel burns, it reacts with oxygen from the surrounding air, releasing heat and generating combustion products, e.g., gases, smoke, particles. The process is known as **oxidation**.

In order for fire to continue conditions must continue to support the reaction.
One of the elements, legs, of the triangle must be broken to stop fire. Fuel may be removed. Oxygen may be removed. Or, the temperature may be reduced below the level necessary for combustion.

**Heat Energy Transfer**
Heat transfer is a critical issue in the study of wildland fire. For a fire to grow and spread, heat must be transferred to the initial and surrounding fuel. Heat allows fire to spread by removing (evaporating) the moisture from the nearby fuel, enabling it to travel more easily. The mechanism and the speed of heat transfer play a great role in wildland fire behavior.
Three mechanisms of heat transfer exist: convection, radiation, and conduction. All three contribute in different ways to the combustion process, depending in part on the available fuel distribution, the wind speed at the fire site, and the slope of the terrain.



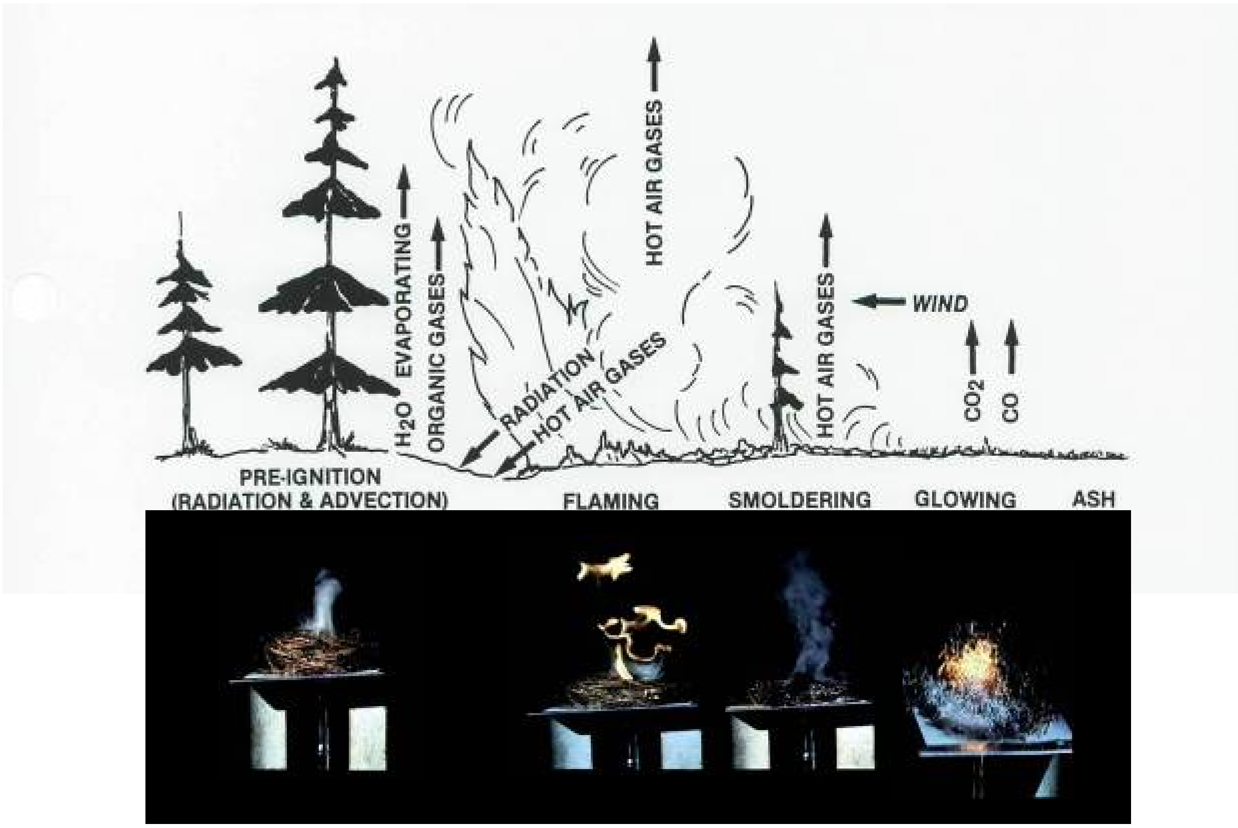

**Conduction** is the process of heat transfer though a solid: when one end of a steel rod is placed in a fire the other end which is not in the fire gets hot.

**Convection** is the process of heat transfer due to the rising of the heated air as it warms: the suns energy warms the earth's surface which warms the air adjacent to the surface and that air begins to rise because it is warmer than the air in shaded areas around it.

**Radiation** is the transfer of heat through energy waves: the suns warmth can be felt through a glass window.

Fire in organic, woody fuels burns in several stages. The amount of energy, heat, required to raise the temperature of woody fuels to the ignition temperature varies with the moisture content of the fuel and the atmosphere. As a fire advances, it pre-heats the adjacent fuel driving off moisture and raising the temperature to the ignition point, normally 400 – 800 degrees Fahrenheit in woody fuels, such as pine litter, hardwood leaves, logging debris or brush. Combustion of woody fuels can be divided into four stages; pre-ignition, flaming, smoldering, and glowing.

# Chapter 4 Smoke Production, Characteristics and Effects




This chapter discusses the combustion process; the effect of fuel properties on smoke production; the characteristics and health hazards of smoke.

## Stages of Combustion

### Pre-ignition Phase

Heat is being absorbed by the fuel; water vapor moves to the fuel's surface and escapes. In this phase, the internal temperature of the fuel is being raised, causing certain components of wood to decompose, releasing organic gases and vapors. This process is called pyrolysis. When these very hot gasses and vapors mix with oxygen, they will ignite.

### Flaming Phase

This begins when the fuel reaches ignition temperature and erupts into flames. The products of flaming combustion are predominately carbon dioxide (CO2) and water vapor. This water vapor is not the result of the heating of the fuels as in the pre-ignition phase but rather a product of the combustion process. The temperatures in this phase range between 600 and 2,500 degrees Fahrenheit. When mixed with oxygen, the heated gases ignite, oxidation occurs, and smoke is produced. Some organic gases cool and condense without passing through the flame zone. Others pass through the flames and are only partially oxidized producing a great variety of emissions. Some compounds with higher molecular weights cool and condense into tar droplets and soot particles. These make up the visible smoke component with which we are primarily concerned. The more inefficient the burning, the more soot and tar particles produced.

**Smoldering Phase**

In this phase, the overall reaction rate of the fire has diminished to a point at which the concentration of combustible gases above the fuel is too low to support a persistent flame. The temperature drops and gases condense, thereby producing smoke. The chemical process is incomplete and a large amount of smoke is produced. Emissions from a smoldering fire are at least twice that for a flaming fire. The heat released is seldom enough to sustain a convection column. The smoke produced during this phase is virtually soot-free, consisting mostly of tar droplets. With insufficient heat to produce a convective column, the smoke is concentrated close to the ground.

**Glowing Phase**

All volatile material in the fuel has been driven off. Oxygen in the air can now reach the fuel; the surface of the charcoal begins to burn with a characteristic yellow glow. There is no visible smoke. Carbon monoxide and carbon dioxide are the main products. This phase continues until the temperature drops or until only non-combustible gray ash remains.

## Fuel Properties As They Affect Smoke Production

The total volume of smoke produced from a prescribed fire depends primarily upon the amount of fuel consumed. Smoke production can last from less than an hour to several weeks. The manner in which combustion and smoke production take place depends primarily on fuel moisture and such physical fuel properties as fuel size, fuel arrangement, and total amount of fuel.

**Fuel moisture-** is controlled by two major factors: weather and the curing stage. The amount of moisture in fuels greatly affects the ease of ignition and the efficiency with which live and dead vegetation burn. By affecting flame temperature, hence combustion efficiency, moisture in the fuel affects the amount and character of emissions. The cleanest fire is the most efficient fire because, by definition, its combustion is the most complete. On the other hand, though the emissions per unit of fuel burned will be greater at higher fuel moistures, the total smoke produced from a burn may be less if some fraction of the fuel, typically the larger round fuels and the duff, have enough moisture that they do not totally burn.

**Fuel Size and Arrangement-** with a given fuel moisture, the time necessary to ignite and consume the fuels depend on the size (surface area) and arrangement. The greater the surface area and the greater the space between fuels, the faster they will burn. As the fuels become packed more tightly and surface area is reduced, the combustion efficiency is decreased and smoke production will increase.
**Fuel Loading-** when using fire in areas with light fuel loads, such as grasslands and frequently burned pine stands (usually under 4 tons per acre), total smoke production is low because smoldering combustion is minimal. The heaviest fuel loadings are normally encountered in piled logging debris, and burning these areas will have the most adverse impact on smoke management.
**Fuel Continuity-** both horizontal and vertical continuity affects the amount of fuel consumed. Sustained ignition will not occur when spacing between the fuel is too large. More smoldering will occur and, thereby, more smoke will be produced.

**Chemical and Physical Characteristics of Smoke**

Products from the combustion of forest fuels are mainly carbon-containing compounds. The most important pollutants being particulate matter and carbon monoxide(CO).
Two products of complete combustion are carbon dioxide(CO2) and water, these make up over 90% of the total emissions. Under ideal conditions, it takes 3.5 tons of air to completely burn one ton of fuel. The combustion of one ton of fuel will produce the following:

| | |
|---|---|
| Carbon Dioxide(CO2) | 2,000 to 3,500 lbs |
| Water Vapor | 500 to 1,500 lbs |
| Particulate Matter | 10 to 2,000 lbs |
| Carbon Monoxide(CO) | 20 to 500 lbs |
| Hydrocarbons | 4 to 40 lbs |
| Nitrogen Oxides | 1 to 9 lbs |
| Sulfur Oxide | Negligible amounts |

**Carbon Dioxide-** is not considered a pollutant, but Carbon Monoxide, Hydrocarbons, Nitrogen Oxides, and Sulfur Oxides are.

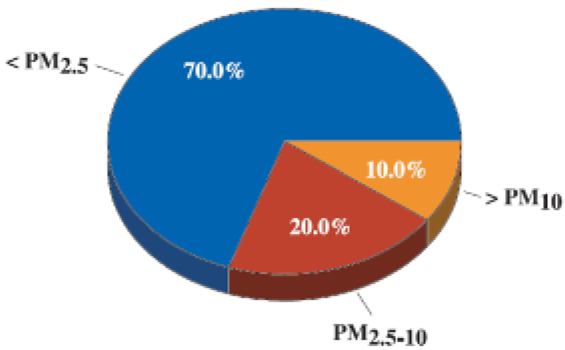
**Carbon Monoxide -**is the most abundant air pollutant produced by prescribed fires. Its negative effect on human health depends on duration of exposure, concentration, and level of activity during exposure. Dilution occurs rapidly enough to minimize the health hazards.
Hydrocarbons are an extremely diverse group of compounds that contain hydrogen, carbon, and sometimes oxygen. The majority of the hydrocarbons have no harmful effects.

**Nitrogen Oxides -**are produced primarily from oxidation of the nitrogen contained in the fuels. Most forest fuels contain less than one percent nitrogen, of that amount 20 percent may be converted to nitrogen oxide when burned.

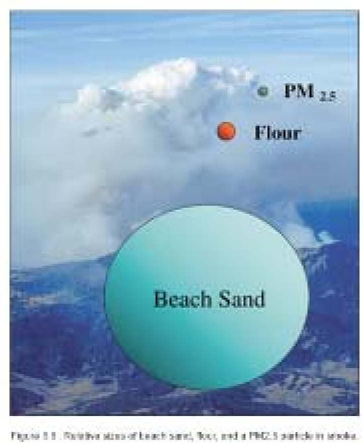
**Sulfur Oxides -**are produced in negligible quantities because of the low elemental sulfur content of forest fuels. Sulfur is lost from the site during burning as is nitrogen.

**Particulate Matter -**is the most important pollutant emitted by fire and is largely responsible for low visibility and aggravated respiratory conditions. It is a complex mixture of solids and tars. Particulate matter from wood smoke has a size range near the wavelength of visible light (0.4 - 0.7 micrometers). This makes the particles excellent scatters of light and, therefore, excellent reducers of visibility. Many are too small to be seen with the naked eye and may stay suspended in the atmosphere for weeks and even years. These very small particles may not be filtered out by smoke masks and may penetrate deeply into the lungs.

Particulate matter is the major problem from forestry smoke. All smoke management systems are based on it. Particulate matter is described and regulated on the basis of its size.




70% by mass are less than 2.5 microns (i.e., pollen)
20% by mass are between 2.5 and 10 microns (i.e.,dust)
10% by mass are greater than 10 microns (i.e., fly-ash)




1 micron = 1/25,000 of an inch.

## Emission Rates

Emission rate is defined as the amount of smoke produced per unit of time.

Downwind concentrations of particulate matter in smoke are related directly to the emission rate at the fire source; the emission rate, in turn, is affected by the amount of fuel being burned, and the rate at which it burns.

Backing fires are most efficient and produce the least amount of smoke.

Head fires consume half the available fuel, are less efficient and produce more smoke.

Ring fires are heavy smoke producers as are aerial ignited burns.

## Residual Smoke

Residual smoke is defined as the smoke produced from smoldering combustion and not contained in a convection column. During the active combustion stage of almost all prescribed burns, smoldering combustion takes place near flaming fuels. Much of the smoke from the smoldering fuel is entrained into the convection column induced by the flames and carried aloft. When flaming ceases, the convection column dissipates and all subsequent smoke produced remains near the ground as residual smoke.

Smoldering combustion frequently causes visibility problems immediately downwind of a burn when the convection column dissipates.

If residual smoke persists into the night or the next day, special problems may arise. In flat terrain, wind is usually minimal at night, causing smoke to build up in the vicinity of the burn. Any nearby drainage may also have an increased concentration of residual smoke. In addition, the particulate matter may serve as nuclei for fog formation if the relative humidity approaches the water saturation point. Residual smoke can and will flow down drainage's causing possible visibility and other problems.

Residual smoke persisting for several days poses additional problems because the burn manager cannot make reliable predications of the wind speed and direction much beyond the day of the burn. The best burn plans should contain provisions to minimize the residual smoke.

**Secondary Emissions**

Secondary emissions pollutants are formed in the atmosphere by photochemical transformation of primary emissions. They include oxidants, such as ozone.

**Health Hazards of Smoke**

Firefighters can face unhealthy levels of smoke when patrolling or holding fire lines on the downwind edge of a wildfire or prescribed fire; during direct attack of an escaped prescribed fire, or while mopping up.

The following is based on an article by Breysse, 1984, in which he discusses the health hazards of smoke.

Inhalation of smoke from whatever source can cause acute or chronic damage to health. The acute, or immediate, symptoms are caused by exposure to high concentrations of smoke over short periods of time. Manifestations range from irritation of the eyes and respiratory tract, to impaired judgment.

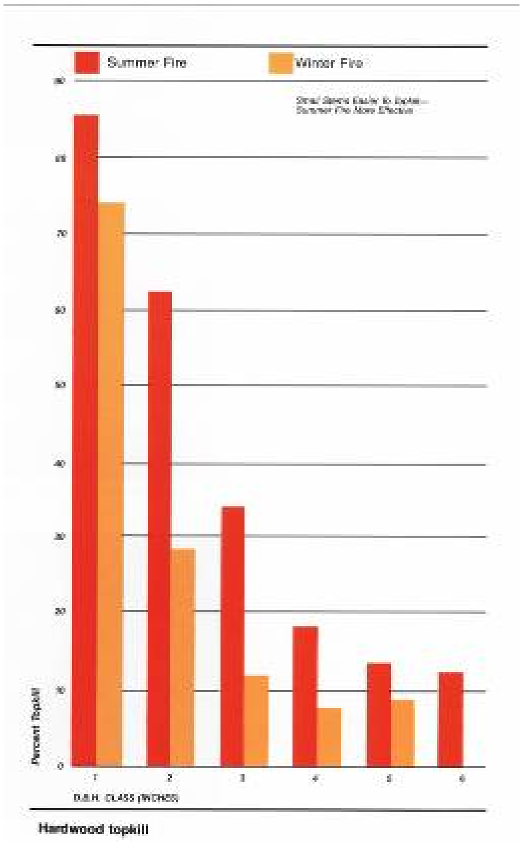
More critical are repeat exposures to relatively low concentrations. These may result in respiratory allergies, bronchitis, emphysema, and cancer. Chronic health hazards are by far the more significant, because 15 or more years usually pass before the victim is disabled.

Some concerns have been expressed as to the amount, if any, of herbicide residue in the smoke that is produced from lands treated with herbicides. A recent study examined 14 sites that were treated with Arsenal, Garlon 4, Pronone 10G, Velpar ULW, and Tordon. The tract sizes ranged from three to 380 acres, and all were burned within 30 to 169 days after treatment. NO herbicide residues were detected in any of the monitoring devices used in the study.

The health implications of short-term exposure and the potential health effects of long-term exposures have not yet been quantified.

# Chapter 5 Environmental Effects

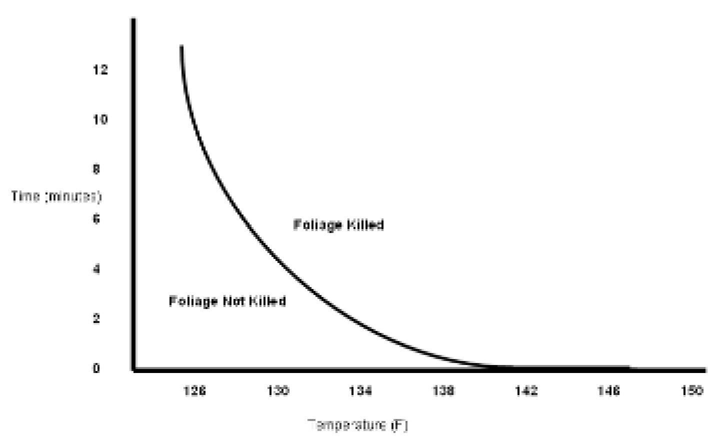
## Effects on Vegetation




Prescribed burning has direct and indirect effects on the environment. Proper use of prescribed fire, and evaluation of the benefits and costs of a burn require knowledge of how fire affects vegetation, wildlife, soil, water and air. Burning techniques and timing of burns can be varied to alter fire effects.

Lethal Temperature

The lethal temperature for plant tissue is in the neighborhood of 140 °F (60 °C). It may be assumed that the buds, needles and branch endings of a pine will die if heated to a temperature exceeding 140 °F (60 °C). An analysis of the lethal effects of fire, therefore, reduces to an analysis of those factors which directly or indirectly affect the temperature of the susceptible parts of a tree.



Of these, the initial vegetation temperature may be one of the most important. The temperature of the foliage of a pine in bright sunlight may exceed 105 °F (40.5 °C). Therefore, an increase of only 35 °F (19.4 °C) would be required to reach the lethal temperature, and the absorption of a relatively small amount of heat by the foliage would accomplish this.
On the other hand, the foliage temperature might be only 35 °F (2.7 °C) or 40 °F (4.4 °C) during a cold period in winter. Under these conditions, considerable heat would be required to raise the temperature up to the lethal value of 140 °F (60 °C). A fairly intense fire during cold winter weather might, therefore, do no more damage than a low-intensity fire in hot summer weather. The same comparison might be made between hot and cold spells both occurring in the winter, or both occurring in the spring.

One of the most noticeable features is the sudden increase in a pine's heat tolerance at temperatures below 29 °F (1.67 °C). At this temperature, since most of the water in the needles and buds would be frozen, large quantities of heat would be required to convert the ice back to water. At a temperature of 29 °F (1.67 °C), pine foliage should tolerate a fire about four times as intense as at a temperature of 95 °F (35 °C). Some field staff has noticed that cold-weather fires have resulted in much less damage than might be expected.
Results for hardwoods should be very similar to those for pine, except that their heat tolerance would be lower. In stands managed for the perpetuation of pine, hardwood sprouts could probably be girdled most effectively by burning in hot, sunny weather.

Fire may injure or kill part of a plant or the entire plant depending on how intensely the fire burns and how long the plant is exposed to high temperatures. In addition, plant characteristics, such as bark thickness and stem diameter, influence the susceptibility to fire. Small trees of any species are easier to kill than large ones.

Southern pine bark has good insulating qualities, and is thicker than the bark of most hardwood species. As a result, hardwood trees are generally much more susceptible to fire injury than are pines. Pine trees three inches or more in ground diameter have bark thick enough to protect the stems from damage by most prescribed fires. However, the crowns are quite vulnerable to temperatures above 1,350°F. Pine needles will survive exposure to 1,300°F for about five minutes, while similar needles exposed to 1,450°F for only a few seconds will die.

**Effects on Soil**
Specific effects on soil may vary greatly. Frequency, duration, and intensity of fire, as well as soil characteristics must be considered. Prescribed burning in the South normally causes little or no detectable change in amount of organic matter in surface soils. In fact, slight increases have been reported on some burned areas. Prescribed under story burns will not cause changes in the structure of mineral soil because the elevated temperatures are of brief duration. However, burning piled or windrowed debris, or burning when fuel and/or soil moisture conditions are extremely low, may elevate temperatures long enough to ignite organic matter in the soil as well as alter the structure of clay soils.

**Effects on Water**
The main effect of prescribed burning on the water resource is the potential for increased runoff of rainfall. When surface runoff increases after burning, it may carry suspended soil particles, dissolved inorganic nutrients, and other materials into adjacent streams and lakes reducing water

quality. These effects seldom occur after Coastal Plain burns. Problems can be avoided in hilly areas or near metropolitan water supplies by using properly planned and conducted burns.

**Effects on Air**

Prescribed fires may contribute to changes in air quality. Air quality of a regional scale is affected only when many acres are burned on the same day. Local problems are more frequent and occasionally acute due to the large quantities of smoke that can be produced in a given area during short period of time.

Smoke consists of small particles (particulate) of ash; partly consumed fuel, and liquid droplets. Other combustion products include invisible gases, such as carbon monoxide, carbon dioxide, hydrocarbons, and small quantities of nitrogen oxides. Oxides of nitrogen are usually produced at temperatures only reached in piled or windrowed slash or in very intense wildfires. In general, prescribed fires produce inconsequential amounts of these gases. Except for organic soils (which are not generally consumed in prescribed burns), forests fuels contain very little sulfur, so oxides of sulfur are not a problem either.

Particulates, however, are of special concern to the prescribed burner because they reduce visibility. The amount of particulate put into the air depends on amount and type of fuel consumed; fuel moisture content, and rate of fire spread as determined by timing and type of firing technique used. Rate of smoke dispersal depends mainly on atmospheric stability and wind speed.

Effects of smoke can be managed by burning on days when smoke will blow away from smoke-sensitive-areas. Precautions must be taken when burning near populated areas, highways, airports and other smoke-sensitive areas. Weather and smoke management forecasts are available as a guide for wind speed and direction. Any smoke impact downwind must be considered before lighting the fire. The burner may be liable if accidents occur as a result of the smoke. All burning should be done in accordance with applicable smoke management guidelines and regulations. During a regional alert when high pollution potential exists, all prescribed burning should be postponed.

**Effects on Human Health and Welfare**

Occasional, brief exposure of the general public to low concentrations of drift smoke is more a temporary inconvenience than a health problem. High smoke concentrations can, however, be a very serious matter, particularly near homes of people with respiratory illnesses or near health-care facilities.

Smoke can have negative short and long-term health effects. Fire management personnel who are exposed to high smoke concentrations often suffer eye and respiratory system irritation. Under some circumstances, continued exposure to high concentrations of carbon monoxide at the combustion zone can result in impaired alertness and judgment. The probability of this happening on a prescribed fire is, however, virtually nonexistent.

More than 90 percent of the particulate emissions from prescribed fire are small enough to enter the human respiratory system. These particulates can contain hundreds of chemical compounds, some of which are toxic. The repeated, lengthy exposure to relatively low smoke concentrations over many years can contribute to respiratory problems.

**Effects on Wildlife**

The major effects on wildlife are indirect and pertain to changes in food and cover. Prescribed fires can increase the edge effect and amount of browse material, thereby improving conditions for deer and other wildlife. Quail and turkey favor food species and semi-open or open conditions that can be created and maintained by burning. Burning can improve habitat for marshland birds and animals by increasing food production and availability.

The negative effects of prescribed fire on wildlife can include destruction of nesting sites and possible killing of birds, reptiles or mammals trapped in the fire. Fortunately, prescribed fires can be planned for times when nests are not being used. Also, virtually all the types of prescribed fire used in the South provide ample escape routes for wildlife. For example, a large tract was operationally burned with aerially-ignited spot fires and immediately examined for wildlife mortality. Fish and game agency personnel found none, but noted deer moving back into the still-smoking burn. The ill-advised practice of lighting all sides of a burn area (ring firing) is a primary cause of animal entrapment and has no place in under-burning. It also results in unnecessary tree damage as the flame fronts merge in the interior of the area.

Prescribed fire does not benefit fish habitat, but it can have adverse effects. Riparian zone (streamside) vegetation must be excluded from prescribed burns to protect high-quality plant and animal habitat, and water quality. When shade is removed, water temperatures will increase. Burning conditions are often unfavorable along streams because of increasing fuel moisture, making line plowing optional. But a buffer zone should always be left. If in doubt, a control line should be put in. All burning in or adjacent to Streamside Management Zones (SMZs) should be done in accordance with established “Best Management Practices)

**Effects on Water Quality**

Prescribed fire is an important and useful silvicultural tool. It can be used to prepare a site for planting by reducing logging debris or to prepare a seedbed for seed fall. Prescribed fire can also be used in established stands for silvicultural purposes; wildlife habitat improvement, and hazard reduction. A concern in the use of fire for any of these management purposes is the effect of the prescribed fire on surface runoff and soil erosion. Studies have shown that properly planned and conducted prescribed burning has a minimal impact on water quality in the South. Most problems associated with prescribed burning can be minimized with proper planning; awareness of changing weather conditions, and by following the guidance of a certified prescribed burn manager who has been through The Virginia Department of Forestry’s Program.

**BMPs for Prescribed Burning**

1. Site preparation burns on steep slopes or highly erodible soils should be conducted only when they are absolutely necessary and should be of low intensity.
2. A significant amount of soil movement can occur when preparing for prescribed burns. Firebreaks should have water control structures to minimize erosion. Locate firelines on contours as much as possible. Water bars should be constructed in firelines at frequent intervals to slow surface runoff in areas subject to accelerated erosion, such as steep grades or highly erodible sloping firelines.
3. Site preparation burning creates the potential for soil movement. All efforts should be made to keep high-intensity site prep burns out of SMZs.
4. Use hand tools when necessary to connect firelines into stream channels.
5. Avoid burning when conditions will cause a fire to burn too hot and expose mineral soil to erosion.
6. Avoid allowing high-intensity fire to enter SMZs.
7. Avoid burning on severely eroded forest soils when the average duff layer is less than one-half inch.

**BMPs for Fireline Construction**

1. Firelines should be constructed along the perimeter of the burn area and, when prescribed, along the boundary of the SMZ. The purpose of protecting the SMZ from fire is to safeguard the filtering effects of the leaf litter and organic material. If a fireline along the SMZ boundary is not prescribed, allowance should be made for a low-intensity backing fire within the SMZ.
2. Firelines should follow the guidelines established for skid trails with respect to water bars and wing ditches and should be only as wide and as deep as necessary to permit safe prescribed burns.
3. Firelines that approach a drainage should be turned parallel to the stream or include the construction of a wing ditch or other structure that diverts concentrated runoff into the woods prior to entry into the stream channel.
4. Firelines on highly erodible sites should be inspected periodically to correct any developing erosion problems before they become too serious.
5. Avoid disturbing existing gullies where possible.
6. Avoid disturbing any more soil surface than necessary.
7. Avoid plowing straight up and down a slope, where possible.
8. Revegetate bare soil areas with slopes greater than 5 percent, where practical.

**Effects on Aesthetics**

The principal effect of prescribed burning on aesthetics can be summarized in one word: contrast. Contrast, or change from the preburn landscape, may be positive or negative depending largely on personal opinion. What may be judged an improvement in scenic beauty by one may be considered undesirable by another.

Many of the undesirable impacts are relatively short term and can be minimized by considering scenic qualities when planning a burn. For example, the increased turbulence and updrafts along roads and other forest openings will cause more intense fire with resulting higher tree trunk char and needle scorch. Generally, the more immediate unfavorable impacts, such as smoke and ash; top killed understory plants, and a blackened forest floor, are necessary to achieve two major benefits - increased visual variety and increased visual penetration.

Variety or diversity in vegetative cover will create a more pleasing, general visual character to the stand. Similarly, scenic qualities of the forest can be better appreciated if the stand can be made more transparent. An example is the reduction of an understory buildup along a forest road that will permit the traveler to see into the interior of the stand, perhaps to a landscape feature, such as a pond or interesting rock outcrop. The smutty appearance of the ground will "green up" fairly quickly. Any scorched needles will soon drop and not be noticeable; flowers and wildlife will increase. Personal reactions will depend on observer distance, duration or viewing time, and aspect.

# Chapter 6 Fire Behavior Factors

There are three major factors that impact fire behavior that the burn manager and burn planner must be thoroughly familiar with before attempting to plan or conduct a prescribed burn. They are weather, fuels and topography. In addition, ignition techniques, both method and pattern, influence the effects of fire on vegetation, soils and smoke production Areas where smoke may be a nuisance or annoyance are also critical.

**Weather**

> **"Knowledge of weather is the key to successful prescribed burning, and is mandatory for proper management of smoke produced by burning."** ***(Wade)***

The individual weather element ranges presented are not a prescription. The burn planner and manager must prescribe specific weather criteria to accomplish the burn objectives.

**Temperature**
Ambient air temperature is probably the single most important factor affecting fuel moisture. The instantaneous lethal temperature for growing plant tissue, including the cambium under the bark and buds, is approximately 145 °F. However, the dwell time around the root collar or in the crown may result in live tissue mortality at lesser temperatures depending on whether the tissue is dormant or actively growing. Plant tissue is more susceptible to mortality when it is actively growing rather than dormant. Hot growing-season fires tend to be lethal to live tissue. Less intense fires in the dormant season tend not to be lethal to live tissue.

CAUTION ! Temperatures of 80 °F+ may result in a Probability of Ignition of 70percent+ which may be very risky and not a good prescribed burning condition if control is a problem

**Relative Humidity**
Relative humidity is the amount of moisture in the air/atmosphere, related to the amount of moisture that the air can hold at a given temperature and atmospheric pressure. The dew point, a related factor, is the air temperature at which water droplets would begin to form (100 percent RH) if the air temperature drops one more degree. Relative humidity is strongly affected by the daily temperature cycle.

> **"Relative Humidity doubles with each 20° drop in temperature – and halves with each 20° increase in temperature."**

Relative humidity is a critical factor affecting fire behavior and probability of ignition. Normally wildland fire will not carry adequately in hardwood fuels if the relative humidity rises above 55 percent and above 65 percent in pine fuels in most fuelbeds in Virginia. If the relative humidity drops below 30 percent wildland fire can be difficult to control and the probability of fire brand ignition, "jumps", rises.

The relative humidity is impacted by the diurnal cycle. Early in the morning the relative humidity is high. As the temperature rises the relative humidity drops. Fire may not carry at 8 a.m. but may carry readily at 10 a.m. and may become difficult to control at 2 p.m. Similarly, fire may fizzle out at dusk as temperature falls and relative humidity rises. Light fuel (1 hour fuels) moisture drops as temperature rises and increases as temperature falls.

**Burning when the relative humidity drops to, or is forecast to drop to 25 percent or below is risky and not in compliance with Virginia's certification program.**

**Pressure or Gradient Winds**

Air moves as a result of temperature and air pressure differences. It moves from high pressure areas to low pressure areas in an attempt to balance out the differences in temperature and pressure. Due to the movement of the earth, this is not a straight line. Wind from a "high" will spiral outward in a clockwise direction. The winds flowing toward a "low" will spiral in a counter-clockwise direction toward the center. These highs and lows are generally shown on weather maps.

**With the wind at your back,**
**the area of low pressure is at your left.**

Knowing where pressure centers are helps the burn manager understand wind and smoke behavior at the fire and helps to predict wind shifts as the pressure center passes.

**Frontal Winds**

A weather front is the boundary layer between two air masses of different temperatures. Fronts start from an area of low pressure. Winds will be the strongest at the frontal boundaries. Wind direction will also shift in a clockwise direction as the front passes.

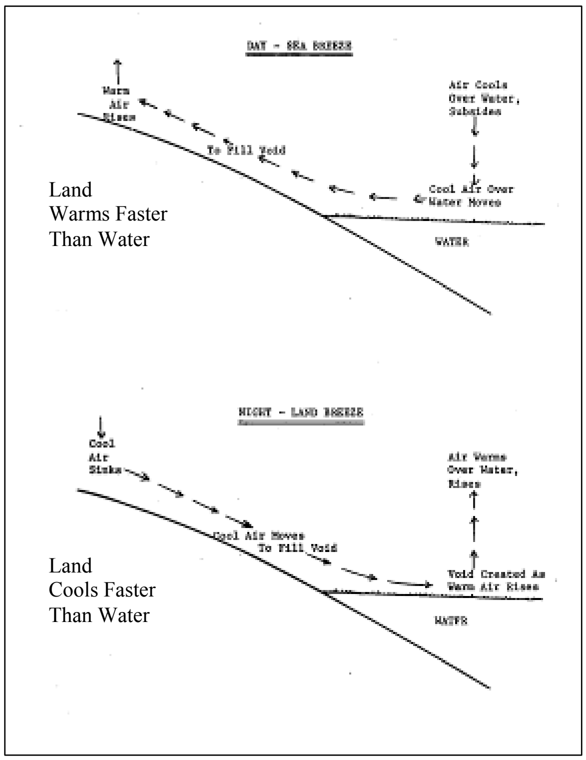
**Local Winds**

General winds are winds that are included in the weather forecast. Local factors will also affect the wind in an area that is too small to be included in the forecast. These are known as "local winds." There are three types of local winds that are important to fire behavior in the southeast: land and sea breezes; eddies, and slope winds.

## Land and Sea Breezes

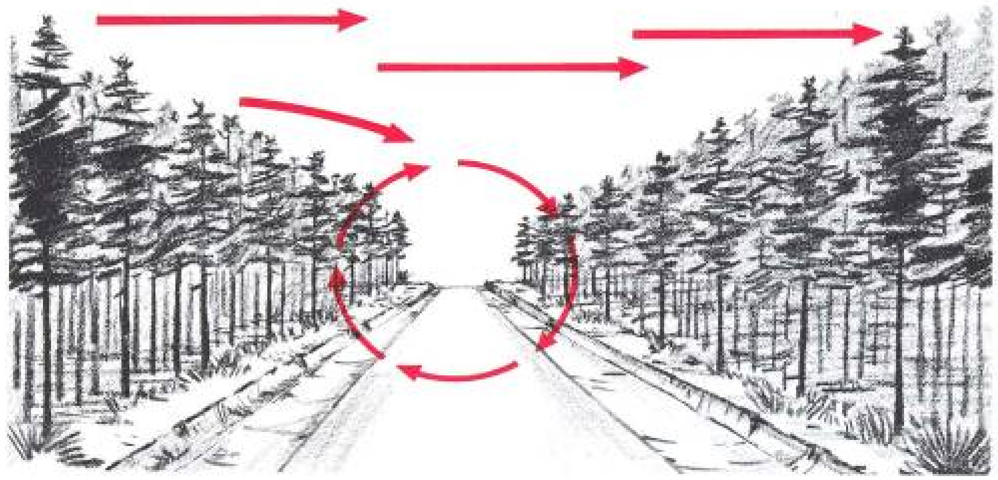
As discussed earlier, land surfaces become warmer than water surfaces during the day. As a result, the air adjacent to the land surface, being warmer, begins to rise and the cooler air (heaver) flows inland to take its place. This local wind begins around 2 to 3 hours after sunrise and ends around sunset.

At night, the reverse is true because the land surface cools more quickly than the water surface causing airflow from land to the water.

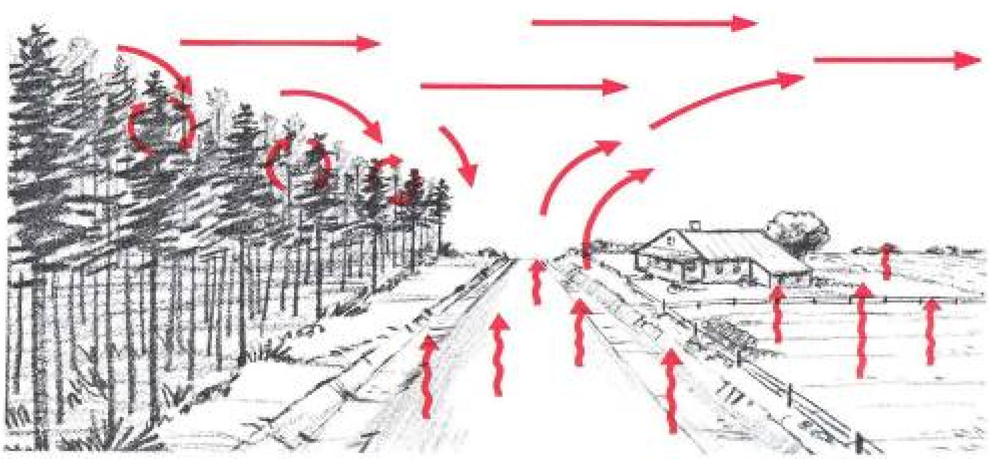


**Eddies**

Eddies are winds that in effect wrap around a topographic, vegetative, or other obstruction. They may be horizontal eddies or vertical. They can dramatically impact fire behavior either on a small scale or large scale. The prescribed burn manager and ignition person should be sensitive to the potential of eddy winds to influence the fire.



Eddies caused by forest openings



Convection and eddies for open areas

In some cases, winds may be channeled or funneled trough gaps, buildings and tree stand openings.

**Slope Winds**

Warmer; lighter air can rise along a slope with cooler air filling in from below. Local winds will flow upslope during the day and down-slope at night. This is true even on the slightest slope, unless the general wind is strong enough to overcome this phenomenon.

**Surface Wind Speed**
Surface wind is the air movement that drives a fire. Fire behavior is best managed when the in-stand surface wind speed is between one and five miles per hour. Wind speeds may be measured on the fire ground with an anemometer. Wind speeds less than one, do not push the fire and may result in unacceptable crown scorch in short trees. Wind speeds in excess of five miles per hour may make the fire difficult to control and may result in flame lengths that cause unacceptable scorch.

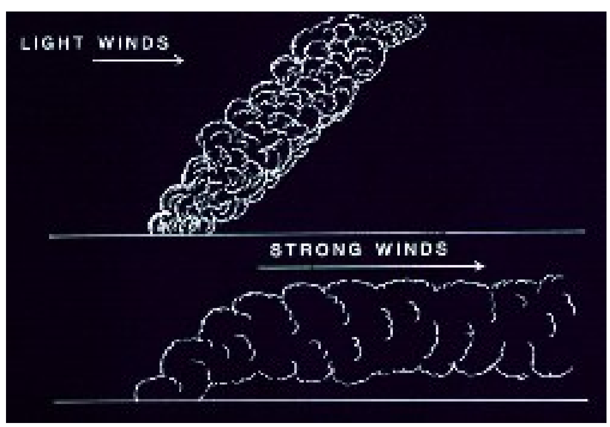
**Suggested Range:**
**Mid-flame wind speed 1 - 5 mph**
**National Weather Service 20 foot wind speed 3-10 mph**

Wind speed as reported by the National Weather Service is measured at 20 feet above the ground in the open, for instance at an airport. The best option is to have an anemometer on site and read wind speeds directly.

**Surface Wind Direction**
Surface wind direction should always be away from areas where smoke might be a nuisance to the public or result in damage (see chapter 6). The burn manager must be aware of approaching fronts and possible wind shifts. It is helpful to tie strips of flagging to limbs near the ignition area or the boundary of the fire to indicate the local wind direction. The flagging picks up eddies and local wind shifts. They help the fire line personnel stay tuned to the wind condition.

**Transport Wind Speed**
Transport wind speed is the average wind speed from the ground to the mixing height. Transport wind determines the direction of smoke dispersal. Fire behavior and smoke dispersal are best managed when the transport wind speed is between nine and 20 miles per hour. Transport wind speeds of less than nine miles per hour may result in smoke not dispersing satisfactorily, while transport wind speeds in excess of 20 miles per hour may result in erratic fire behavior, which is difficult to control.

**Suggested Range:**
**Transport wind speed 9 – 20 mph**



**Transport Wind Direction**
Transport wind direction, like surface wind direction, should be away from smoke-sensitive areas. But, since transport winds can carry smoke long distance, (up to 50 miles or more) special attention must be given to the air shed drainage area. Transport wind direction is influenced by the jet stream and may be different from surface wind direction. Transport winds have a strong influence on plume rise and dispersal.

Smoke generally disperses horizontally and vertically. Smoke does not disperse consistently. Sometimes, it seems to form a “glob” and drift away. Other times, it appears to “dissolve” into the air.

**Atmospheric Stability**
Atmospheric stability is an indication of the atmosphere’s resistance to turbulence and vertical motion. In prescribed fire activities, the atmosphere is usually described as stable, neutral or unstable. For prescribed fire, the air mass should be neutral to slightly unstable. Unstable air carries smoke up. If smoke is hotter than the ambient air, it will rise. An air mass that is substantially unstable could result in an uncontrollable fire, while a stable air mass might result in smoke problems in the vicinity of the burn. During some stable air situations, an inversion occurs and smoke settles to the ground.

Atmospheric stability is reported by the NWS. Watching sources of smoke, such as from a chimney or a fire gives an indication of stability. If the air mass is unstable, smoke rises straight up from the chimney. If the air mass is stable or there is an inversion in the area, smoke from the chimney may drop down to the ground level.

The Dispersion Index is a good indicator of stability; the higher the index, the more unstable the air.

*Stable conditions or a low mixing height keep smoke near the ground*

*Unstable conditions and/or a high mixing height provide for rapid smoke dispersion*

**Haines Index (HI):**
An atmospheric index used to indicate the potential for wildfire growth by measuring the stability and dryness of the air.
The HI numbers are computed for three elevations using the following parameters:
HI = STABILITY TERM (A) + MOISTURE TERM (B)
NWS Wakefield uses low elevations to compute the moisture and stability terms for HI where:
A = 950-850 MB TEMP
B = 850 MB TEMP-DEW POINT

Moisture and stability terms are categorized as follows:

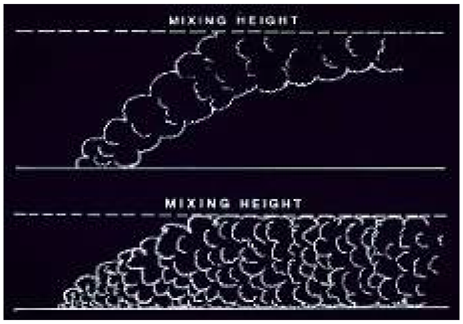
| | |
|---|---|
| A=1 when 3 deg C or less | B=1 when 5 deg C or less |
| A=2 when 4-7 deg C | B=2 when 6-9 deg C |
| A=3 when 8 deg C or more | B=3 when 10 deg C or more |

Haines Index classifications are assigned to values 2 through 6 as shown below:

| Haines Index | Potential for Large Fire Growth |
|---|---|
| 2 or 3 | Very Low |
| 4 | Low |
| 5 | Moderate |
| 6 | High |

**Mixing height**
Mixing height is defined as the height to which relatively vigorous mixing of the atmosphere occurs or the depth of the unstable air in the boundary layer, and is used for forecasting smoke or pollutant trajectories. The mixing height varies throughout the day and night. Air begins to rise as the temperature of the earth's surface rises after sunrise in a zone of active convection. When the mixing height is less than 1,650 feet above the earth's surface smoke does not usually disperse adequately for prescribed burning. When the mixing height is above 6,500 feet above the earth's surface smoke dispersion will not be a problem, but fire may be difficult to control. The mixing height reported by the NWS is calculated based on the average elevation for the reporting area. In mountainous areas, the mixing height may be closer to the earth's surface than reported by the NWS. In mountain and valley areas, care needs to be taken to ensure that smoke is not trapped in a valley.

**Suggested Range:**
**Mixing height 1,650 ft to 6,500 ft**




The higher this “lid,” the better are the conditions for smoke management. This is because a reasonably deep layer of vigorous mixing is needed to maintain low background concentrations in the lower atmosphere. During stable atmospheric regimes, there is no mixing height; that is, there is no height below which dispersion processes are rapid. Because high smoke concentrations are maintained for extended distances in such conditions, NO BURNING SHOULD OCCUR.

**Ventilation Factor**
The ventilation factor may help the burn manager intuitively visualize the ability of the air column to disperse smoke. The ventilation factor may be calculated by multiplying the mixing height by the transport wind speed. Normally, transport wind speed would be in miles per hour and mixing height would be in feet, which results in a large number with units that are difficult to grasp. To simplify the concept, the actual number may be divided by the minimum number to give a relative factor.

Ventilation factor = Transport wind speed x Mixing height
Minimum ventilation factor = 9 MPH x 1,650 feet = 14,850 or 1
Max. ventilation factor = 20 MPH x 6,500 feet = 130,000 or 130,000/14,850 = 8.7

**Minimum Ventilation Factor: 2000**

**Sky Cover**
The degree of cloud cover affects the drying rate of fuels. The more extensive the cloud cover the slower the drying rate will be. Prescribed burning may be possible with extensive cloud cover if the mixing height, transport wind and Dispersion Index are appropriate. Cloud cover may delay the effect of the diurnal cycle and necessitate a later start time to allow one hour fuel moisture to drop to a workable level.

**Smoke Dispersal:**
Dispersion is a combination of vertical mixing and horizontal transport. These two components are independent of each other. Vertical mixing is a function of atmospheric stability. A stable airmass is characterized by poor vertical mixing; an unstable airmass is characterized by good vertical mixing. Horizontal transport is a function of wind speed: the stronger the wind, the better the horizontal transport.

Smoke Dispersion will be forecast using one of the following terms:

| | |
|---|---|
| VERY POOR | very high air pollution potential |
| POOR | moderate to high air pollution potential |
| FAIR | marginal air pollution potential |
| GOOD | moderate to low air pollution potential |
| VERY GOOD | low air pollution potential |
| EXCELLENT | very low air pollution potential |

Dispersion is related and often interchanged with the term "VENTILATION." The ventilation index is a product of mixing height TIMES the transport wind and is measured in knot-feet.

The Dispersion Index is the most reliable predictor of prescribed burn smoke behavior. The ventilation index is incorporated into the Dispersion Index calculation. The Dispersion Index estimates the capacity of the atmosphere to dissolve and disperse prescribed fire smoke. The Dispersion Index is not a perfect predictor and should be used conservatively based on personal experience. In Virginia, the Dispersion Index is reported by the National Weather Service in the forestry weather forecast.

**Suggested Range:**
**Dispersion index (day time) Good to Excellent**

**Keetch-Byram Drought Index**
The moisture conditions of the litter, duff, humus and soil are critical to fire behavior, fire effects, and the ability to control prescribed fire. The burn planner must prescribe an acceptable KBDI range to accomplish the burn objectives. This will vary by season and burn objective. The following discussion of the drought index is taken from the Virginia Department of Forestry web site, http://www.dof.virginia.gov/fire/kbdi.shtml.

The Cumulative Severity Index (CSI) or Keetch-Byram Drought Index (KBDI) is a continuous reference scale for estimating the dryness of the soil and duff layers. This system was originally developed for the southeastern United States and is based primarily on recent rainfall patterns. The KBDI, specifically developed to equate the effects of drought with potential fire activities, is the most widely used system by fire managers in the south. This mathematical system for relating current and recent weather conditions to potential or expected fire behavior results in a drought index number ranging from 0 to 800. This number accurately describes the amount of moisture that is missing; a rating of 0 defines a point of no moisture deficiency (soil saturation

where the next drop of water will run off over the surface) and 800 defines the maximum drought possible (oven dry).
Prolonged droughts (high KBDI) influence fire intensity since more fuel is available for combustion (i.e. fuels have a lower moisture content). In addition, dry organic material in the soil can lead to increased difficulty in fire suppression. High values of the KBDI are an indication that conditions are favorable for the occurrence and spread of wildfires, but drought is not by itself a prerequisite for wildfires. Other weather factors, such as wind, temperature, relative humidity and atmospheric stability, play a major role in determining the actual fire danger.

**These KBDI numbers correlate with potential fire behavior as follows:**

**0 - 200** Soil and fuel moisture are high. Most fuels will not readily ignite or burn. However, with sufficient sunlight and wind, cured grasses and some light surface fuels will burn in spots and patches.

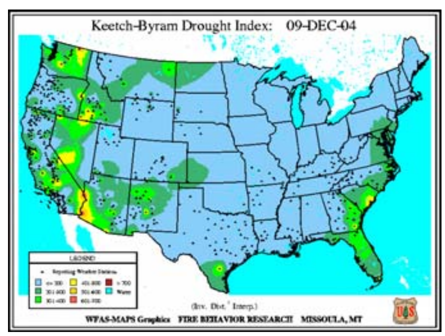
**201 - 400** Fires more readily burn and will carry across an area with no "gaps." Heavier fuels will still not readily ignite and burn. Also, expect smoldering and the resulting smoke to carry into and possibly through the night.

**401 - 600** Fire intensity begins to significantly increase. Fires will readily burn in all directions exposing mineral soils in some locations. Larger fuels may burn or smolder for several days creating possible smoke and control problems.

**601 - 800** Fires will burn to mineral soil. Stumps will burn to the end of underground roots and spotting will be a major problem. Fires will burn thorough the night and heavier fuels will actively burn and contribute to fire intensity.

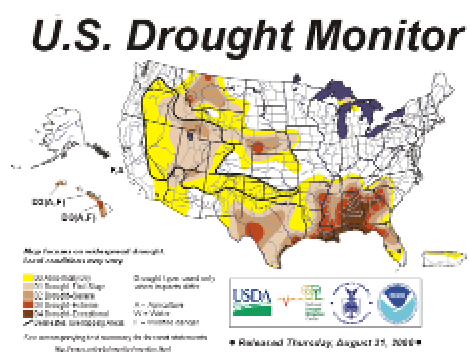
KBDI may be tabulated for a given site by monitoring the temperature and rainfall over time.

A regional KBDI map may be obtained from the Web site http://www.fs.fed.us/land/wfas/kbdi.gif.
Placing a copy of the current KBDI map with the burn plan report serves as good documentation of the regional drought conditions at the time of the burn.



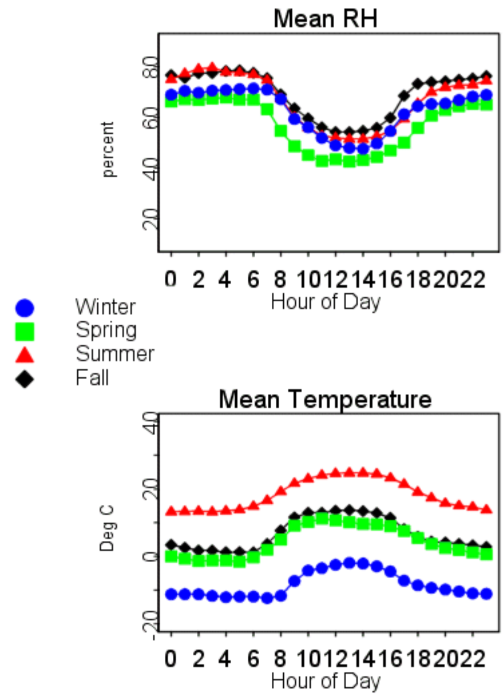

## The Drought Monitor

Another online source of drought information is the Drought Monitor, which is based on the Palmer Drought Index. The weekly map can be found at http://drought.unl.edu/dm/monitor.html. Historical drought monitor maps are archived.



**Diurnal Cycle**

The diurnal cycle is the cycle of weather factors in a 24 hour period from sunrise to sunset to sunrise. As the sun rises, the air temperature rises. As the sun sets, the air temperature decreases. Conversely, as the sun rises the relative humidity decreases, and as the sun sets, the relative humidity increases. Mixing height tends to rise from sunrise and declines as dusk approaches. After sunrise, the air mass tends to become unstable. As the sun begins to set, the air mass tends toward stability. Prescribed burn managers must be sensitive to the diurnal cycle and its effect on fire and smoke behavior. The graph represents a 10 year average by season. Note how consistent the pattern is for the 24 hour cycle.




## Sources of Fire Weather Information

### Forecasts

The National Weather Service, NWS, publishes fire weather forecasts in Virginia daily through out the 24 hour period. This information is constantly available via weather radio and the Internet. A fire weather forecast is published each morning by about 7:30 a.m. and may be obtained on the Internet at the VDOF Web site. This is a forecast, not the actual weather. The Internet sites where fire weather information may be obtained are:

In Virginia, the NWS forecasts fire weather in five (5) regions, which in turn are broken into multiple county zones. The following is an example Fire Weather Forecast:

Wakefield, VA (Eastern VA)
http://www.erh.noaa.gov/displayprod.php?product=WBCFWFAKQ

Sterling, VA (Northern VA)
http://www.weather.gov/data/LWX/FWFLWX

Blacksburg, VA (Western VA)
http://www.weather.gov/data/RNK/FWFRNK

Charleston, WV (very extreme NW portion of VA)
http://www.srh.noaa.gov/data/RLX/FWFRLX

Morreston, TN (SW portion of VA)
http://www.srh.noaa.gov/data/MRX/FWFMRX

HANOVER-CAROLINE-CHESTERFIELD-HENRICO-KING WILLIAM-KING AND QUEEN-
ESSEX-WESTMORELAND-RICHMOND-CHARLES CITY-NEW KENT-JAMES CITY-
INCLUDING THE CITIES OF...ASHLAND...COLONIAL HEIGHTS...RICHMOND...
TAPPAHANNOCK...WILLIAMSBURG
435 AM EDT WED SEP 24 2008

| | TODAY | TONIGHT | THU |
|---|---|---|---|
| CLOUD COVER | MCLEAR | PCLDY | CLOUDY |
| PRECIP TYPE | NONE | RAIN | RAIN |
| CHANCE PRECIP (%) | 10 | 40 | 80 |
| MAX/MIN TEMP | 74 | 56 | 67 |
| MAX/MIN RH (%) | 35 | 82 | 67 |
| WND20FT2MIN/EARLY(MPH) | N 8-12 G19 | | NE 10-14 |
| WND20FT2MIN/LATE(MPH) | NE 12-16 | NE 9-13 G20 | NE 10-14 |
| PRECIP AMOUNT | 0.00 | 0.01 | 0.67 |
| PRECIP DURATION | 0 | 2 | 7 |
| MAX MIXING HGT(FT-AGL) | 5210 | | 1980 |
| TRANSPORT WIND (MPH) | NE 30 | | N 30 |
| VENT RATE (FT-MPH) | 169710 | | 95730 |
| DISPERSION (EVENING) | | GOOD | |
| LAL | 1 | 1 | 1 |
| HAINES INDEX | 5 | 4 | 2 |

REMARKS...NONE.

.FORECAST FOR DAYS 3 THROUGH 7...
.THURSDAY NIGHT...RAIN. LOWS IN THE LOWER 60S. NORTHEAST WINDS
10 TO 15 MPH.
.FRIDAY...RAIN IN THE MORNING...THEN RAIN LIKELY IN THE AFTERNOON
AND EVENING. HIGHS IN THE LOWER 70S. MINIMUM RH 66 PERCENT UNTIL
EARLY EVENING. NORTHEAST WINDS 10 TO 15 MPH.
.SATURDAY...MOSTLY CLOUDY WITH A CHANCE OF SHOWERS. LOWS IN THE

http://www.erh.noaa.gov/displayprod.php?product=WBCFWFAKQ 9/24/2008

**Note: The fire weather reported by the NWS is a forecast NOT the actual weather or a prescription !!**

**Actual Fire Weather Direct measurements**

Ambient temperature, relative humidity, and wind speed & direction should be measured on site just prior to the burn, during the burn, and following the burn. There are several types of gadgets that may be used. An anemometer measures wind speed; a thermometer measures ambient temperature, and a sling psychrometer can be used to measure relative humidity. A Kestral or similar device may be used to measure all three. When using special gadgets, care must be taken to ensure that they are accurately calibrated. A belt weather kit contains several useful devices including a sling psychrometer, an anemometer and a compass. When using a belt weather kit, it is important to keep the anemometer orifices clean and clear of obstruction. Clean water should be used for the wet bulb on the sling psychrometer. Total recording weather stations are effective on large operations or when lots of fires are conducted.

belt weather kit

Kestral

weather station kit

**Weather observations**

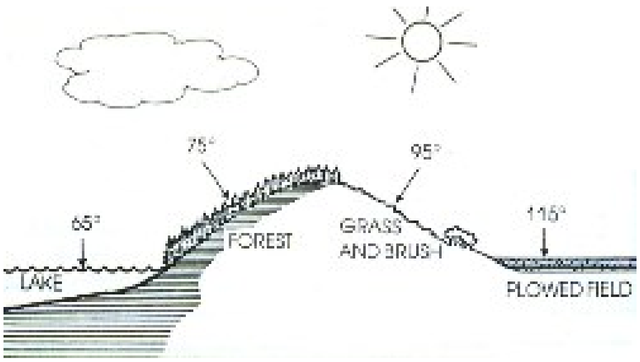
Certain weather elements can be observed but not readily measured at the burn site. Atmospheric stability, transport wind direction, and sky cover may be observed on site but not measured. Each of these should be observed and documented during a burn.

**Documentation**

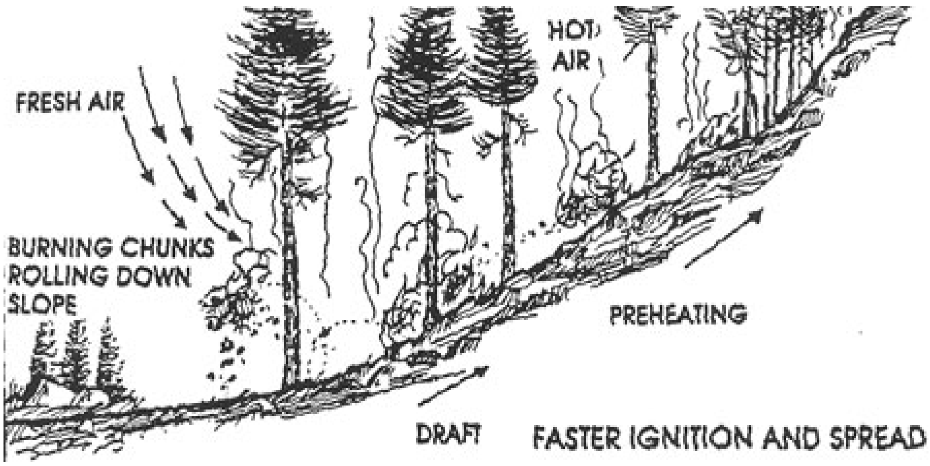
All actual fire weather elements should be observed and recorded on site throughout the burn.

> **Weather conditions change continuously:**
> **Stay updated – Stay alert - Keep the burn crew informed**

**Topography**




Because heat rises, fuels on a slope tend to be affected by convective heat causing them to dry faster than those on a flat surface. As a flame front approaches on a slope, the fuels upslope from the flame are heated by the flames, convective energy. Fire tends to burn more rapidly up slope than on a flat surface or down slope. The steeper the slope, the stronger the influence of convective energy is.




**Aspect** in the northern hemisphere slopes that face south and west tend to dry faster due to the incident angle of the sun, while north facing slopes tend to be cooler and moister.

**Natural boundaries** in the topography, such as rivers, open fields, highways, swamps, and creek bottoms, may serve as passive fuel breaks. Open edges may have faster fuel-drying rates due to direct exposure to the sun.

**Gaps, chimneys, chutes, draws, ridge lines and other landforms** can funnel air flows that result in updraft winds. Fires burning in these types of land forms can be affected by these updraft winds. Winds may curl around hills and bluffs causing erratic fire behavior.

## Fuels

Physical characteristics of woodland fuels have several different characteristics that affect the way they burn:

### Fuel Shape

The important aspect of fuel shape is the surface area compared to the mass of the individual piece. In other words, fuels like pine needles have a higher fuel to oxygen ratio than logs. Pine needles have a high surface area ratio and may ignite rapidly and burn quickly. Oaks leaves have a high surface area ratio but due to their flatness may be matted down and not support combustion. On the other hand, logs have a low surface area ratio that causes them to ignite slowly and, in some cases, not burn. Some of the shapes of fuels are needles, leaves, limbs, logs, palmetto fronds and peat.

### Fuel Size

Fuel size affects fuel moisture and the rate of drying. The drying time lag in hours can be related to thickness or diameter:

| Time lag | Diameter |
|---|---|
| 1 hour | <1/4” |
| 10 hour | ¼ to 1” |
| 100 hour | 1 to 3” |
| 1000 hour | >3” |

One-hour fuels, normally grasses or pine straw, reach equilibrium with the moisture in the atmosphere rapidly. As relative humidity drops during the diurnal cycle, one hour fuels dry and become more flammable. As the relative humidity rises during the diurnal cycle, one-hour fuels pick up moisture from the atmosphere and become less volatile. Since one-hour fuels dry faster, they tend to be the primary fuel that carries fire in the fuel bed.

Ten-hour fuels, for example, the small litter and dead brush, may be part of the flammable fuel bed.

One-hundred and one-thousand-hour fuels in some cases may be harvested or removed from the site in some other way and thus would not be part of the fuel bed. When 100 and 1,000-hour fuels are part of the fuel bed and when their moisture content has dropped to the point that they are flammable, very intense fires may occur.

**Fuel Arrangement**

Fuels are arranged through the forest in different ways. Whether fuels are matted tightly or lofted affects the oxygen surface area and thus the flammability. In some cases, fuel may be suspended vertically in limbs and vines. This type of arrangement is referred to as a fuel ladder that can support flames from the ground up into the canopy.

Fuel ladder

Mixed fuels

**Fuel Distribution**

Fuels may be distributed in different ways. They may be evenly broadcast; in piles, clumped; or patchy. Fuel distribution affects flame spread and may affect ember pitching.

Pile

Broadcast and clumpy

**Fuel Volume**

The volume of fuel in the burn area will affect fire behavior and smoke production. A great deal of research has been put into estimating the fuel volume for each of the 13 fuel models for predicting prescribed burn fire behavior (see chapter 3 section 3.3.2.2.). Actually measuring fuel volume can be time consuming and is typically not done for an individual burn. To adjust for fuel moisture content, fuel volumes are reported in oven dry weight.

**Fuel moisture**

Fuel can vary in moisture content from saturated-- holding the maximum amount of water possible, to oven-dry-- no moisture. Saturated fuels will not burn without a substantial pre-drying energy input. Oven-dry fuels are readily combustible. Ambient air temperature is the driving force for relative humidity, fuel moisture, and fuel drying. The hotter it is the faster fuel dries. Relative humidity, shading, fuel arrangement, aspect, wind speed and fuel size are all factors that the prescribed burn planner and manager must be knowledgeable about. In southern fuels, it is typically the fine fuels that form the fuel bed and carry the fire. The prescribed burn planner and manager should be able to prescribe a desired fine-fuel moisture content to accomplish a burn objective and then to determine fine-fuel moisture at the burn site on the day of the burn. Likewise, the burn manager should be able to predict the fine-fuel moisture content at the peak of the diurnal cycle based on the actual weather conditions on site at the time fire is first ignited.

**Probability of ignition** is an indicator of how readily a fuel bed will ignite when an ignition source is present, or, conversely, whether a fuel bed will burn at all. A probability of 70+ indicates very flashy conditions where control would be difficult and jumps or escape very likely. A probability of ignition of 30 or less indicates a moist fuel bed that probably will not carry fire.

**Probability of Ignition**

| | | Fine Dead Fuel Moisture % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Shading | Dry-Bulb Temp. °F | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | 100-109 | 100 | 100 | 80 | 70 | 60 | 60 | 50 | 40 | 40 |
| | 90-99 | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 40 | 30 |
| | 80-89 | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 40 | 30 |
| Unshaded | 70-79 | 100 | 80 | 70 | 60 | 60 | 50 | 40 | 40 | 30 |
| | 60-69 | 90 | 80 | 70 | 60 | 50 | 50 | 40 | 30 | 30 |
| | 50-59 | 90 | 80 | 70 | 60 | 50 | 40 | 40 | 30 | 30 |
| | 40-49 | 90 | 80 | 70 | 60 | 50 | 40 | 40 | 30 | 30 |
| | 30-39 | 80 | 70 | 60 | 50 | 50 | 40 | 30 | 30 | 20 |
| | 100-109 | 100 | 90 | 80 | 70 | 60 | 50 | 50 | 40 | 40 |
| | 90-99 | 100 | 90 | 80 | 70 | 60 | 50 | 50 | 40 | 30 |
| | 80-89 | 100 | 80 | 70 | 60 | 60 | 50 | 40 | 40 | 30 |
| Shaded | 70-79 | 90 | 80 | 70 | 60 | 50 | 50 | 40 | 30 | 30 |
| | 60-69 | 90 | 80 | 70 | 60 | 50 | 40 | 40 | 30 | 30 |
| | 50-59 | 90 | 80 | 70 | 60 | 50 | 40 | 40 | 30 | 30 |
| | 40-49 | 90 | 80 | 60 | 50 | 50 | 40 | 30 | 30 | 30 |
| | 30-39 | 80 | 80 | 60 | 50 | 50 | 40 | 30 | 30 | 20 |

**Fuel Models**

For planning purposes, it is useful to divide fuels into different categories. This helps the planner to estimate fire and smoke behavior and to plan for the effects of fire. Fire behavior fuel models describe the fuel bed--the fuel that will carry a fire. Other materials in the stand may be flammable under some conditions but do not typically carry a fire. The planner should consider the fuels that will carry the fire, under the conditions the planner prescribes, to achieve the burn objective. In turn, these fuel models are an important part of computer modeling of fire behavior.

In A Guide for Prescribed Fire in Southern Forests, fuels and fuel conditions were divided into six broad types; 1) grass (with Pine overstory); 2) light brush; 3) pine needle litter; 4) palemetto-gallberry; 5) windrowed logging debris, and 6) scattered logging debris or small dry piles. These types along with the size of the burn allow the planner to predict the distance smoke will travel under a given Dispersion Index.

Another system of dividing fuels into types or models is in popular use. The Aids to Determining Fuel Models for Estimating Fire Behavior describes 13 fuel models which are divided into four categories:

**FIRE BEHAVIOR**

| **Fuel model** | **Fuel loading** 1 hr. | 10 hr. | 100 hr. | Live | **Moisture of Extinction** **dead fuels** |
|---|---|---|---|---|---|
| | (tons per acre) | | | | Percent |
| **Grasses and grass-dominated** | | | | | |
| 1. Short grass (1 foot) | 0.74 | 0.00 | 0.00 | 0.00 | 12 |
| 2. Timber (grass and understory) | 2.00 | 12.00 | 0.50 | 1.00 | 15 |
| 3. Tall grass (2.5 feet) | 3.01 | 0.00 | 0.00 | 0.00 | 25 |
| **Chaparral and shrub fields** | | | | | |
| 4. Chaparral (6 feet) | 5.01 | 4.01 | 2.00 | 5.01 | 20 |
| 5. Brush (2 feet) | 1.00 | 0.50 | 0.00 | 2.00 | 20 |
| 6. Dormant brush, hardwood slash | 1.50 | 2.50 | 2.00 | 0.00 | 25 |
| 7. Southern rough | 1.13 | 1.87 | 1.50 | 0.37 | 40 |
| **Timber litter** | | | | | |
| 8. Closed timber litter | 1.50 | 1.00 | 2.50 | 0.00 | 30 |
| 9. Hardwood *(& pine)* litter | 2.92 | 0.41 | 0.15 | 0.00 | 25 |
| 10. Timber litter (& understory) | 3.01 | 2.00 | 5.01 | 2.00 | 25 |
| **Slash** | | | | | |
| 11. Light logging slash | 1.50 | 4.51 | 5.51 | 0.00 | 15 |
| 12. Medium logging slash | 4.01 | 14.03 | 16.53 | 0.00 | 20 |
| 13. Heavy logging slash | 7.01 | 23.04 | 28.05 | 0.00 | 25 |

These fuel models are for the entire United States. In the South, fuel model 2 is typical for grasses; fuel model 9 is typical for pine and hardwood under stories; fuel model 7 is specific to the lower coastal plain of the Southeast, and fuel model 11 is typical of logging slash fuel loads.

Fire tends to burn more aggressively the lighter the fuel and the heavier the fuel load. Thus, a fuel model 2 would not generate as much heat or smoke as a fuel model 3, all other conditions being the same. Likewise, a fuel model 2 will burn more aggressively in terms of spread rate than a fuel model 9.

The fuel loading data in the Fire Behavior table above is for the entire U.S. Typically, in the South, fuel loads are not as heavy as some in the Northwest. The burn planner may choose to use a fuel model 2 when the conditions appear to be more similar to a fuel model 9 in order, based on substantial experience, to more accurately predict spread rate.

Fuel model 2 - grass

Use fuel model 3 table values for estimating fire behavior in kudzu or cogon grass.

Fuel model 9 – hardwood & pine understory litter, light brush, and blackberries

Fuel model 4 (not typical of the Southeast – note backing fire, down slope, and quantity of smoke). This fire is burning in very dry conditions in resinous fuels. The only condition in the Southeast that might be similar to this would be a swamp during a very dry period with very low green-fuel moisture content, or a lower coastal plain upland site with heavy loading of wax myrtle, yaupon, and/or gallberry.


Fuel model 7 (Southern rough) – palmetto, gallberry

Fuel model 11 – typical clear cut

**Piles**

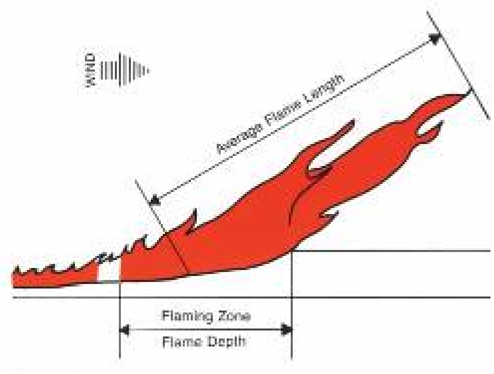
Piles are not a natural distribution of fuels on the forest floor and thus are not a part of any of the fuel models listed above. Windrows are piles typically containing 100 and 1000 hour fuels. Special problems for burn managers result when piles are present. The convective energy of burning piles can loft burning embers that may result in jumps or escapes.

# Chapter 7 Ignition Techniques and Tools

The device used to set a prescribed burn and the pattern in which the fire is ignited affect fire behavior and smoke production. The prescribed burn planner must prescribe the device and pattern required to achieve the burn objective.

**Flame length**

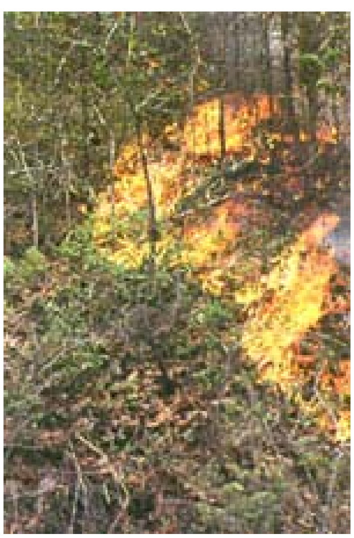
Flame length can be used as a prescription parameter to predict fire effects. Flame length in a given fuel under given weather conditions differs depending on the direction of ignition, heading or backing. A backing fire may have a flame length of one foot while a heading fire under the same conditions may have a six foot flame length. Similarly, the effect of flame length is different in dormant versus growing tissue. A six foot flame length may not cause unacceptable scorch during the dormant season, while the same flame length may result in severe scorch in the growing season. Note in the diagram that flame length may be different from flame height.



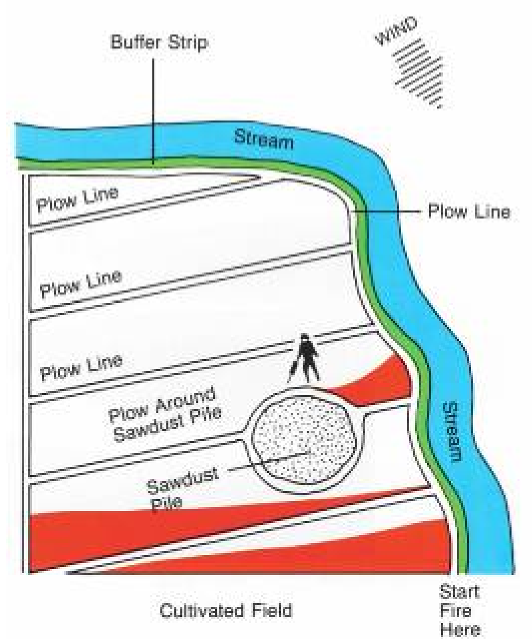

**Pattern of Ignition**

Fire is pushed by the wind. The direction fire burns in relation to the wind determines the pattern. All patterns other than head and back are some combination of heading, backing, or flanking.

**Backing**



Backing fires burn against the wind into the fuel. Backing fires have relatively short flame lengths and slow spread rates compared to the other ignition patterns. Backing fires take longer to pass a point and thus dwell at a point for an extended period of time. Because of the dwell time, the time required for the flame front to pass a point or stem, backing fires can raise the temperature of the growing tissue under the bark and may have a girdling effect on stems at or near the ground line.



Backing fires generally result in more complete combustion of the fuel during the flaming stage and thus tend to produce less smoke. Most prescribed burns are started with a backing fire on the downwind side of the area to be burned. Once a substantial "black" area is established using the backing technique, other ignition patterns may be employed to accomplish the burn objective.

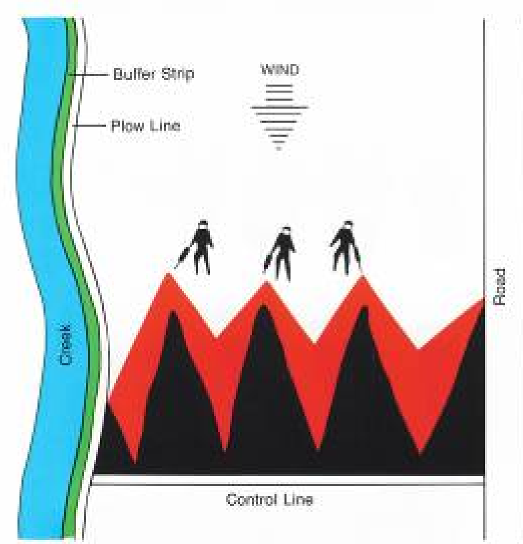
**Heading**

A head fire burns with the wind, being pushed by the wind. Head fires fanned by the wind are more intense and the flame front passes a point rapidly. Head fires have longer flame lengths and faster spread rates than backing fires. Because of the rapid and incomplete fuel consumption as the flame front passes, head fires produce more smoke. Due to the longer flame length, head fires tend to damage or kill plant tissue higher off the ground. However, head fires may not have long dwell times and may not girdle stems.

Usually a back fire is backed off the downwind side of a tract until a safe "black" area exists before a head fire is set.

**Flanking**

Lighting fire directly into the wind is referred to as the flanking technique. The flame front is neither moving into or with the wind but rather across the wind. Flanking fires tend to be less intense than a head fire but more intense than a backing fire. Any shift in the wind direction may turn a flanking fire into a head fire and a backing fire. The convective energy at the bases of the flanks tend to swirl and may cause more heat at a higher level.




Flanking fire technique

**Strip Head**

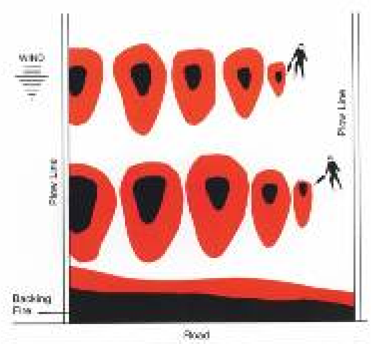
Strip head firing consists of lighting a series of fires across the wind, typically progressing from the down wind side of the burn area. Strips are typically ignited only after a safe "black" area has been established by backfiring along the downwind side of the burn area. Strip head firing is probably the most commonly employed ignition technique used to extend or spread fire across the burn area. The heat convection along the line where the heading fire and the backing fire meet can result in elevated temperatures in the tree crowns and may result in unacceptable scorch. In young stands such as pine plantations, spot ignition may be more effective than strip head fires to accomplish the burn objective.

Care must be taken when using multiple ignition people to ensure that the up-wind ignition person does not get ahead of the down-wind ignition person thereby trapping the down-wind ignition person between two ignition lines.

**Spot / Point Source**

Igniting fire in spots rather than in lines is the spot or point source technique. Each spot consists of heading, backing, and flanking behavior. Spots may create a mosaic in the fuel bed. Spot ignition results in a fire that is less intense than a head fire but more intense than a backing fire. Wind shifts are not a problem with spot ignition the way a wind shift can be a problem with flank ignition. When a helicopter equipped with the delayed aerial ignition, DAID, system is employed, the result may be spot ignition. A safe "black" area should be established using a backing fire on the down-wind side of the burn area prior to setting spots.

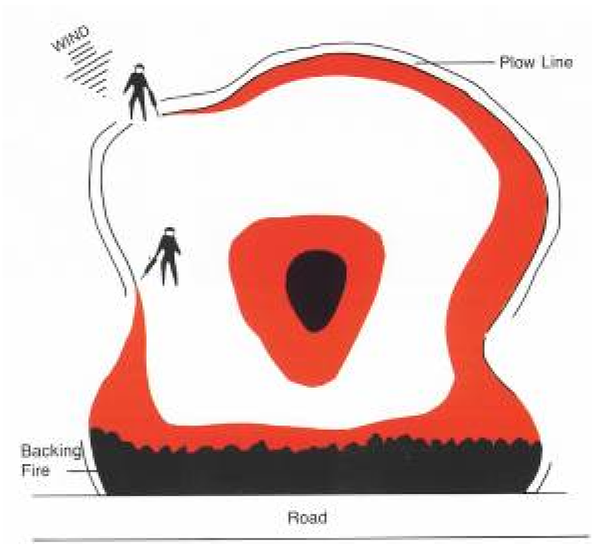
Point source ignition




**Ring**

Lighting the entire perimeter of the burn area is called ring firing. A substantial "black" safe area should be established before proceeding with ring firing. After the "black" is established, the flanks should be ignited and, finally, the up-wind side should be ignited. Under certain weather and fuel conditions, ring firing can result in a convection column over the fire, which causes the fire to draw air from the entire burn perimeter resulting in an intense fire. Ring firing is typically used with site preparation burning where an intense fire is desired to consume most of the fuels in the fuel bed to facilitate tree planting.

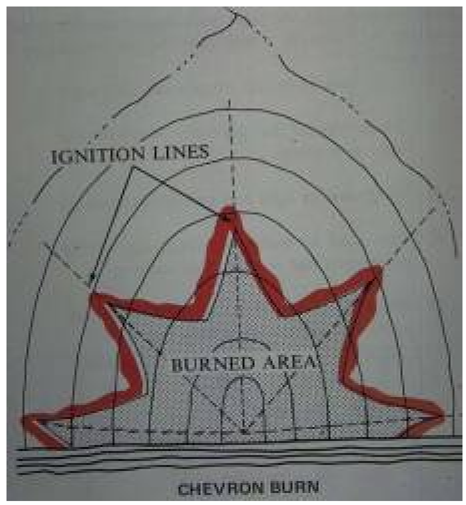
**Center**




Center firing consists of putting a single spot ignition in the center of the burn area. Center firing is typically employed in combination with ring firing to initiate the desired convection column. In combination, the technique is referred to as center-ring firing. Under dry fuel and weather conditions, dramatic convection columns capable of lofting substantial amounts and sizes of burning embers may result. Center-ring firing should only be employed with substantial experience and when adequate staff and equipment are available to hold the fire in the planned burn area.

**Chevron**

Lighting fire in a series of Vs with the bases of the Vs, or chevrons, connected at the interior ends is referred to as the chevron ignition technique. Because of the convection effect at the bases of the Vs, the chevron ignition technique tends to burn more intensely than a backing fire. The chevron technique may be used to "hurry-up" a fire along a line where it is prudent to get the fire away from the line as quickly as possible. Igniting the fuels along the edge of a highway, in some cases, may be an example. The chevron technique may be used along slopes and ridge lines to prevent the fire from burning too intensely up the slope. The chevron technique may be effective but should be used only based on substantial experience.




Hurry-up techniques may be used to complete the planned burn within the planned time frame. Several of the ignition techniques, (strip-head, flank, spot, and chevron) listed above may be considered hurry-up. In some cases, where fire is not burning as intensely as anticipated or planned, head firing may be used as a hurry-up technique to accomplish the burn plan objective. Rounding the corners of a burn area may be employed as a hurry-up technique in some cases.

Keeping firing lines as straight as possible will reduce the likelihood of jumps. The exception is the chevron technique. In corners of the flame front, the two opposing sides of a corner may work together resulting in convection that can cause flaming embers to cross the fire line.

**Tools of Ignition**

**Drip torch**

The hand-held drip torch is the most commonly used ignition technique for prescribed burning. All drip torches are similar. They consist of a manually vented canister, a looped tube and a wick. The loop in the tube prevents flame from flashing back from the wick into the canister.

**CAUTION**

**Never use a drip torch without a loop in the wick tube !!**

The drip torch fuel mixture is a combination of gasoline and diesel fuel. The ratio of gas to diesel fuel varies from 1/3 gas in 2/3 diesel to ½ gas in ½ diesel. The richer the gas in the mixture the flashier the mixture and the more readily it will ignite. If the mixture is too rich, it will tend to make the torch sputter. The greater the ratio of diesel fuel in the mixture the longer it will sustain flame after dripping from the torch. The mixture may need to be adjusted slightly depending on the vegetative fuel moisture; the relative humidity; the wind speed, and the air temperature. Torches should never be stored or filled with a pure gas mixture. Gasoline is extremely volatile.

**Suggested**
**Drip torch fuel mix:**
1/3 gas to 2/3 diesel fuel

Caution should be used while using a drip torch to ensure that the fuel mix does not get on clothing or boots to prevent the torch person from becoming inflamed. In the event the fuel mix does get on the torch person, the torch person should stop work; get away from the fire, and change clothing or drench the clothing in water.

Drip torch

Drip torch alternative, fusee

**ATV Torch**

Burners can mount a modified drip torch on an ATV to speed up the ignition process. ATV torches can negotiate rough terrain, thick grass and small brush. However, ATV torches are subject to tip over or may fall into stumps holes and become trapped. The torch and fuel tank should be mounted with a quick disconnect device to allow jettisoning in the event of an emergency. A water tank with pressure spray capability can be mounted on the front for dealing with unwanted ignitions. The ATV torch should be equipped with a fire extinguisher that is mounted away from the torch, preferably on the front of the ATV.

**Tractor Torch (for piles & windrows)**

A tractor torch may be used for igniting piles and windrows. The tractor torch is similar to an ATV torch with a greater fuel capacity and a higher reach.

**Aerial ignition**
Aerial ignition can be employed to ignite fires in any one of the previously discussed patterns with the possible exception of the chevron. The advantage of aerial ignition is speed. A large area can be ignited quickly with an aerial torch, resulting in quick burn out and securing personnel from the burn. Aerial burning requires a substantial commitment of fire crew personnel and fire suppression units to ensure that the fire can be held.

**Heli-torch**
The fuel for a heli-torch is a mix of gasoline and a gelling agent similar to napalm. The torch should be attached to the helicopter with a quick disconnect device so that the torch can be dropped in the event of an emergency, such as a helicopter engine failure. A heli-torch operation is probably cheaper than the DAID system.

**Helicopter Delayed Aerial Ignition Device, DAID**

DAID (Delayed Aerial Ignition Device) dispenser mounted in helicopter

DAID machine hopper with "ping-pong" balls.

Spot ignition with "ping-pong balls."

Cam mechanism that allows ball to fall into pocket where it is injected.

Pockets where balls are injected.

DAID machine: side view.

The DAID ball.

The DAID is sometimes referred to as the "ping-pong ball" system. On board a helicopter, a trained fire specialist operates a device packed with small plastic spheres filled with a precise amount of potassium permanganate, an inorganic chemical oxidant. The little plastic spheres are about the size and shape of ping-pong balls, thus the name. An arm of the machine holds each ball and injects it with a measured quantity of ethylene glycol, and the ball is rolled down a chute and immediately jettisoned from the helicopter. Within 30 seconds, the chemicals in the ball react thermally to produce a small fire. As the ball hits the forest floor and the exothermic reaction causes the plastic to burn, it ignites the forest fuel. The plastic ball and its contents are completely consumed by the fire. The end result is a spot of fire that, when multiplied by the number of balls dropped, enables ignition quickly and safely. Efficiency is gained due to the speed with which ignition of the burn area can be completed.

# CAUTION

**Due to the uncertainty of where helicopter ignition system fuels may fall it is necessary to have substantial equipment and personnel on site to hold the fire within the planned burn area !**

# Chapter 8 Fire as a Tool

Resource managers have used fire as a tool for many purposes. The better the burn planner understands fire effects the better job the planner can do prescribing fire to accomplish an objective.

The U.S Forest Service Web site, Fire Effects Information System, FEIS, located at http://www.fs.fed.us/database/feis/, contains information about fire effects on many forest plants and animals. The prescribed burn planner can use information from this Web site to help develop a burn objective.

The season of the burn; the return interval (number of years between burns in a sequence) of fire in a stand, and the intensity of the burn must be understood to use fire effectively.

Prescribed burn objectives may include: site preparation; fuels management/reduction; wildlife habitat; timber stand improvement; ecological manipulation/restoration; agro-forestry; disease control, and aesthetics.

The prescribed burn planner should be as specific as possible when defining the burn objective and avoid trying to include too many objectives. To be effective, the resource objective must be specific so that the fire objective can be tailored to accomplish the resource objective. In a burn area, there may be sub-areas with different burn objectives. A burn area map delineating areas with different resource and fire objectives is essential to the burn manager.

The information in the following matrix is general in nature. With experience; the FEIS home page, and by calling on the experience of neighboring prescribed burn managers, the burn planner can become proficient in prescribing resource and fire objectives.

**Common Prescribed Burning Objectives**

| Purpose | Time of Burn | Size of Burn | Type of Fire | Frequency | Remarks |
|---|---|---|---|---|---|
| Reduce Fuels | Winter | Large enough to break fuel continuity. | Not critical. (Do not ring fire.) | 2-4 years | Use line-backing fire, or spot fires under moist conditions for initial burn. Grid-firing technique excellent for maintenance burns. |
| Improve Wildlife Habitat | | | | | General – Protect transitional or fringe areas. Do not burn stream bottoms. |
| Deer Habitat | Winter preferred | Small or leave unburned areas in a mosaic. | Backing fire or spot fires. | 2-4 years | Want to promote sprouting and keep browse within reach. Repeat summer fires may kill some rootstocks. |
| Turkey Habitat | Winter preferred; summer burns in July – August | Small or leave unburned areas in a mosaic. | Backing fire or spot fires. | 2-4 years | Avoid April through June nesting season. |
| Quail Habitat | Later winter | 25+ acres | Not critical. (Do not ring fire.) | 1-2 years | Avoid April through June nesting season. Leave unburned patches and thickets. |
| Dove Habitat | Winter | Not critical. | Not critical. (Do not ring fire.) | Not critical. | Leave unburned patches and thickets. |
| Waterfowl Habitat | Late fall or winter | Not critical. | Heading fire. | 2+ years | Marshland only. Do not burn in hardwood swamps. |
| | | | | | |

| Purpose | Time of Burn | Size of Burn | Type of Burn | Frequency | Remarks |
|---|---|---|---|---|---|
| Control Competing Vegetation | Heavy roughs in winter, otherwise not critical. | Not critical | Not critical. (Do not ring fire.) | 2-8 years | Summer burns result in higher rootstock kill and affect larger stems. Exclude fire from desirable hardwoods in pine-hardwood type. |
| Improve Forage For Grazing | Winter through late spring for most situations. | Not critical but will be damaged by overuse if too small for herd. | Not critical. (Do not ring fire.) | 3 years | Split range and burn one-third each year. Individual herbs and grasses respond differently to fire and season of burn. Consult expert. |
| Improve Accessibility | Will vary with understory and desired use. | Varies with individual situation. | Depends on amount of fuel present. | As needed | Coordinate with other resource objectives. They will dictate size, timing and frequency of burn. |
| Control Disease | Brownspot, winter | Depends on size of infected area. Include a buffer strip. | Strip-heading or heading fire. | 2-3 years | Burn when humidity is above 50%. Avoid leaving unburned pockets of infected seedlings within or adjacent to burn. |
| Enhance Appearance | Late fall through late winter. | Varies with each situation. | Backing fire or spot fires. | 1+ years | Requires precise prescription to protect vegetative type changes. Know effect of fire frequency and season of burn on both annual and biennial flowering plants. Provide pleasing visual lines. |
| | | | | | |

| Purpose | Time of Burn | Size of Burn | Type of Fire | Frequency | Remarks |
|---|---|---|---|---|---|
| Perpetuate Fire - Dependent Species | Will vary with species. | Will vary but usually fairly small. | Will vary with fuel conditions and species .requirements. | Will vary with species. | Fire intensity, timing and frequency all dictated by species requirements. |
| Young Pine Stands | Winter | Varies with size of stand. | Backing fire. | 2-4 years | Pine diameter 3 inches or more at ground. Pine height above 10 ft. Burn only after a strong cold front with rain. |
| Dispose of Logging Debris | Not critical. | Small areas mean fewer nighttime smoke problems. | Center firing with helitorch preferred. | | Smoke management is a must! Take care not to damage soil or water resources with these hot fires. If a broadcast burn will not meet objectives, pile – do not windrow debris. |
| Prepare Sites For Seeding | Natural seeding, summer to early fall prior to seed fall. | Large enough to prevent concentrations of birds & rodents (usually 10 acres or more). | Not critical. (Do not ring fire.) | | Be careful not to kill seed trees. If logging debris present, manage your smoke. |
| | Direct seeding, fall to late winter for spring sowing. Previous winter for fall sowing of longleaf. | Large enough to prevent concentrations of birds & rodents (usually 10 acres or more). | Not critical. Center firing with helitorch preferred if slash present. | | If logging debris present, smoke management is a must! Take care not to damage soil or water resources with these hot fires. |
| | | | | | |

| Purpose | Time of Burn | Size of Fire | Type of Fire | Frequency | Remarks |
|---|---|---|---|---|---|
| Prepare Sites For Planting | Growing season for hardwood control. | Large enough to prevent concentrations of birds & rodents (usually 10 acres or more) | Not critical. Central firing with helitorch preferred if slash present. | | If logging debris present, smoke management is a must! Take care not to damage soil or water resources with these hot fires. |

Note: To eliminate sweetgum from a pine stand in the Piedmont region of Virginia, it is necessary to start when the sweetgum has a ground diameter of less than 6 inches. The return interval must be annual until the sweetgum is satisfactorily controlled. Some species of plants do not produce seed every year. Blackberry is an example. If soft mast is an important part of the resource management objective the return interval should be at least two years.

# Chapter 9 Prescribed Burn Laws

**Synopsis of Forest Fire and Burning Laws**

**10.1-1141 -- Civil Action - Liability for Escaped Fires** - If a person carelessly, negligently or intentionally without using reasonable care and precaution to prevent its escape, starts a fire on forest land, brushland or wasteland, he is liable for the costs of suppressing the fire.
**10.1-1142-A—Regulating the Burning of Woods, Brush, Etc**. - Owner to cut and pile material for safe burning, and take reasonable care to prevent its escape. Class 3 Misdemeanor.
**10.1-1142-B -- 4 PM Burning Law** - During the period February 15 through April 30, it shall be unlawful to burn before 4:00 p.m. within 300 feet of woodland, brushland or field containing dry grass, although the precautions have been taken. Class 3 Misdemeanor.
**10.1-1142-C—Unattended fire** - Unlawful to leave open-air fires burning within 150 feet of woodland, brushland or field containing dry grass or other inflammable material. Class 3 Misdemeanor.
**18.2-86 -- Arson** - If any person maliciously sets fire to any wood, fence, grass, straw or other thing capable of spreading fire on land, that person shall be guilty of a Class 6 felony.
**18.2-87 -- Intentionally set fires** - Class 1 Misdemeanor and liability for suppression of fire if a person intentionally sets fire to brush, woods, etc., and if he intentionally allows the fire to escape to lands of another whereby the adjoining property is damaged or jeopardized.
**18.2-88 -- Carelessly set fires** - Class 4 Misdemeanor and liability for costs of suppression if a person carelessly or intentionally set fire whereby the property of another is jeopardized or damaged.
**10.1-1158 -- Prohibition of all open burning where serious fire hazards exist.** - Governor may prohibit open burning due to extreme fire conditions. Class 3 Misdemeanor.

**Virginia Certified Prescribed Burn Managers Course.**

**§ 10.1-1150.1. Definitions.**
As used in this article unless the context requires a different meaning:

**"Certified prescribed burn manager"** means any person who has successfully completed a certification process established by the State Forester under § 10.1-1150.2.

**"Prescribed burning"** means the controlled application of fire or wildland fuels in either the natural or modified state, under specified environmental conditions, which allows a fire to be confined to a predetermined area and produces the fire behavior and fire characteristics necessary to attain planned fire treatment and ecological, silvicultural, and wildlife management objectives.

**"Prescription"** means a written statement defining the objectives to be attained by a prescribed burning and the conditions of temperature, humidity, wind direction and speed, fuel moisture, and soil moisture under which a fire will be allowed to burn. A prescription is generally expressed as an acceptable range of the prescription elements.
(1998, c. 156.)

**§ 10.1-1150.2. State Forester to establish certification process.**
The State Forester shall develop and administer a certification process and training course for any individual who desires to become a certified prescribed burn manager. The training program shall include the following subjects: the legal aspects of prescribed burning; fire behavior; prescribed burning tactics; smoke management; environmental effects; plan preparation, and safety. A final examination on these subjects shall be given to all attendees. The State Forester may charge a reasonable fee to cover the costs of the course and the examination.
(1998, c. 156.)

**§ 10.1-1150.3. Voluntary certification.**
To be certified as a prescribed burn manager, a person shall:

1. Successfully complete all components of the prescribed burn course developed by the State Forester and pass the examination developed for the course;
2. Successfully complete a training course comparable to that developed by the State Forester and pass the examination developed for Virginia's course;
3. Demonstrate relevant past experience, complete a review course and pass the examination developed for Virginia's course.

(1998, c. 156.)

**§ 10.1-1150.4. Prescribed burn elements.**
Prescribed burning shall be performed in the following manner:

1. A prescription for the prescribed burn shall be prepared by a certified prescribed burn manager prior to the burn. The prescription shall include: (i) the landowner's name, address and telephone number, and the telephone number of the certified prescribed burn manager who prepared the plan; (ii) a description of the area to be burned; a map of the area to be burned; the objectives of the prescribed burn, and the desired weather conditions or parameters; (iii) a summary of the methods to be used to start, control and extinguish the prescribed burn and (iv) a smoke management plan. The smoke management plan shall be based on guidelines presented in the Virginia Department of Forestry publication, "Voluntary Smoke Management Guidelines for Virginia," and the U.S. Forest Service's technical publication, "A Guide to Prescribed Fire in Southern Forests." A copy of the prescription shall be retained at the site throughout the period of the burning;
2. Prescribed burning shall be conducted under the direct supervision of a certified prescribed burn manager, who shall ensure that the prescribed burning is in accordance with the prescription and
3. The nearest regional office of the Virginia Department of Forestry shall be notified prior to the burn.

(1998, c. 156.)

**§ 10.1-1150.5. Liability.**

A. Any prescribed burning conducted in compliance with the requirements of this article, state air pollution control laws, and any rules adopted by the Virginia Department of Forestry shall be in the public interest and shall not constitute a nuisance.

B. Any landowner or his agent who conducts a prescribed burn in compliance with the requirements of this article, state air pollution control laws, and any rules adopted by the Virginia Department of Forestry shall not be liable for any damage or injury caused by or resulting from smoke.

C. Subsections A and B of this section shall not apply whenever a nuisance or damage results from the negligent or improper conduct of the prescribed burn or when the prescribed burn elements described in § 10.1-1150.4 have not been complied with.

(1998, c. 156.)

**§ 10.1-1150.6. Revocation of certification.**

If the actions of any certified prescribed burn manager or the prescriptions prepared by him violate any provision of this article, state air pollution control laws, or Virginia Department of Forestry rules or threaten public health and safety, his certification may be revoked by the State Forester.

(1998, c. 156.)

Exemption to the 4:00 p.m. Burning Law
For Certified Prescribed Burn Managers ONLY:

**Deadline**

Prior to February 1st of the year an exemption is desired.

**Requirements**

Form 180 Exemption Application Form (see appendix) must be completely filled out and required documents submitted to the State Forester.

Each project you plan on burning during the exemption period will need a separate exemption application completed and submitted.

The application can be submitted at anytime from May 1st through the following February 1st. The applicant will be notified once a decision is made regarding the exemption.

**Conditions**

The exemption is for the entire period the 4 PM burning law is in effect, from February 15th to April 30, and can be revoked at anytime should conditions warrant.

It is critical that all requirements of the certified prescribed burn manager be strictly followed.

**Remember**

Call the nearest VDOF Regional Office on the morning of the planned burn.

The 4:00 p.m. Law § 10.1-1142 B shall not apply if:

The fire is set for "prescribed burning" that is conducted in accordance with a "prescription" and managed by a "certified prescribed burn manager" as those terms are defined in § 10.1-1150.1;

The burn is conducted in accordance with § 10.1-1150.4;

The State Forester has approved the application for the prescribed burn and

The burn is being conducted for one of the following purposes:

control of exotic and invasive plant species that cannot be accomplished at other times of the year; wildlife habitat establishment and maintenance that cannot be accomplished at other times of the year or management necessary for natural heritage resources.
The State Forester may on the day of any burn planned to be conducted pursuant to this subsection revoke his approval of the prescription for the burn if hazardous fire conditions exist. The State Forester may revoke the certification of any certified prescribed burn manager who violates any provision of this subsection.

**Department of Environmental Quality (DEQ) laws relating specifically to prescribe burning.** (Refer to page 130 for more info)
9 VAC 5-40-5630 (9a) -- Burning shall be at least 1,000 feet from any occupied building, unless occupants have given prior permission.
9 VAC 5-40-5630 (9b) -- The burning shall be attended at all times.

*Note: For complete information on the Fire Laws of Virginia refer to the Code of Virginia or “Virginia’s Forest Fire Laws,” Department of Forestry, Publication No. 2, Revised 1996. For complete information on the Regulations for the Control and Abatement of Air Pollution, contact the State Air Pollution Control Board.

# Chapter 10 The Plan

### Comprehensive Prescribed Burn Planning

**NO PLAN,**
**NO BURN**

No prescribed burn should be attempted without first preparing a detailed burn plan. The plan is more than just a plan. The plan should become a report of what is done to prepare for the burn; what happens during the burn, and evaluates the effects of the burn. The document, including the pre-plan, checklists, burn execution documentation, and post burn evaluation, becomes a "shield" that serves to protect the prescribed burn manager and the person who obtains the burn permit from charges of gross negligence. Adhering to a well-prepared burn plan enables the prescribed burn manager to proceed with confidence that the objectives can be accomplished without problems.

There is no set form for a burn plan, but there are certain groups of information that must be included in any good burn plan. The burn planner and manager should develop a plan form for each burn. No two burns are alike. Each burn has its own unique considerations.

The five steps to successful prescribed burning are analysis; prescription, preparation, execution and evaluation. These steps may be thought of as: the pre-plan (analysis), the written plan (analysis and prescription); pre-burn (preparation); burn execution, and evaluation. All burn plans should include each of these steps:

#### Pre-plan

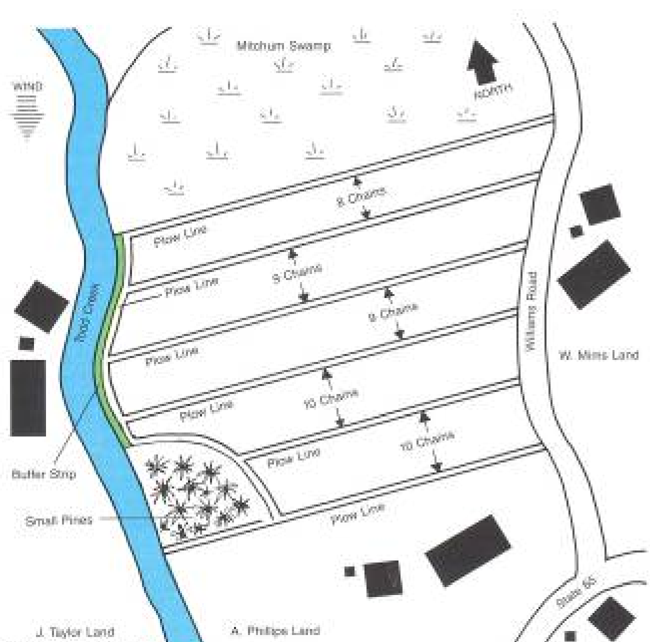
Prescribed burning is an efficient silvicultural tool when undertaken properly. Frivolous burning can be an expensive proposition when the objectives are not met or an escape occurs. Typically the resource manager thinks about using fire in conjunction with some other resource activity: harvesting, wildlife habitat management, ecological restoration, etc. Plans for the burn should be considered when implementing other resource activities. For example timber harvesting should utilize as much of the tree as possible to limit the amount of residual material that becomes fuel for the fire.

#### Written Plan

A formal written plan should be initiated once the resource manager has committed to using prescribed fire. A plan is not required by law but a plan is required for liability protection under the Virginia Prescribed Burn Certification Law (see chapter 9 Prescribed Burn Law). The minimum standards for a burn plan are provided in the regulation.  Additional information is helpful in addition to the minimum requirements.

**Basic Information**
A burn plan should include certain basic information.  The landowners name along with contact information, phone number and mailing address, should be included.  The name, phone number, and mailing address if the person who obtains the burn permit along with the permit number, date and time should be included.  When the burn is executed, the certified burn manager's certification number should be included.

The legal property description, county, of the burn area must be included.  In addition to the legal description, a sketch of the property and burn area on a map (example: 7.5 minute USGS topographic) should be included as a part of the land description.  In Virginia, the two mile per inch Department of Transportation county road maps can be very helpful.  The land description should include the acres within the burn perimeter and the acres expected to burn (excluding creek bottoms or other areas that are not expected to burn through).  The property description should include a description of the topography and soils.



Burning unit map

A detailed description of the timber stand, including type and size of overstory and understory, timber volume, and the fuel conditions, is an essential part of the burn plan.  Tree size, fuel loading and characteristics are important.

**Objectives**
The prescribed burn objectives are the basis of a prescription. Every plan should include three objectives: a safety objective, a resource objective, and a fire objective.

**Safety Objective:**

| **My fire**<br>**My smoke**<br>**My problem**<br>**Wherever they go** |
|---|

**The most important objective of any prescribed burn is safety**: Personal safety; safety of the neighbors; public safety, both physically and from an air quality perspective, are all important. Public safety and air quality issues are becoming a more significant concern for burn managers. The burn manager must be sensitive to National Ambient Air Quality Standards and areas of non-attainment. It is important that a prescribed burn not significantly degrade the air mass.

**The burn manager must be cautious to protect his or her own safety**. The burn manager is responsible for the burn activity. The burn will probably fail to meet the resource objective if the burn manager cannot perform due to injury.

**Crew safety** is essential to the accomplishment of the resource objective. If a crew member is unable to perform, then the rest of the crew, the resources, the neighbors and the public may be put at risk.

**Neighbors must be protected** by keeping the fire within the planned burn area. Neighbors must also be protected from smoke. The burn manager should contact neighbors prior to the burn and be knowledgeable of any special concerns, such as a neighbor with a respiratory problem.

**Public safety** is a growing concern for burn managers. With a growing population that is becoming more litigious and an expanding wildland-urban interface, it is essential that the burn manager, when conducting the burn, take all necessary precautions to protect the public. Highway accidents resulting in bodily harm, fatalities and property damage can result if the proper precautions are not taken. An escaped burn can cause substantial property damage to neighboring structures and natural resources and cause smoke problems.

**Resource Objective:**
When the resource manager first conceives of using fire, a resource objective is established. It may be single in purpose or it may include a combination of objectives. Most of the prescribed burning in Virginia is done for one of three objectives: site preparation; wildlife habitat, or hazardous fuels reduction management. Other burn objectives include: timber stand improvement; ecological restoration; agro-forestry; tree disease control, and aesthetics.
The burn plan must clearly define the burn objective in quantifiable terms. For example, if the burn is designed to clear the site to facilitate tree planting, then 100 percent of the fine fuels should be consumed, at least 50 percent of the 10-hour fuels should be consumed, and no more than 50 percent of the duff should be consumed. In the case of a fuel reduction burn, an example objective would be: 100 percent of the fine fuels should be consumed; 50 percent of the 10-hour fuels should be consumed, 75 percent of the duff should be consumed, and none of the humus

should be consumed. The burn planner must establish the objective to accomplish the resource need.

**Fire Objective:**

The fire objective is dictated by the resource objective. Season of burn; fire intensity; flame length; rate of spread; backing versus heading are all factors to be considered in the fire objective. The fire objective should include: start time; time for completion of ignition, and burnout time. For example, the burn may start at 9 a.m.; ignition completed by 3 p.m., and burn out complete by 5 p.m..

Computer models (not included in this publication) such as BEHAVE (http://www.fire.org/) can be very helpful in predicting fire behavior.

**Smoke screening (See chapter 2 Smoke Management)**

Smoke screening is a detailed process that requires the gathering of information and analysis. Smoke screening should be completed well in advance of the burn. The smoke sensitive areas and the acceptable wind directions should be investigated and listed in the burn plan. A copy of the smoke screening maps should be attached to the plan and become a part of the plan.

As the burn progresses, smoke behavior should be noted in the plan. There should be a contingency plan if for some reason smoke ends up in an area where it will cause a problem.

**Weather**

The burn plan should include a section defining the "desired" weather conditions necessary to accomplish all of the objectives of the burn: safety, resource and fire. The plan should also provide a place for the predicted weather for the day of the burn from the National Weather Service and a place to record the actual weather as observed throughout the burn.

**Pre-burn activity**
The burn plan should include all of the pre-burn activities required to accomplish the burn objective.

**Fire breaks**
The plan should specify the type of fire breaks for the burn. Fire breaks may be in different forms. Normally, fire breaks are designed to contain the planned burn by establishing a fuel break where the flames can be held.

**Minimum Standards for Prescribed Burning Plans**
The plan/prescription shall include:

(i) the landowner's name, address, and telephone number, and the telephone number of the certified prescribed burn manager who prepared the plan;
(ii) a description of the area to be burned; a map of the area to be burned; the objectives of the prescribed burn, and the desired weather conditions or parameters;
(iii) a summary of the methods to be used to start, control, and extinguish the prescribed burn and (iv) a smoke management plan.

**Pre-mopup**
The burn area can be prepped following fire break establishment to eliminate snags and other problem fuels adjacent to the break. Felling and removing snags will reduce the risk of a fire brand crossing the break and will reduce residual smoke. Moving dry tops away from the break will reduce the risk of hot spots and lofted fire brands. This prep work may reduce the amount of mop-up required following the burn.

**Notify neighbors**
Neighbors should be notified of plans to burn prior to the day of the burn so that they might take precautions or burn their own property at the same time. The burn plan should include a list of the neighboring landowners and contact information so that the burn manager can contact neighbors on the day of or during the burn if necessary.

Smoke-on-the-road signs in the area of the burn on the day of the burn helps to make local people aware of potential visibility problems.

**Notify officials**
Some of the most important officials to notify are the Virginia Department of Forestry County personnel. Other important officials include the sheriff and the local volunteer fire department chief. Contact information should be included in the plan.

**Equipment preparation**
Equipment needs should be determined and spelled out in detail in the plan. It is the burn planner's responsibility to specify the proper equipment for the operation.

**Crew training & briefing**

The crew composition should be specified in the burn plan. All crew members should be trained and in good physical condition. Prior to the initiation of the burn, the crew should be briefed, particularly about the ignition plan, communications, their responsibilities, and their contingency duties. One crew member, other than the prescribed burn manager, should be assigned the responsibility of monitoring and recording weather conditions, fire behavior, and smoke behavior. Part of this crew member's responsibility should include keeping the entire crew informed of weather conditions and fire behavior.

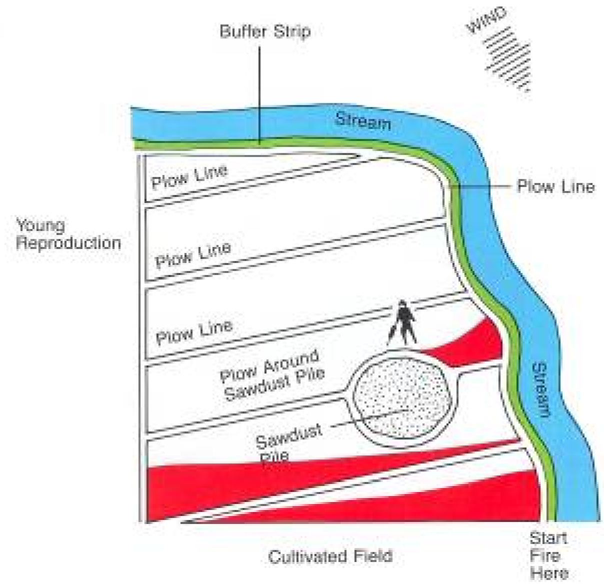
**Contingencies**


The burn plan must anticipate anything that might go wrong, such as jumps, wind shifts, and smoke on the road. The plan should provide direction and contact information for the burn manager to deal with contingencies. Contingencies should be considered by the prescribed burn planner and manager. Such things as a change in the wind causing smoke on a road and heavy fuels on an adjoining property are examples of situations that need contingency planning. The burn manager should plan how to deal with each contingency and define the role of each crew member in the event a contingency situation develops.

## Burn execution plan

### Ignition plan

The burn plan should include an ignition plan, which specifies the initiation of ignition and the extension of ignition. The ignition plan should include a sketch or map indicating the test burn, black lining, and ignition extension.




The ignition plan consisting of a description as well as a sketch, is a part of the burn plan, and should be reviewed with the crew on the day of the burn. The sketch should point out the place to conduct the test burn as well as how "black lining" will be conducted and how ignition will be advanced.

### Test burn

The plan should specify where the test burn should be ignited based on the prescribed wind direction. In the sketch above, a test burn would be conducted and observed at the starting point prior to proceeding with ignition.

### Back burning

The plan should specify where backing fires should be started to back fire off of down-wind lines to make them safe from jumps. The width of the "black" determines how effective it may be in reducing the risk of jumps and varies with the circumstances. The higher the wind speed; the lower the relative humidity, and the lower the fine fuel moisture content, the wider the black should be.

### Extending ignition

The plan should specify how, after the test burn and after the "black" has been established, ignition is to be extended to achieve the flame objective, which, in turn, should accomplish the resource objective.

### Ignition Devices

The plan should specify what type ignition device to use. There are several ignition devices that may be employed. Normally burn block size is a factor to consider when planning which ignition device to use.

### On site documentation plan

On-site documentation should include: weather; fire behavior; smoke behavior, and times. Actual time of start; test burn; ignition advancement, and completion should be recorded in the burn plan along with the actual ignition pattern and method.

**Burn out**
Burn out should be completed prior to the downturn in the diurnal cycle or shortly thereafter. Normally, this is around 5 p.m. but varies with season and daylight savings time. The burn manager should plan ignition so that it is complete at early to mid-afternoon. The burn manager may elect to modify the ignition technique and use a more aggressive technique in the event the spread rate is not sufficient to complete the burn out by the targeted time. This can be risky and may compromise the objectives. Preferably, the burn manager will have anticipated spread rate and provided adequate ignition to complete the burn. This may require plowing cross fire breaks so that more area can be ignited quicker. Strip head fires are frequently employed. However, in an understory burn, strip head fires may result in undesirable scorch where the flames merge. An alternative is spot ignition.

**Mopup & secure**
The plan for mopup should be included in the Smoke Management Plan and included with the burn plan. Mopup may begin soon after the passage of the flame front when the area has cooled sufficiently for crew members to enter the area. Mopup is the process of working through the burned area to cool off smoldering spots that are producing smoke that may end up down drainage later in the day. The burn manager should commit sufficient resources and staff to this task to ensure that a minimal amount of smoke is being produced as evening approaches. Water tankers, bladder bags, shovels and rakes are all commonly employed for mopup activities. Mop-up may be more critical in areas close to Smoke Sensitive Areas.

In addition, all fire breaks need to be patrolled frequently following the passage of the flame front to ensure that no fire has crossed the break. Flaming cat faces and snags can present problems, both as a source of embers that might blow across the fire break and as a source of residual smoke. They must be dealt with during mopup.
Virginia law stipulates that the burn area must be tended until the fire is dead out. In some cases, this may require that the burn area be tended for several days. The definition of dead out may not be clear, but it is wise to err on the safe side.

**Safety meeting**
Prior to securing from the burn, it is important to conduct a crew meeting to discuss the burn. Problems, safety situations and accomplishment of objectives should be discussed. The burn manager may gather information from individual crew members, and the crew member responsible for recording weather can make appropriate notes. In some cases, the post burn safety meeting may be the beginning of the evaluation process.

**Evaluation & on site documentation**
Evaluation of burn objective accomplishment may be included in the plan for long range resource management plans. The burn planner can set out the special evaluation techniques to be used.

## Chapter 11 Pre-burn

**Fire breaks**
Sufficient fire breaks and control lines must be established around the burn area prior to initiation of the burn in accordance with the plan. This can be done months in advance, but a final cleaning and inspection of the breaks to determine adequacy must be done on the day of the burn just prior to ignition.

The straighter the fire break the better. Nooks and bends in the line may result in fire swirls that can loft fire brands across the break. Best Management Practices should be followed to prevent sedimentation in water courses when constructing and maintaining fire breaks. The burn plan should specify where the fire breaks for the planned burn are to be constructed and the character of the breaks.

Breaks designed to hold a backing fire may be smaller than breaks required to hold a heading fire. When a helicopter ignition is used, breaks should be substantial-possibly 50 feet or more in width to protect against wayward ignition material. If the control lines for helicopter burning are hand, or ATV ignited and the black area is adequate, no additional plowed fire break clearing is called for.

- Established – fire breaks
  - Temporary
    - Plowed
    - Wet lines
  - Permanent
    - Pushed
- Passive – fire breaks
  - Streams
  - Poorly drained areas
  - Fields
  - Roads

Breaks may be natural barriers, such as roads or streams. These are referred to as passive breaks. Normally, fire breaks are constructed by plowing with a fire plow or pushing with a bull dozer. Plowed breaks are not permanent and may result in water channels that affect hydrology and/or result in erosion. Plowed breaks may be rehabilitated with a bush and bog harrow set to pull the soil back to the center. Plowed breaks have the advantage of being cheaper and faster than permanent pushed breaks.

Pushed fire breaks may be maintained as access roads for other activities. Permanent fire breaks may be maintained with a farm tractor and a disk harrow.

Disked breaks

Road-side break

In some cases, fire breaks may be established by hand raking. Hand raking is slow and labor intensive but may be necessary in some cases if equipment access is limited or the area is sensitive. Using the "one lick and go" method with a crew makes the work go faster.

Plowed, pushed and disked breaks may be seeded with a mix of grasses beneficial to wildlife following the burn. Re-vegetating the breaks minimizes erosion.

In some cases wet lines may be used by spraying water or foam. This may be risky in the event of a change of wind direction. A substantial mobile source of water and personnel are required for this type fire break.

Wet lines are useful where low-impact burning is called for in parks, preserves, golf courses and ecologically sensitive areas. Wet lines are also useful for burning in the wildland-urban interface, where it is necessary to burn close to buildings. Wet lines are very temporary and cannot be depended on to hold fire for a long period after application.

Class A foam can be used as a wet line to form a more substantial fire break than plain water.

**Equipment**.
All personal and crew equipment should be in place and ready in accordance with the burn plan prior to the initiation of the burn. Equipment should be serviced, fueled, sharpened, etc., prior to the day of the burn and staged for the burn. Everything should be in place on the morning of the burn.


Loaded and ready to go


Tractor mounted plow


ATV & “Mini-engine” standing by


Nurse tanker


Trailer plow


Disk harrow

**Communications**

Two types of communication during a burn are desirable: contact with a location that can relay a request for emergency assistance and between crews working on the burn. Communications can be by CB, business band or similar radios, or cellular phones. Where service is available, cellular phones are the best alternative for requesting emergency assistance in most areas. It can be vital to have fast response by emergency help in case the fire gets out of control or an injury occurs.

**Hand tools & drip torch**

Prescribed burning sometimes requires unique equipment, but often common tools and equipment can be adapted for effective use. In selecting and evaluating equipment for a prescribed burn, it is important to understand the purpose and design requirements of each piece. Two kinds of equipment are needed for prescribed burning: that used to suppress or control the fire, and that used to ignite the fire.

**PPE (personal protective equipment)**

Personal safety does not always receive the same emphasis on prescribed burns as it does on wildfires. Even experienced burners often cut corners on safety during “routine burns.”

Two factors associated with prescribed fires reinforce this false concept. First, prescribed fires are scheduled when weather and environmental conditions are favorable, and second, the desired fire behavior is usually "moderate" when compared to wildfires in similar fuels. In reality, there is only one difference between a wildfire and prescribed fire. That difference is the actual prescription process. In addition, a prescribed fire can transition to wildfire status in the blink of an eye. Studies of wildfire incidents have shown that many injuries and fatalities occur on "routine fires" and on "quiet" parts of the fire. Firefighters on "routine" mop up have lost their lives when unexpected fire infernos erupted from the ashes of a dying fire. Likewise, many injuries and a number of fatalities have occurred on "controlled fires" across the nation either because fire behavior was underestimated or standard fireline safety precautions were not observed.

1) Fatalities Have Occurred On Prescribed Burns
2) Fatalities Have Occurred During Mop Up
3) Fatalities And Injuries Often Occur During Routine Conditions
All wildland fire is inherently dangerous and the same safety procedures are required on all fires, including prescribed burns.

Personal Protective Equipment, frequently called "PPE" is the cornerstone of personal safety. Agencies and companies should have in place a policy that identifies the minimum requirements for PPE on all prescribed burns. In addition, each individual should maintain a set of personal standards that ensures personal requirements have been met. PPE requirements should be addressed in the written safety plan.
Personal Protective Equipment provides a measure of safety in what is an inherently unsafe environment. Recommended items of Personal Protective Equipment for prescribed burning include:
_ Hard hat
_ Eye Protection (goggles or shield)
_ Bandanna or dust mask
_ Boots
_ Gloves
_ Fire Shirt and pants or jumpsuit
_ Fire Shelter (carried on belt or harness)
*** Other PPE may include the following: radio, canteen, hearing protection, saw chaps and compass.

Prescribed burning equipment comes in various and assorted styles. It is the burn planner's responsibility to specify the proper equipment for the operation, and it is the burn manager's responsibility to see that all equipment is adequate, functioning properly and in place.

Long-sleeved shirts and pants made of 100 percent cotton or wool or NOMEX* material. Shirts should be of sufficient length to allow overlap of gloves and shall be worn with sleeves down and fastened and shirt tails tucked into pants. Pants shall not have cuffs or frayed bottoms and must extend to cover boot tops. Hats, coats and coveralls must also meet these fabric requirements. Clothing or footwear made of synthetic materials is forbidden.

*Nomex clothing is designed and manufactured so that it will not burn and is the most effective protection for crew members. Some organizations specify the personal gear a crew member must wear while others leave the decision to the individual. CHECK YOUR AGENCY/ORGANIZATION PROCEDURES and follow them THE life you save maybe your own




**Clothing that will melt, such as synthetic fibers and plastic-soled boots, should never be worn when working on a burn.**

## Chapter 12 Executing the Burn

**The burn manager is responsible for the decision to put fire on the ground!**

**Burner's Check List**

A checklist developed during planning can serve as an excellent tool for the prescribed burn manager on the day of the burn. The following list might serve as the structure of a detailed checklist in which all the specifics are spelled out.

-Obtain current fire weather forecast.
-Monitor actual weather before Test Burn.
-Inspect fire breaks.
-Pre-ignition crew review.
-Ensure all equipment and personnel are in place and ready.
-A communications check of all gear and procedures should be conducted.
-Test fire.
-Proceed with ignition.
-Backfiring.
-Ignition extension.
-Complete ignition by one hour prior to dusk.
-Monitor actual weather during the burn.
-Check smoke drift and any impacts to down-wind Smoke Sensitive Areas.
-Burn out (by dark).
-Mop up may be initiated as the flame front passes if sufficient crew members are available. The sooner smolder can be knocked down the sooner latent smoke production will cease. Virginia law specifies that the burn must be attended until it is "dead out."
-Follow up crew review; tailgate safety meeting, and evaluation.
-Monitor smoke at critical, down drainage Smoke Sensitive Area.

**Piles**
Special attention needs to be paid to any piles in the burn area during execution of the burn due to potential pile-burning problems. If the plan calls for burning the piles, a careful review of the conditions should be conducted.
Pile alternatives include: scatter, break up, isolate and burn at a different time under different conditions.
If conditions are not perfect for pile-burning, DO NOT push the envelope !
It is better to leave a pile unburned than to risk an escape or smoke problem. The few acres gained by pile burning are not worth the risk.
The burn manager should consider all piles carefully and make an informed decision whether to proceed.

**Contingencies:**
If a potential smoke or fire problem is observed, stop burning and plow out.

**What to do if a problem develops:**

Call 911. This will put all emergency responders on notice including the sheriff, volunteer fire departments, and the VDOF – stay on the line with the 911 operator to ensure that your location is properly identified.
If there are injuries, call for an EMT via 911.
Post road guards if there is smoke on a road.
Take precautions to prevent further accidents.
Notify potentially affected people.
Investigate and document immediately.
Secure witness information.
If at night, check for fog.
Take pictures.
Secure detailed weather records.
Seek expert independent advice.
DOCUMENT! DOCUMENT! DOCUMENT!

# Chapter 13 Evaluation

| |
|---|
| The job is not done until the paper work is complete. |

**Evaluation**
The extent of evaluation varies with the landowner's objective. Evaluation can be helpful in developing long-range resource management plans. In some cases, evaluation may consist of a drive by; in other cases, evaluation may be detailed, sophisticated and complex.

Evaluation of the burn is essential to determine if the objectives have been met. Evaluations may be done on the day of the burn; the day after the burn; the week after the burn, the month after the burn; the season after the burn, and the year after the burn depending on what is to be evaluated. At the time of evaluation, many things may be reviewed, such as smoke behavior; fuel consumption and load reduction; scorch; mortality of various components of the stand; the need for subsequent burns to accomplish a long term resource objective; insect infestation; etc.

There are many techniques of evaluating: photo points; wires around logs; rods in the duff; paint marks on tree butts; heat sensing gadgets that record temperature levels--both thermocouple types and chemical types. These types of evaluation must be initiated prior to the burn.

Post-burn evaluation may be initiated by the burn manager during at a wrap-up tailgate session prior to securing the crew from the burn. A crew member, possibly the individual who maintained the weather data during the burn, may make notes for inclusion in the burn plan. Observation relating to the accomplishment of the burn objectives, resource, flame and safety should be made.

A tailgate safety meeting immediately after the burn can determine any potential risks that may need to be avoided in future burns. Evening or next day early morning checks can determine the extent of residual smoke and potential problems. Checking down drainage SSA can be very important and informative. Follow-up evaluations can determine fuel consumption, scorch and mortality. Late winter or early growing-season burns in pine stands can be followed by pine beetle inspection several times during the growing season.

**Optional Evaluation Techniques**

Photo Points:  Photo points may be established prior to the burn so that a post burn sequence of pictures can be made with the exact same precise camera height, horizontal angle and vertical angle.  A compass and clinometer can be helpful in this process.  If a picture is worth one thousand words, a sequence of pictures must be worth one million words.

Longleaf pine release from Loblolly pine

Light under-burning under young stand

**Scorch**

Trees may be scorched in several places: the roots, the root collar, the stem or bole, and the crown. Scorch estimates are subjective. The evaluator must make estimates based on what can be observed and the evaluator's experience.

Needle Scorch

The best indicator of crop tree damage is percent foliage discoloration. Assuming that buds and branchlets are not heat-killed, even crown scorch approaching 100 percent generally will not kill trees unless secondary factors, such as insect attack or drought, materialize.

| Percent Crown Scorch | Damage |
|---|---|
| 0 to 33 | Some volume growth loss may occur the first postfire growing season but will be minor. |
| 34 to 66 | Volume growth loss usually less than 40 percent and confined to first postfire growing season. |
| 67 to 100 | Reducation may be as high as a full year's volume growth spread over 3 years. |

If, however, loblolly pine stands are burned in the fall (September or October), after the trees have undergone their last needle flush of the growing season but prior to the onset of dormancy, research indicates that 100 percent crown scorch is likely to kill them. Slash pine appears to be more tolerant of severe crown scorch during the fall.

If more than 15 percent of a southern pine tree's needles are actually consumed by flames, the tree's chances of survival would be poor even if very little of the rest of the crown is scorched. Young, vigorous trees are more likely to survive severe crown damage than are older individuals. Magnitude and duration of growth responses in southern pines due to various levels and seasons of defoliation are not well documented. Both negative and positive responses have been observed, but the preponderance of evidence shows a direct relationship between diameter and height growth loss and crown scorch. Providing no crown consumption took place, the above table will help in estimating potential growth loss in loblolly and slash pines over three inches dbh. These "ballpark" estimates can be used for other southern pines as well, until more specific results become available.

A good indicator of hardwood control is a series of bark cracks extending into the cambium near ground level. This indicates sufficient heat was applied to penetrate the bark and kill the cambium. Although large hardwoods can be damaged by periodic fires, they are difficult to kill. Judge the success of burning for brownspot control by the number of longleaf seedlings with all infected needles burned off, but still having a protective sheath of green needles around the unharmed terminal bud.

Root collar and bowl scorch: Duff tends to build up around the base of older pine trees. This ring of duff may be referred to as a "duff doughnut." Intense burning of the "duff doughnut" may result in damaging the tree cambium in the area of the root collar and possible mortality of the tree.

Monitoring the "duff doughnut" around large pine;
Checking a "duff doughnut" following a burn.

Crown scorch

Crown scorch is typically estimated as a percent of the length of the live crown. Southern pines normally survive severe crown scorch but a growth loss is incurred. Follow-up visits to the stand during the following growing season can be made to determine if pine beetles have invaded the stand when crown scorch occurs. Crown scorch and pine beetles can wipe out any positive gains from a burn.

**Soil scorch**

Scorched soil?

Site prep burns

Scorched soil can reduce the site index and have substantial ecological impact. Soil scorch may result in soil erosion. Site restoration may be required in some cases. Soil scorch is evident when all of the organic matter is burned out of the soil and nothing but grit and sand is left. In extreme cases, the heat may be so intense it causes the sand to form glass beads.

**Forms:**

Each evaluation may require a specific form. There are no standard forms, however a suggested format is part of the plan presented in the appendix beginning on Page 124. Each burn and each organization may develop forms that are appropriate for their needs. The burn manager should ensure that adequate documentation is completed and that the information is attached as part of the completed plan.

# Chapter 14 Rules of Thumb

Don’t burn on organic soils unless the water table is very close to the surface.

Heading fires produce about three times more particulates than backing fires.

Burn when fuels are dry, but not too dry. Wet fuels produce substantially more particulate than do dry fuels.

Start burning logging debris by midmorning.

Site prep burning behind chopping or other mechanical treatment gives best results if done 10 to 15 days after treatment.

Windrows are the most polluting of all southern fuel types.

Broadcast-burn scattered debris if possible.

Do not pile when either ground or debris is wet.

Dirt in piled debris will increase the amount of smoke produced by up to four times. Shake out dirt while piling; "bump” piles while burning, and repile as necessary.

Use a smoke management plan. Consider smoke sensitive areas. Look several miles downwind and down-drainage for potential targets.

If nighttime Dispersion Index forecast is poor or very poor [less than 13], stop burning by 3 p.m.

Doubling the Dispersion Index implies a doubling of the atmospheric capacity to disperse smoke within a one thousand square-mile area.

Assuming 1 ton of fuel per acre is being consumed by smoldering combustion during poor nighttime dispersion conditions, expect visibility in the smoke to be less than 1/2 mile within 1.5 miles of the fire.

Obtain and use latest weather and smoke management forecasts.

Relative humidity will roughly halve with each 20ºF rise in temperature and double with each 20ºF drop in temperature in a given air mass.

Expect increased spotting when relative humidity drops below 30 percent. Be EXTREMELY careful when the relative humidity is below 25 percent.

Burn when mixing height is above 1,650 feet [500 meters].

Do not burn under temperature inversions.

Burn areas with low-fuel loading and large-sized trees on marginal days at the high end of the prescription window.

Never underburn during a drought. Soil moisture is needed to protect tree roots and lower litter.

Decrease smoke concentration by: increasing transport wind; mixing height, or plume rise.

Other rules:

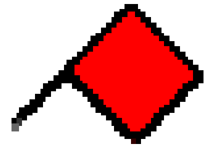
Expect control problems when the probability of ignition is 70 percent or higher.

Expect control problems if the burn area has cured cogongrass or kudzu near the fire lines, unless otherwise mitigated.

Consider the fuel model(s) outside and adjacent to the planned burn area with regard to rate of spread and the flame length in the event of spotting.

Consider KBDI indices in relation to seasonal averages for the area.

# Chapter 15 Red Flag Situations



If any of the following conditions exist, analyze further before burning.
Understory burning:
No written plan
No map
No safety briefing
Heavy fuels
Dry duff and soil
Gusty and or swirling wind
Extended drought
Inadequate control lines
No updated weather forecast for area
Forecast does not agree with prescription
Poor visibility
Personnel or equipment stretched thin
Burning large area using ground ignition
Communications for all people not available
No backup plan or forces available
No one notified of plans to burn
Behavior of test fire not as prescribed
A smoke-management plan has not been used
Smoke-sensitive area downwind or down drainage
Organic soil present
Not enough personnel or equipment available to control an escaped fire
Personnel on fire not qualified to take action on escaped fire
Gusty and or swirling wind
Temperature in excess of 80 °
Area contains windrows
A lot of dirt in piles
Poor nighttime smoke dispersion forecast
Have not looked down drainage
Mixing height is below 1,650 feet (500 meters)

If any of the following conditions exist, stop burning and plow out existing fire:
Fire behavior is erratic
Spot fire or slop-over occurs and is difficult to control
Wind shifting or other unforeseen change in weather, probability of ignition is 70 percent or higher.
Smoke not dispersing as predicted
Public road or other sensitive area smoked in
Burn does not comply with all laws, regulations and standards
Large fuels igniting, not enough personnel to mopup, likely to smoke in SSA

# Chapter 16 Burning Young Stands

The information included here is based in part on an unpublished paper, Prescribed Burning in Young Stands; Opportunity Overlooked?, by John R. Stivers, and the personal experience of the author. The information is primarily anecdotal.

**Objectives**

Some of the uses of fire for managing timber stands were presented in Chapter 8– Fire as a Tool. Fire can be used to manage young pine stands for several objectives:

**Fuels management:** Young stands of pine are particularly vulnerable to damage from fire. Under certain conditions a substantial investment in stand establishment can be wiped out by fire. A prescribed burn under proper conditions can reduce the fuel load in a young stand and reduce the risk of an unplanned fire. Properly timed fire is particularly effective in longleaf pine stands. Fire can reduce the fuel load and control brown spot needle blight when longleaf is still in the grass stage. The key is to burn in such a way as to not scorch the longleaf terminal buds.

**Wildlife habitat:** Fire in young stands, where adequate sun light reaches the ground, can stimulate succulent browse growth and stimulate seed production, both of which provide a food source for a wide variety of wildlife. Recently burned areas can also serve as good “bugging” areas for young turkey poults or quail bitties.

**Thermal thinning:** Fire can thermally thin overstocked pine stands when applied under precise conditions. A fire in a young stand may kill the smaller shorter stems without lethally scorching the bigger stems. Fire can be used to thin out natural reproduction in a young planted loblolly stand by keeping the temperature in the crowns low and by allowing the dwell/residence time at the root collar to linger. This works well in young longleaf stands that have been invaded by volunteer loblolly seedlings.

**Timber stand improvement:** Fire can eliminate undesired species from young pine stands. Young undesirable hardwoods are particularly susceptible to fire where the growing tissue can be raised to the lethal range. The required temperature and stem size, bark thickness, varies by species. Typically a first burn will only kill stems that are 3 inches or less at the root collar. Sweet gums are often a target species. However, multiple burns are typically required to displace sweet gum from a stand.

**Agro-forestry:** Fire can stimulate browse for domestic live stock in agro-forestry management regimes. New shoot sprouts especially in grasses and legumes are nutritious for animals.

**Pruning:** Young pine stands that are burned properly tend to self prune readily and the form class in stands where fire has been used tends to be higher. Fire scorches the lower limbs without scorching the upper limbs.

**Conditions**
Several things must be right for fire to be used in young stands:

**Continuous, readily burnable fuel**: Conditions must be just right for burning in young stands. Continuous light fuels; one hour fuels, with the fuel moisture at approximately 5 percent or 6 percent, must be in the stand. Wire grass; pine needles, or broom sedge serve as good fuel beds for burning in young stands. If the fuels are too moist, the fire will not carry. If the fuel is too dry, the flame length may be too long and result in crop tree scorch. If good burnable fuels are not present, the fire may finger around and then burn with the wind in spots resulting in unacceptable scorch.

**Steady wind**: A steady ground level wind of 1 to 3 miles per hour is required in young pine stand burns to push the heat up and out of the stand. If there is no wind, the heat may rise straight up and result in unacceptable scorch. If the wind is greater than 3 miles per hour, the flame length may be too long and again result in unacceptable scorch.

**Cool air**: Ambient air temperature of $50^{\circ F}$ or less is required to prevent excessive crown scorch.

**Dormant season**: Young pine stand burning should only be done in the dormant season when buds are hardened off and not as susceptible to scorch. Normally in Virginia, the weather and fuel conditions for burning young pine stands occur in late winter prior to bud break. During this season, cold fronts pass through the state from the northwest. Immediately following the passage of a cold front, the relative humidity tends to drop and wind direction remains steady. At the same time, one-hour fuels dry out quickly while heavier fuels and the deeper duff remain moist and will not burn. It is important to monitor weather predictions several days in advance and have all resources for burning ready to take advantage of proper conditions. Timing is important.

**Sufficient tree size**: Crop trees must be of sufficient root collar size and bark thickness to prevent the growing tissue from reaching the lethal level during flame front passage. The optimum size varies depending on air temperature and species. The colder the air, the smaller the stem that can withstand the passage of the flame front. Longleaf tends to have a thicker bark than loblolly, and longleaf needles serve to protect the terminal bud better than loblolly. Fire may be passed under very young longleaf with root collar diameters of two inches or greater and are two feet or taller. The bigger the root collar and the taller the tree, the less risk of scorch. Loblolly, on the other hand, has thinner bark than longleaf and more exposed buds. Tree heights of 10 - 15 feet and root collar diameters of three inches and greater are required before burning can be done without too great a risk of unacceptable scorch.

**Flat terrain**: Burning in young stands can be done in flat to hilly terrain. It can be difficult to control flame length on slopes where slope breezes may form and convection temperature may be higher in the crowns. Normally young stands should only be burned using a backing fire. Burn block size should be kept small since the spread rate of backing fires is slow. Long, narrow blocks are preferable. Larger areas may be burned in a burning window by breaking up the block with multiple cross fire breaks. Strip-head firing should be avoided.

**An experienced burn manager:** An experienced burn manager is essential for successfully burning young stands. In order to gain experience, a burn manager can work with an experienced burn manager. Small burn blocks, 20 acres or less, can be attempted by the inexperienced burner to start out. Larger blocks may be attempted as experience is gained. It is important to remain cautious. The risks are great and the values are typically high.

# Chapter 17 RX Burning in the Wildland-Urban Interface and Ecologically Sensitive Areas

## The Wildland-Urban Interface

The wildland-urban interface, WUI (the term used here includes both the interface and the intermix conditions), has existed since people started living in communities dating back to Native Americans. Fire has always been a problem when it gets where people don't want it. People have used fire in the WUI since prior to European settlement to prevent unwanted fire.

Farmers burn off fields as an agricultural treatment but also to prevent unwanted fire. Some urban dwellers have burned their lawns to improve grass growth. As people move into the hinterlands to enjoy the aesthetics of rural living, they put themselves and their property into close proximity to wildland fuels. The new breed of interface residents does not have the fire background that earlier rural residents had, and so they may unwittingly put themselves in a hazardous position. The challenge is to manage the fuels in close proximity to residences and other assets in such a way as to preserve the aesthetic values that make the WUI attractive in the first place.

Fire can continue to be an efficient tool for managing fuels in the urban interface. Prescribed burning can be done without putting property and aesthetics at risk. A keen understanding of all the factors involved is essential to success. Fire behavior doesn't change because the fire is in the WUI. What does change is the potential for damage to property and smoke problems. If these two factors can be dealt with, then fire can be used.

The people in the WUI must be informed of the effectiveness and efficiency of fire. Smoke will be an acceptable nuisance when managed properly viewed in relationship to catastrophic fire. Here again, the new WUI resident may not appreciate the risk.

The major difference between safe, successful WUI burning and rural prescribed burning is tract size. The smoke from a three-acre burn does not result in the problem that the smoke from a 300-acre burn may cause. Trac size and fuel load are very critical. In some cases, a pre-burn fuel treatment may be needed to get fuels down onto the ground.

## WUI Fire Breaks and Fire Control

Plowed or even raked fire breaks are unacceptable in some situations in the WUI. Plowing may cause the formation of water channels that could result in erosion. Plowing may be unsightly. Raking may disturb sensitive plants or animals. The burn plan for WUI and sensitive area burns must address these concerns. In some cases, wet lines and foam may be the best alternative.

The major equipment difference for WUI burning is water. The control of burns around buildings calls for large quantities of water with an adequate delivery system similar to most rural fire departments. A garden hose connected to a domestic water source is inadequate. A very maneuverable engine capable of delivering large quantities of water and capable of being replenished rapidly is necessary. Multiple engines may be required if there are multiple exposures. The use of wet lines as fire breaks versus plowing bare soil may be important.


Type 7 engines

Mini engine

Water buffalo and large crew

Tanker

A tanker capable of delivering a large quantity of water may be available from a local volunteer fire department. Volunteer firemen usually enjoy a good burn and may very well join in for the experience. Some units are capable of drafting from local water sources. All tankers are capable of drawing water from a fire hydrant.

WUI burning requires a large crew. All sides of the burn must be staffed all the time until that area of the burn is dead out to prevent escapes that might result in property damage. Fire can do strange things--creep around; follow roots, and pop up where it might be least expected.

A leaf blower can be a handy device for moving leaves and other light fuels away from buildings or for clearing a fire break. The tank at the top of the blower shown here can be filled with water. By pulling a lever, the operator can inject a stream of water into the air stream that results in a mist. The mist serves to wet the line.

Class A foam

Class A foam can be used effectively to protect a structure and to lay down a wet line. The foam material is biodegradable.

Type 7 engine with foam unit

**Dealing with Neighbors and the Nuisance Factor**

Public relations must be extensive and effective if WUI prescribed burning is to be accepted and tolerated. The burn manager planning a WUI burn should pay particular attention to neighbors, community leaders and community officials. A pre-burn meeting for the stakeholders can be used to inform the public and allay concerns. In some cases it may be necessary to get buy in from the local fire chief.

WUI burns should be conducted only when the ventilation factor is high and the Dispersion Index is category V or higher. A lot of good can be done with WUI burns. The political impediments are great. WUI burning, while not new, is controversial in today's communities. The cost of doing the necessary public relations work will be high and demand exceptional communications skills.

# Chapter 18 Prescribed Burn Program Administration

Prescribed burning administration becomes more important when an organization, company or consultant plans to burn a large number of acres in multiple tracts during a season. Administration is assumed for a landowner who owns one small trac. Burning can be coordinated with other management activities and considerations such as herbicide application; fertilizer application; harvesting; hunting season, and nesting season. Finding the “window” that works for the burn objectives and the weather is important.

The burn plan is the essential tool for the administrator. The plan spells out the equipment and personnel requirements as well as the season of the burn and the acceptable wind direction. The administrator must provide for those requirements similar to the administration of any function. Employment and purchase are options. Lease and contract are other options.

The number of days when the weather is suitable for burning in the dormant or growing season is limited. In Virginia, in the early spring, there may be only 14 days suitable for burning. In the late summer, there may be a similar number. Nighttime burning conditions are even more constraining. The prescribed burn manager must be prepared when the weather window opens. People, equipment and plans must be ready.

The administrator must assign priorities to individual burn projects. Then, based on the individual burn plans, the administrator must be prepared to select the next burn project to undertake based on the weather--particularly the wind direction--on the next available day. A chart of tracs arranged by priority, listing the acceptable wind directions for the individual tracs, can be a useful tool in this process.

**Potential Problems**

On all prescribed burns, take time to observe: (1) fire behavior; (2) smoke dispersion, and (3) effects on the vegetation. Document this information by making it a part of the written plan. When a potential problem is observed, stop burning and put the fire out if possible. Notify your office and the State Forestry Office immediately. Request help in getting out flaggers and signs along roads. Also, notify people who may be affected if smoke is threatening communities, airports, farms or homes.

**What to Do After an Incident Occurs:**

A. Investigate the incident to determine if it was caused by smoke from the prescribed burn. If not, determine and document the actual cause immediately. Do not wait! Valuable evidence will be lost.
B. Secure names, addresses and telephone numbers of witnesses.
C. If at night, check to determine if fog was present in the area.
D. Check for other sources of smoke. Remember - it takes only a very small amount to smell, but a lot to cause reduced visibility.
E. Take pictures of both the incident site and the burn.
F. Secure weather records.
G. Seek expert advice.

# Glossary / Appendix

There are numerous glossaries of terms available:

Internet links to online glossaries related to wildland fire:

http://flame.fl-dof.com/Env/RX/guide/glossary.html

http://nrfa.fire.org.nz/nrfa_biz/equipment/glossary.PDF

http://www.rap.ucar.edu/projects/wfc/acronym/glossary.html

http://www.fire.blm.gov/training/standards/GLOSSARY.PDF

http://www.pfmt.org/fire/

**Air Contaminant** A dust, fume, gas, mist, odor, smoke, vapor, soot, pollen, carbon, acid or particulate matter or any combination thereof.
**Air Mass** A wide-spread body of air having approximately the same characteristics of temperature and moisture content throughout its horizontal extent. In addition, the vertical variations of temperature and moisture are approximately the same over its horizontal extent.
**Air Pollution** The general term alluding to the undesirable addition to the atmosphere of substances (gases, liquids or solid particles) either that are foreign to the natural atmosphere or are in quantities exceeding their natural concentrations.
**Air Quality** The composition of air with respect to quantities of pollution therein; used most frequently in connection with "standards" of maximum acceptable pollutant concentrations. Used instead of "air pollution" when referring to programs.
**Air Pollution Health Advisory** A statement issued by a National Weather Service Forecast Office when atmospheric conditions are stable enough such that the potential exists for pollutants to accumulate in a given area. The statement is initially issued when conditions are expected to last at least 36 hours. See Air Pollution Alert.
**Ambient Air** Literally, the air moving around us; the air of the surrounding outside environment.
**Anticyclone** An area of high atmospheric pressure with closed anticyclonic circulation. Anticyclonic flow is clockwise
**Atmospheric Stability** The degree to which vertical motion in the atmosphere is enhanced or suppressed. Vertical motions and pollution dispersion are enhanced in an unstable atmosphere. A stable atmosphere suppresses vertical motion and limits pollution dispersion.
**Available Fuel** The portion of the total combustible material that fire will consume under given conditions. This could be duff, woody, herbaceous material or litter.

**Backing Fire** A fire spreading against the wind or downhill. Flames tilt away from the direction of spread.
**Cold Front** The leading edge of a relatively cold air mass that moves in such a way that cold air displaces warmer air. The heavier cold air causes some of 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.
**Convective Phase** The phase of a fire when most of the emissions are entrained into a definite convective column.
**Convection Column** That portion of a smoke plume sharply defined by the buoyant forces of heated air and affluents.
**CSI/Keetch-Byram Index** Cumulative Severity Index. An indication of drought, ranges from 0 to 800, with 800 indicating extreme drought conditions.
**Cyclone** Loosely, a low pressure with counter-clockwise flow. On a very small scale, the term is frequently misused to describe tornadoes. See Surface Low.
**Deepening** A decrease in the central pressure of a low. This is usually accompanied by intensification of the cyclonic circulation (counter-clockwise wind flow around the low) See Filling.
**Dispersion** In air pollution terminology, loosely applied to the removal (by whatever means) of pollutants from the atmosphere over a given area; or the distribution of a given quantity of pollutant throughout a volume of atmosphere.
**Disturbance** A weather system usually associated with clouds, rain and/or wind.
**Divergence** The expansion or spreading out of a horizontal wind field. Generally associated with high pressure and light winds.
**Emission** A release into the outdoor atmosphere of air contaminants.
**Emission Rate** The amount of smoke produced per unit of time (lb/min). Emission Rate = Available Fuel x Burning Rate x Emission Factor.
**Filling** An increase in the central pressure of a low. Counter-clockwise wind flow around the low usually decreases as filling occurs. See Deepening.
**Fine Particulate Matter** "Fine" particulates are those particles less than 10-15 microns in size. Fine particles have longer residence time in the atmosphere, are more harmful to health and have greater impact on visibility than larger particles. "Inhalable particulate" matter are those particles less than 10 microns in diameter. "Respirable particulate" matter are those particles less than 2.5 microns in size. Respirable particulates have an especially long residence time in the atmosphere and penetrate deeply into lungs. Particles from smoke are primarily in the respirable size range.
**Firing Technique** A method of igniting an area to consume the fuel in a prescribed pattern; e.g., heading or backing fire, spot fire, striphead fire, and ring fire.
**Fuel Loading** The amount of fuel present expressed quantitatively in terms of weight per unit area.
**Fuel Moisture Content** The quantity of moisture in fuel expressed as a percentage of the weight when thoroughly dried at 212 degrees F. **Fuel Type** an identifiable association of fuel elements of distinctive species, form, size, arrangement or other characteristics, that will cause a predictable rate of fire spread or difficulty of control, under specified weather conditions.
**Head Fire** A fire spreading with the wind or uphill. Flames tilt in the direction of the spread.
**Inversion** An increase of temperature with height in the atmosphere. Vertical motion in the atmosphere is inhibited allowing for pollution buildup. A "normal" atmosphere has temperature decreasing with height.

**Micron** A unit of measurement equal to 1/25,000 of an inch.
**Mixing Height** Measured from the surface upward, the height to which relatively vigorous mixing (random exchange of air parcels) due to convection occurs. Same as mixing depth. Use of this term normally implies presence of an inversion and the base of the inversion is the top of the mixed layer and defines the mixing height.
**Non-convective-lift Fire Phase**. The phase of a fire when most emissions are not entrained into a definite convective column.
**Particulate Matter** Any liquid or solid particles. "Total suspended particulates" as used in air quality are those particles suspended in or falling through the atmosphere. They generally range in size from 0.1 to 100 microns.
**Plume** The segment of the atmosphere occupied by the emissions from a single source or a grouping of sources close together. A convection column, if one exists, forms a specific part of the plume.
**Prescribed Burning** Controlled application of fire to wildland fuels in either their natural or modified state, under such conditions of weather, fuel moisture, soil moisture, etc., as allows the fire to be confined to a predetermined area and at the same time to produce the intensity and heat and rate of spread required to further certain planned objectives of silviculture wildlife habitat management, fire hazard reduction, etc.
**Pressure Gradient** The difference in atmospheric pressure between two points on a weather map. That is, the magnitude of pressure difference between two points at sea level, or at constant elevation above sea level. Wind speed is inversely related to pressure gradient. If distance between constant pressure lines is reduced by one-half, wind speed will be doubled. Conversely, if distance between lines is doubled, wind speed will be reduced by one-half.
**Residual Combustion Stage** The smoldering zone behind the zone of an advancing front.
**Residual Smoke** Smoke produced after the initial fire has passed through the fuel.
**Smoke Management** Conducting a prescribed fire under fuel moisture and meteorological conditions, and with firing techniques that keep the smoke's impact on the environment within acceptable levels.
**Smoldering Phase** The overall reaction rate of the fire has diminished to a point at which concentrations of combustible gases above the fuel is too low to support a persistent flame. The temperature drops and gases condense, the smoke produced is virtually soot-free, consisting mostly of tar droplets less than a micrometer in size.
**Stable Layer of Air** A layer of air having a temperature change (lapse rate) of less than dry adiabatic (approximately -5.4 degrees F per 1,000 feet) thereby retarding either upward or downward mixing of smoke.
**Surface High** (High, High Pressure System, High Pressure Ridge) An area on the earth's surface where atmospheric pressure is at a relative maximum. Winds blow clockwise around highs in the Northern Hemisphere but, due to friction with the earth's surface, tend to cross constant pressure lines away from the high center. Air is usually subsiding within a surface high. This causes warming due to air compression. This, in turn, results in stable atmospheric conditions and light surface winds.
**Surface Low** An area on the earth's surface where atmospheric pressure is at a relative minimum. Winds blow counter-clockwise around lows in the Northern Hemisphere but, due to friction with the earth's surface, tend to cross constant pressure lines toward the low center. Upon converging at the low center, air currents are forced to rise. As air rises, it cools due to expansion. Cooling reduces its capacity to hold moisture; so cloudiness and precipitation are

common in lows. If a low center intensifies sufficiently, it will take on the characteristics of a storm center with precipitation and strong winds.
**Transport Wind Speed** A measure of the average rate of the horizontal transport of air within the mixing layer. May also be the wind speed at the final height of plume rise. Generally refers to the rate at which emissions will be transported from one area to another.
**Ventilation Factor** Mixing Height in meters multiplied by Transport Wind speed in meters/sec.
**Warm Front** The leading edge of a relatively warm air mass which moves in such a way so that warm air displaces colder air. Winds associated with warm frontal activity are usually light and mixing is limited. The atmosphere is relatively stable when compared to cold front activity.
**Wind Shear** A variation in wind speed and or direction in a layer of the atmosphere or between layers. The variation may be in the horizontal or vertical and may result in significant turbulence depending upon the magnitude of the wind speed/direction differences. A strong wind shear may act like an inversion and inhibit plume rise. It may also fracture the smoke plume, not allowing smoke to rise much above terrain levels. A strong, horizontal anticyclonic shear results in downward motion and may bring smoke aloft to the surface.

## Synopsis of Forest Fire and Burning Laws

**10.1-1141 -- Civil Action - Liability for Escaped Fires** - If a person carelessly, negligently or Intentionally, without using reasonable care and precaution to prevent its escape, starts a fire on forest land, brushland or wasteland, he is liable for the costs of suppressing the fire.
**10.1-1142-A—Regulating the Burning of Woods, Brush, Etc**. - Owner to cut and pile material for safe burning, and take reasonable care to prevent its escape. Class 3 Misdemeanor.
**10.1-1142-B -- 4 PM Burning Law** - During the period February 15 through April 30, it shall be unlawful to burn before 4:00 p.m. within 300 feet of woodland, brushland or field containing dry grass, although the precautions have been taken. Class 3 Misdemeanor.
**10.1-1142-C—Unattended fire** - Unlawful to leave open-air fires burning within 150 feet of woodland, brushland or field containing dry grass or other inflammable material. Class 3 Misdemeanor.
**18.2-86 -- Arson** - If any person maliciously sets fire to any wood, fence, grass, straw or other thing capable of spreading fire on land shall be guilty of a Class 6 felony.
**18.2-87 -- Intentionally set fires** - Class 1 Misdemeanor and liability for suppression of fire if a person intentionally sets fire to brush, woods, etc., and if he intentionally allows the fire to escape to lands of another whereby the adjoining property is damaged or jeopardized.
**18.2-88 -- Carelessly set fires** - Class 4 Misdemeanor and liability for costs of suppression if a person carelessly or intentionally set fire whereby the property of another is jeopardized or damaged.
**10.1-1158** -- Prohibition of all open burning where serious fire hazards exist. - Governor may prohibit open burning due to extreme fire conditions. Class 3 Misdemeanor.

**9 VAC 5-40-5630 (9a)** -- Burning shall be at least 1,000 feet from any occupied building, unless occupants have given prior permission.

**9 VAC 5-40-5630 (9b)** -- The burning shall be attended at all times.

*Note: For complete information on the Fire Laws of Virginia, refer to the Code of Virginia or "Virginia's Forest Fire Laws," Department of Forestry, Publication No. 2, Revised 1996. For complete information on the Regulations for the Control and Abatement of Air Pollution, contact the State Air Pollution Control Board.

## Literature Cited

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A publication of the National Wildfire Coordinating Group
Produced by: Prescribed Fire and Fire Effects Working Team
PMS 420-2, NFES 1279

Health Hazards of Smoke, 1984
Written by: P.A.Breyssee

Fire Weather, 1970
USDA Forest Service Agricultural Handbook 360
M.J.Shroeder and C.C.Buck

Southern Forestry Smoke Management Guidebook, 1976
USDA Forest Service General Technical Report SE-10
Produced by: Southern Forest Fire Laboratory Staff

A Guide to Wildland Fuels Smoke Management, 1981, 1989
Virginia Department of Forestry
Prepared by: Roland B. Geddes, 1981
Revised by: Don T. Morton, 1989

Smoke Management Guide for Prescribed Burning in the Southeast, 1990
Hugh E. Mobley, Forestry Consultant
Montgomery, Alabama

A Drought Index For Forest Fire Control,
Keetch, John J., Byram, George M.
Southeastern Forest Experiment Station
USDA Research Paper SE-38

References / Bibliography

Albibi, Frank A.  1976. Estimating Wildfire Behavior and Effects. USDA Forest Service. General Technical Report INT-30. Intermountain, Forest And Range Experiment Station, Ogden, Utah

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FireWeb www.pfmt.org/fire

Hanby, Kent. 2003. Smoke Management Guidelines for Prescribed Burning in Alabama. Alabama Forestry Commission

Hardy, Colin C, & Bill Leenhouts. 2001. Introduction. In Smoke Management Guide for Prescribed and Wildland Fire, 2001 Edition. National Wildfire Coordination Group. PMS 420-2/ NFES 1279

Helms, John A. 1998. The Dictionary of Forestry. The Society of American Foresters

Leuschen, Tom, Dale Wade, & Paula Seamon. 2001. Fire Use Planning. in Smoke Management Guide for Prescribed and Wildland Fire, 2001 Edition. National Wildfire Coordination Group. PMS 420-2/NFES 1279

Mobley, Hugh E. et al. 1990 (Revised 1996). Smoke Management Guidelines for Prescribed Burning in the Southeast. NFES 2108

National Interagency Fire Center. 1993. NWCG Fireline Handbook, Appendix B Fire Behavior. NFES 2165

National Wildfire Coordination Group. 1994. Smoke Management Techniques, RX-450 Instructor's Guide. NFES 2475

National Wildfire Coordination Group. 2001. Smoke Management Guide for Prescribed and Wildland Fire, 2001 Edition. PMS 420-2/NFES 1279

National Wildfire Coordination Group. 2002. Prescribed Fire Complexity Rating System Guide, PMS 424, available online at http://www.nwcg.gov/pms/RxFire/rxfire.htm

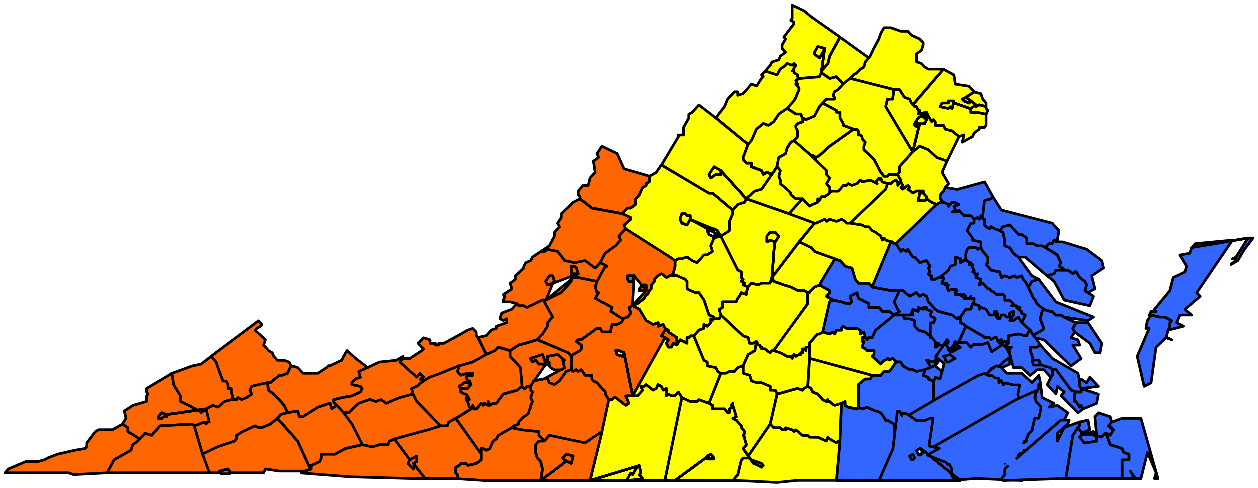
Ottmar, Roger D., Janice L. Peterson, Bill Leenhouts, and John E. Core. 2001. Smoke Management: Techniques to Reduce or Redistribute Emissions. In Smoke Management Guide for Prescribed and Wildland Fire, 2001 Edition. National Wildfire Coordination Group. PMS 420-2/NFES 1279

Pyne, Stephen J. 1997. Fire in America: A Cultural History of Wildland and Rural Fire (Weyerhaeuser Environmental Book)

Wade, Dale D. et al. 1988. A Guide for Prescribed Fire in Southern Forests. NFES 2108

# Directory of Department of Forestry Offices

New Regional Boundaries as of 10/01/2008



**Eastern / Coastal Region**

**Regional Office Tappahannock**
623 Lewis Street
Tappahannock, Virginia 22560-0759
Phone: 804.443.2211
Fax: 804.443.3164

**Waverly Office**
135 Bank Street
Waverly, Virginia 23890-0198
Phone: 804.834.2300
Fax: 804.834.3232

**Central / Piedmont Region**

**Regional Office Charlottesville**
470 George Dean Drive
Charlottesville, Virginia 22903
Phone: 434.977.5193
Fax: 434.296.3290

**Farmville Office**
717 East 3rd Street
Farmville, Virginia 23901-1605
Phone: 434.392.4159
Fax: 434.392.1550

**Western / Mountain Region**

**Regional Office Salem**
210 Riverland Drive
Salem, Virginia 24153-0100
Phone: 540.387.5461
Fax: 540.387.5445

**Abingdon Office**
1240 West Main Street
Abingdon, Virginia 24212
Phone: 276.676.5488
Fax: 276.676.5581

## Directory of Department of Environmental Quality Regional Offices

Toll Free 1-800-592-5482
Richmond (804) 527-5020
Woodbridge (703) 490-8922
Abingdon (540) 676-4800
Tidewater (804) 552-1840
Bridgewater (540) 828-2595
Roanoke (540) 562-3666

## Prescribed Burn “Watch Out” Situations

IF ANY OF THE FOLLOWING CONDITIONS EXIST, ANALYZE FURTHER BEFORE BURNING:

- ❑ No written plan
- ❑ No map
- ❑ No safety/planning briefing
- ❑ Heavy fuels
- ❑ Dry duff and soil
- ❑ Extended drought
- ❑ Inadequate control lines
- ❑ No updated weather forecast
- ❑ Forecast does not agree with prescription
- ❑ Forecast does not agree with on site conditions
- ❑ Poor visibility
- ❑ Personnel and equipment stretched thin
- ❑ Burning a large area with hand crews
- ❑ Communications not available for all crew
- ❑ No backup plan or forces
- ❑ Notifications not made
- ❑ Behavior of test fire not as prescribed
- ❑ A smoke-management system has not been used
- ❑ Smoke-sensitive area downwind or down drainage
- ❑ Organic soil present
- ❑ Daytime Dispersion Index below 40
- ❑ Not enough personnel or equipment available to control an escaped fire
- ❑ Personnel on fire not qualified
- ❑ Area contains windrows
- ❑ A lot of dirt in piles
- ❑ Poor nighttime smoke dispersion forecast

❑ Have not looked down drainage

❑ Mixing Height is below 1,650 feet (500 meters)

❑ Debris was piled when wet

❑ Pile exteriors are wet

IF ANY OF THE FOLLOWING CONDITIONS EXIST, STOP BURNING AND PLOW OUT EXISTING FIRE:

❑ Fire behavior erratic

❑ Spot fire or slop-over occurs and is difficult to control

❑ Wind shifting or other unforeseen change in weather

❑ Smoke not dispersing as predicted

❑ Public road or other sensitive are smoked in

❑ Burn does not comply with all laws, regulations and standards

❑ Large fuels igniting and burning; not enough personnel to mop-up before dark, and likely to smoke in a smoke sensitive area

## Web Sites of Interest

There are numerous Web sites with information that those interested in prescribed burning would find useful:

http://www.nv.blm.gov/fuels/1000_sampling.htm
http://www.cis-online.co.za/tables/rh_tables.htm
http://www.cpc.ncep.noaa.gov/products/expert_assessment/drought_assessment.html
http://www.crh.noaa.gov/pub/metcon.shtml
http://www.fs.fed.us/
http://www.erh.noaa.gov/okx/fuelmoist.html
http://www.rce.rutgers.edu/pubs/pdfs/fs403.pdf
http://www.nationalfiretraining.net/sa/
http://fire.r9.fws.gov/pftc/default.htm
http://www.srh.noaa.gov/data/forecasts/ALZ047.php?warncounty=ALC081&city=Auburn
http://www.noaa.gov/
http://www.drought.noaa.gov/palmer.html
http://www.fs.fed.us/land/wfas/kbdi.gif
http://www.nwcg.gov/
http://www.nwcg.gov/pms/pubs/SMG-72.pdf
http://www.nwcg.gov/pms/pubs/catalog/catalog2004.pdf
http://www.usfa.fema.gov/fire-service/nfa/nfa.shtm
http://www.nationalfiretraining.net/ea/
http://www.fs.fed.us/land/wfas/map_list.html
http://firehogs.com/
http://www.fs.fed.us/fire/links/links_firephotos.html
http://www.forestry.state.al.us/
http://forestry.state.al.us/Weather.htm
http://fire.boi.noaa.gov/FIREWX/BHMFWFMOB.html
http://www.ice.ucdavis.edu/afe/
http://weather.gfc.state.ga.us/PointForecast/help.pdf
http://weather.gfc.state.ga.us/
http://www.gfc.state.ga.us/
http://lists1.safesecureweb.com/mailman/listinfo/firenet
http://www.fs.fed.us/fire/planning/nist/firestat.htm
http://flame.fl-dof.com/fire_weather/info/adi/
http://www.icess.ucsb.edu/resac/nffl_1_desc.html
http://www.interfacesouth.org/swuinet.html
http://jfsp.nifc.gov/
http://www.tncfire.org/
http://www.fs.fed.us/fire/fmt/
http://www.fs.fed.us/land/wfas/experment.htm
http://www.fs.fed.us/land/wfas/nfdr_map.htm
http://www.fs.fed.us/pnw/fera/
http://www.firewise.org/error/404.html
http://www.iawfonline.org/

http://www.rxfire.com/
http://www.nwcg.gov/pms/RxFire/rxfire.htm
http://www.wildfirenews.com/archive/082202.html
http://www.firehouseinternational.com/usersite/fire/fireproduct.asp?categoryid=2242&productid=4520&page=1
http://www.fire.org/
http://drought.unl.edu/dm/monitor.html

## Commonwealth of Virginia State Air Pollution Control Board Regulations for the Control and Abatement of Air Pollution

9 VAC 5 CHAPTER 40.
EXISTING STATIONARY SOURCES.

PART II.
Emission Standards.

ARTICLE 40.
Emission Standards For Open Burning (Rule 4-40).


9 VAC 5-40-5600. Applicability.

A. Except as provided in subsection C of this section, the provisions of this article apply to any person who permits or engages in open burning or who permits or engages in burning using special incineration devices.
B. The provisions of this article apply throughout the Commonwealth of Virginia.
C. The provisions of this article do not apply to such an extent as to prohibit the burning of leaves by persons on property where they reside if the local governing body of the county, city or town in which such persons reside has enacted an otherwise valid ordinance (under the provisions of _ 10.1-1308 of the Virginia Air Pollution Control Law) regulating such burning in all or any part of the locality.

Definitions

"Open burning" means the burning of any matter in such a manner that the products resulting from combustion are emitted directly into the atmosphere without passing through a stack, duct or chimney.

9 VAC 5-40-5620. Open burning prohibitions.

A. No owner or other person shall cause or permit open burning of refuse or use of special incineration devices except as provided in 9 VAC 5-40-5630.

B. No owner or other person shall cause or permit open burning or the use of a special incineration device for disposal of rubber tires, asphaltic materials, crankcase oil, impregnated wood or other rubber or petroleum-based materials except when conducting bona fide firefighting instruction at firefighting training schools having permanent facilities.
C. No owner or other person shall cause or permit open burning or the use of a special incineration device for disposal of hazardous waste or containers for such materials.
D. No owner or other person shall cause or permit open burning or the use of a special incineration device for the purpose of a salvage operation or for the disposal of commercial/industrial waste.
E. Open burning or the use of special incineration devices permitted under the provisions of this article does not exempt or excuse any owner or other person from the consequences, liability, damages or injuries which may result from such conduct; nor does it excuse or exempt any owner or other person from complying with other applicable laws, ordinances, regulations and orders of the governmental entities having jurisdiction, even though the open burning is conducted in compliance with this article. In this regard, special attention should be directed to 10.1-1142 of the Code of Virginia, which is enforced by the Department of Forestry.
F. With regard to the provisions of subsection E of this section, special attention should also be directed to the regulations of the Virginia Waste Management Board. No disposal of waste by open burning or transportation of waste to be disposed of by open burning shall take place in violation of the regulations of the Virginia Waste Management Board.
G. Upon declaration of an alert, warning or emergency stage of an air pollution episode as described in 9 VAC 5 Chapter 70 (9 VAC 5-70-10 et seq.) or when deemed advisable by the board to prevent a hazard to, or an unreasonable burden upon, public health or welfare, no owner or other person shall cause or permit open burning or use of a special incineration device; and any in-process burning or use of special incineration devices shall be immediately terminated in the designated air quality control region.

9 VAC 5-40-5630. Permissible open burning.
Open burning or the use of special incineration devices is permitted in the following instances provided the provisions of subsections B through G of 9 VAC 5-40-5620 are met:

9. Open burning is permitted for forest management and agriculture practices approved by the board (see 9 VAC 5-40-5631), provided the following conditions are met:
a. The burning shall be at least 1,000 feet from any occupied building unless the occupants have given prior permission, other than a building located on the property on which the burning is conducted and
b. The burning shall be attended at all times.

9 VAC 5-40-5631. Forest management and agricultural practices.

A. Open burning is permitted in accordance with subsections B and C of this section provided the provisions of subsections B through G of 9 VAC 5-40-5620 are met.

B. Open burning may be used for the following forest management practices provided the burning is conducted in accordance with the Department of Forestry's smoke management plan:

1. To reduce forest fuels and minimize the effect of wildfires.
2. To control undesirable growth of hardwoods.
3. To control disease in pine seedlings.
4. To prepare forest land for planting or seeding.
5. To create a favorable habitat for certain species.
6. To remove dead vegetation for the maintenance of railroad, highway and public utility right-of-way.

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF ENVIRONMENTAL QUALITY
APPLICABILITY FACT SHEET
SEASONAL RESTRICTIONS ON OPEN BURNING

Seasonal restrictions on open burning are contained in Article 40 [Emission Standards for Open Burning (Rule 4-40)] of Part II of 9 VAC 5 Chapter 40, specifically 9 VAC 5-40-5630.

LATEST CHANGES

On June 21, 2006, the State Air Pollution Control Board adopted revisions to the open burning rule. These changes were published in the Virginia Register on Sept. 18, 2006 (23 VAR 28) with an effective date of Oct. 18, 2006.

The changes expanded the seasonal restriction:

From three months to five (May, June, July, August and September.

Into new localities (see highlighted in the list below) in the emissions control areas.

To prohibit the use of special incineration devices. A special incineration device is a pit incinerator, conical or teepee burner, or any other device specifically designed to provide good combustion performance.

**EMISSIONS CONTROL AREAS**

**Northern Virginia Emissions Control Areas:** Arlington County, Fairfax County, Loudoun County, Prince William County, Stafford County, Alexandria City, Fairfax City, Falls Church City, Manassas City and Manassas Park City.

**Hampton Roads Emissions Control Areas:** Gloucester County, Isle of Wight County, James City County, York County, Chesapeake City, Hampton City, Newport News City, Norfolk City, Poquoson City, Portsmouth City, Suffolk City, Virginia Beach City and Williamsburg City.

**Richmond Emissions Control Areas:** Charles City County, Chesterfield County, Hanover County, Henrico County, Prince George County, Colonial Heights City, Hopewell City, Petersburg City and Richmond City.

**Western Virginia Emissions Control Areas:** Botetourt County, Frederick County, Roanoke County, Roanoke City, Salem City and Winchester City.

**Fredericksburg Emissions Control Areas:** Spotsylvania County and Fredericksburg City.

SUMMARY OF REQUIREMENTS

Article 40 restricts the use of open burning to destroy certain waste products during the months of May, June, July, August, and September in certain emissions control areas (see list above).

The seasonal restrictions apply to the open burning of waste for the:

Destruction of clean-burning waste and debris waste resulting from property maintenance, from the development or modification of roads and highways, parking areas, railroad tracks, pipelines, power and communication lines, buildings or building areas, sanitary landfills, or from any other clearing operations.

Destruction of clean-burning waste and debris waste on the site of local landfills.

The seasonal restrictions do not apply to certain open burning activities; however, these activities have their own conditions and restrictions (consult the regulations for the specifics). These include the open burning of waste for the:

- Elimination of a hazard, which constitutes a threat to the public health, safety or welfare.
- Training and instruction of government and public firefighters. This includes the burning of buildings that have not been demolished.
- Destruction of classified military documents.
- Use of camp fires or other fires that are solely for recreational purposes, for ceremonial occasions, for outdoor noncommercial preparation of food, and for warming of outdoor workers.
- Disposal of leaves and tree, yard and garden trimmings located on the premises of private property.
- Disposal of household refuse by homeowners or tenants.
- Destruction of any combustible liquid or gaseous material (including hazardous waste or commercial/industrial waste) by burning in a flare or flare stack.
- Disposal according to forest management and agriculture practices.

Air quality information from DEQ monitors is unofficial until quality-assured by the DEQ Office of Air Monitoring.

**About the Air Quality Index**

The Air Quality Index is a measurement of air quality that is calculated from ozone and fine particle pollution measurements over the past few hours. A higher AQI indicates a higher level of air pollution, and consequently, a greater potential for health problems.

| Level | Color | Description |
|---|---|---|
| ** | White | Air quality information is unavailable. |
| 0-50 | Green | Good air quality. Little or no health risk. |
| 51-100 | Yellow | Moderate air quality. People who are unusually sensitive to air pollution may be mildly affected. |
| 101-150 | Orange | Unhealthy for sensitive groups. These groups may experience health problems due to air pollution. |
| 151-200 | Red | Unhealthy. The general public may experience mild health effects. Sensitive groups may have more serious health problems. |
| 201-300 | Purple | Very unhealthy. Everyone is susceptible to more serious health problems. |

**More information from EPA**

**About air quality**

DEQ monitors levels of ozone and particle pollution from stations around Virginia. Both of these are pollutants that, at high levels, may raise health concerns in some people.

Ground-level ozone is the main ingredient in smog. It is a colorless gas formed by the reaction of sunlight with vehicle emissions, gasoline fumes, solvent vapors, and power plant and industrial emissions. Ozone formation is most likely in hot, dry weather when the air is fairly still.

Particle pollution monitoring is now available on the web for select areas in Virginia. Particle pollution is made up of particles found in soot, dust, smoke, and fumes. The burning of coal, oil, diesel and other fuels produces these particles. The particles are small enough to enter deep into the lungs and cause health problems.

Ozone and particle pollution have been linked to short-term health concerns, particularly among children, asthmatics, people with heart or lung disease, and older adults. The effects of these pollutants can be minimized by avoiding strenuous activity or exercise when levels are high. You can use the forecast for the following day to plan your activities during the summer months.

More information on the health effects of air pollutants is available from AirNow.

**What can I do?**

Be aware. Keep an eye on the pollutant levels and forecasts for your area.

When levels are high, stay inside if you can. Avoid strenuous outdoor activity.

Help keep pollutant levels low by avoiding unnecessary fuel consumption. Use carpools and fuel-efficient vehicles.

Avoid the use of any other gasoline engines, such as mowers and other lawn equipment, or boat motors.

Save power by turning off lights and appliances when they are not needed.

Avoid burning yard debris or brush on code orange or above days.

# Exemption to the 4 PM Law Application

Form 180
02/14/2008

## VIRGINIA DEPARTMENT OF FORESTRY
## APPLICATION FOR EXEMPTION TO THE 4PM BURNING LAW §10.1-1142B

Applicant Name: ____________________

Organization: ____________________

Mailing Address: ____________________

____________________

Phone Number: ____________________ Fax Number: ____________________

E-mail Address: ____________________

County of Proposed Burn: ____________________

Purpose of Proposed Burn (please be brief but specific as to the target species and type of burn):

____________________

____________________

____________________

Reason for Exemption Request (briefly explain why the burn needs to be accomplished during exemption period):

____________________

____________________

____________________

Virginia Certified Prescribed Burn Manager Name: ____________________ Cert. Number: ____________________

Applicant must attach a copy of the Burn Plan to include the Smoke Management Plan and Location Map. The Burn Plan must be specific for the area to be burned under this application. This application will be reviewed and evaluated for approval. A copy of the processed application will be returned via US mail or fax.

If approved, this exemption is only good for the Certified Prescribed Burn Manager identified on this application and is only valid through the last day of February following the date the exemption is approved. On the day of the prescribed burn, I agree to call the Regional Office of the Virginia Department of Forestry prior to the start of the burn.

I agree to the conditions under which this application is approved and agree that no alteration will be made to the proposed plan once approved for exemption. I understand that I am responsible for the burn, liable to laws pertaining to escaped fires and all parts of §10.1-1105 of the *Code of Virginia*.

____________________ APPLICANT NAME (print) ____________________ APPLICANT SIGNATURE ____________________ DATE

Attach a copy of the Burn Plan including Smoke Management Plan and Location Map.

**Applications must be received prior to February 1.**

Send application to: State Forester, Virginia Department of Forestry, 900 Natural Resources Drive, Suite 800, Charlottesville, Virginia 22903

**Department of Forestry Use Only – Application Review and Evaluation**

Date Application Received: ____________________ Attached: ☐ Burn Plan ☐ Smoke Management Plan ☐ Location Map

☐ Approved Exemption No.: ____________________ ☐ Check Here if You Provided Attachments Electronically

☐ Denied Comments: ____________________

Reviewed By: ____________________ NAME (print) ____________________ SIGNATURE ____________________ DATE

# Sample Burn Management Plan

Form 69
09/15/2006

## VIRGINIA DEPARTMENT OF FORESTRY
## PRESCRIBED BURN MANAGEMENT PLAN

page 1

### I. Location and Identification

Landowner Information

Name: ____________________ Phone Number: __________

Address: ____________________

Tract Information

County: __________ Coordinates: __________

Location: ____________________

Acres: ______ Tract #: ______ Parcel: ______ Map Attached: ☐Yes ☐No

Reason for the burn: ☐ Site Prep ☐Fuel Reduction ☐Wildlife

### II. Weather

Prescription Conditions

| | | | |
|---|---|---|---|
| A. Surface Wind | ______ Direction ______ MPH | D. Relative Humidity (%) | ______ |
| B. Transport Wind | ______ Direction | E. Temperature | ______ |
| C. Mixing Height (meters) | ______ | F. Cumulative Severity Index | ______ |

Burn Day

| | Forecast | | On Site | |
|---|---|---|---|---|
| | **Day** | **Night** | **Prior** | **At Conclusion** |
| A. Surface Wind | ______ Direction ______ MPH | ______ Direction ______ MPH | ______ Direction ______ MPH | ______ Direction ______ MPH |
| B. Transport Wind | ______ Direction ______ MPH | ______ Direction ______ MPH | | |
| C. Mixing Height (meters) | ______ | ______ | | |
| D. Relative Humidity (%) | ______ | ______ | ______ | ______ |
| E. Temperature | ______ | ______ | ______ | ______ |
| F. Cumulative Severity Index | ______ | | | |

No burning when CSI is at or above 500 during the growing season or when CSI is at or above 300 during the dormant season.

### III. Objectives of the Burn

____________________

____________________

____________________

# VIRGINIA DEPARTMENT OF FORESTRY
# PRESCRIBED BURN MANAGEMENT PLAN



## IV. Screening for Smoke Sensitive Targets

Use double 30 degree template. Attach map.

A. None within 20 miles: Proceed with burn, follow recommendations to reduce smoke impact for all forestry burns. (located in VA Smoke Management Guide)

B. Target(s) within 10 to 20 miles: The following minimum conditions must be met, and the above mentioned recommendations should also be followed.

Mixing Height: 500 meters (1,640 ft.)

Ventilation Factor of 2,000
[Mixing Height (meters) X Transport Wind Speed (meters/sec)]

C. Target(s) within 10 miles:

**SPECIAL CAUTION IS NECESSARY**

All of the conditions in A and B above must be met and the following should be considered. The distance to the target, nature of the target, size of the burn, amount and nature of the fuel, fuel moisture, topography, and presence of organic soil. These factors along with the meteorological conditions all combine to determine the quantity and duration of the smoke produced.

**An alternative to burning may need to be prescribed unless conditions change allowing the potential target(s) to not be impacted by the smoke from your burn.**

## V. Other Considerations

A. Department of Forestry Regional office notified, as well as county fire department dispatcher.

B. Home owners within 1,000 feet. (Permission required through the Emission Standards for Open Burning according to the State Air Pollution Control Board.)

C. Local Ordinances and the Forest Fire Laws of Virginia.

D. Keep fires out of large piles of debris and sawdust piles which may produce smoke for extended periods of time. It is DOF policy not to burn bulldozed piled debris as a site preparation method.

E. If smoke does cross a road you need to place a flag person at both ends with radio communications.

F. Burn to be completed 1 hour prior to sunset.

G. What are the fuel conditions and characteristics? ______________________________

______________________________________________________________

______________________________________________________________

## VI. Burning Plan / Strategy

A. Equipment On Site

| | Recommended | Actual |
|---|---|---|
| Number of tractor / fire plow units | ________ | ________ |
| Number of pickups | ________ | ________ |
| Additional water supply | ________ | ________ |
| Burn trailer | ________ | ________ |
| Number of hand carried radios | ________ | ________ |

Other, specify ______________________________________________

______________________________________________

# VIRGINIA DEPARTMENT OF FORESTRY
# PRESCRIBED BURN MANAGEMENT PLAN



B. Personnel On Site — Recommended — Actual

| | Recommended | Actual |
|---|---|---|
| Number of DOF employees | ____________ | ____________ |
| Number of non-DOF employees | ____________ | ____________ |

Landowner(s) list ____________________________________________

Other, specify ____________________________________________

C. Ignition Pattern (starting point shown on map) ______________________________

____________________________________________

____________________________________________

____________________________________________

____________________________________________

D. Ignition Method ☐ Drip Torch ☐ Aerial ☐ Other ____________

E. Special Fire Control and Smoke Considerations ______________________________

____________________________________________

____________________________________________

____________________________________________

____________________________________________

E. Planned Mop-up Activities ______________________________

____________________________________________

____________________________________________

____________________________________________

____________________________________________

**<u>Prepared By</u>**

____________________ PRINT NAME

____________________ SIGNATURE

____________ DATE

____________________ CERTIFICATION NUMBER

____________________ PHONE NUMBER

# VIRGINIA DEPARTMENT OF FORESTRY
# PRESCRIBED BURN MANAGEMENT PLAN



## EVALUATION IMMEDIATELY AFTER THE BURN

**Evaluation By** ______________________ ______________________
PRINT NAME SIGNATURE

1. Acres Burned ____________
2. Spotting ____________ Distance (comments) ______________________
3. Any Escapes ______________________
4. Objectives Met ______________________
5. Smoke Problems ______________________
6. % Understory Vegetation Consumed ☐ < 25% ☐ 26-50% ☐ 51-75% ☐ >75%
7. % Material > 3" Diameter Consumed ☐ < 25% ☐ 26-50% ☐ 51-75% ☐ >75%
8. % Of Area With Crown Discoloration ☐ < 25% ☐ 26-50% ☐ 51-75% ☐ >75%
9. Live Crown Consumption ______________________
10. Adverse Publicity ______________________
11. Remarks ______________________

______________________

## FUTURE EVALUATION

**Evaluation By** ______________________ ______________________ ____________
PRINT NAME SIGNATURE DATE

1. Insect / Disease Damage ______________________

______________________

2. Tree Mortality ______________________
3. % Understory Kill ☐ < 25% ☐ 26-50% ☐ 51-75% ☐ >75%
4. Soil Movement ______________________
5. Other Remarks ______________________

______________________

______________________

______________________

______________________

______________________