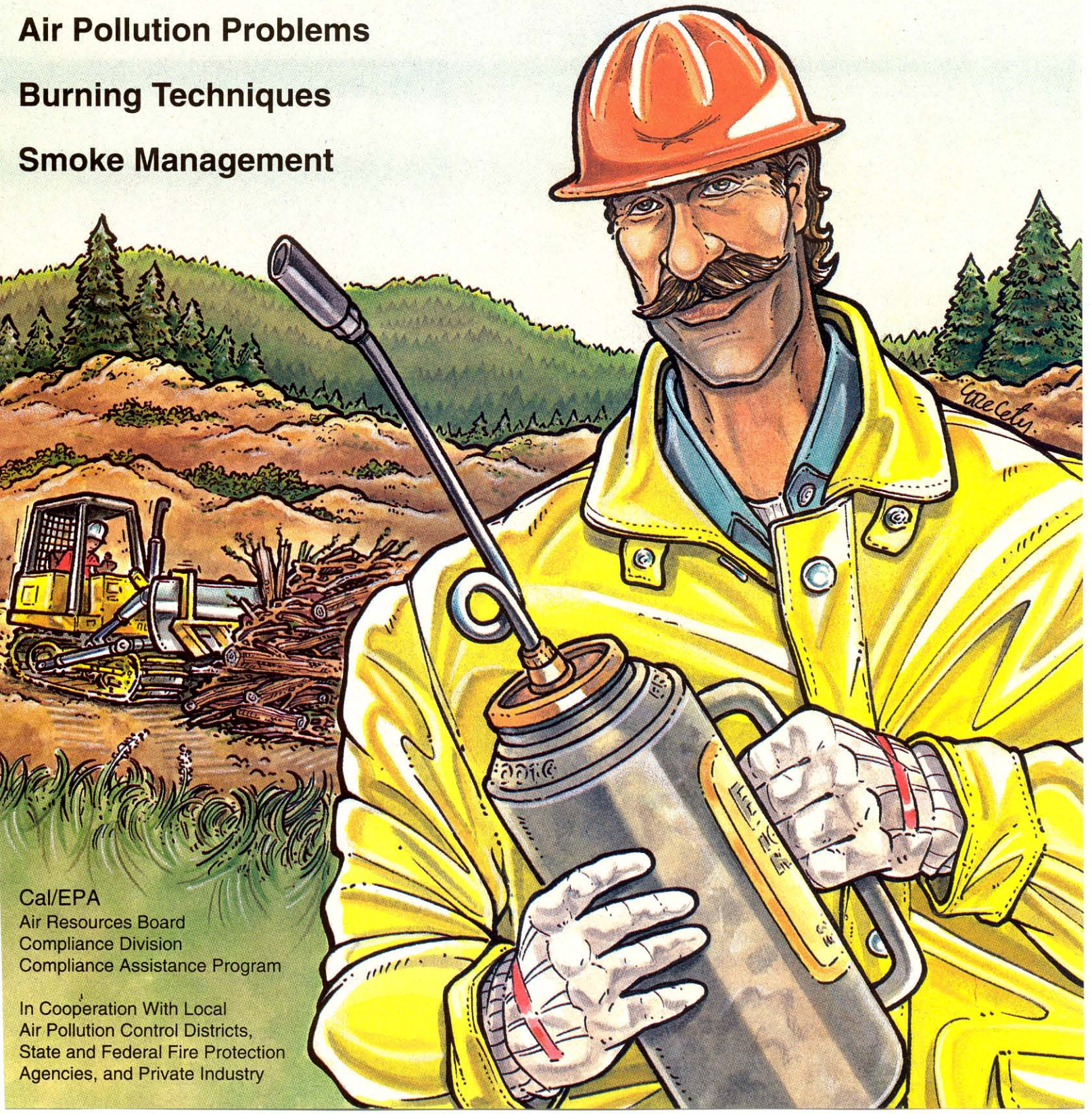
Forest Management Burning Handbook

Air Pollution Problems

Burning Techniques

Smoke Management



Cal/EPA
Air Resources Board
Compliance Division
Compliance Assistance Program

In Cooperation With Local Air Pollution Control Districts, State and Federal Fire Protection Agencies, and Private Industry

Burning Can Be A Smoky Business...

Fire is a natural, valuable tool in forest management. Controlled open burning in forest management is used to clear logged areas for planting, abate fire hazards, control disease and unwanted vegetation, and improve wildlife habitat. **But Open Burning Produces Smoke,** which, if not carefully managed, is a nuisance to neighbors and can impact public health. Smoke can also reduce visibility on roadways and cause deadly traffic accidents.

This handbook is designed mainly for the small private landowner or contractor burning forest debris. The Compliance Assistance Program at the California Air Resources Board and your local air pollution control district are asking for **your help** to reduce air pollution. This handbook can help you learn about the pollutants in smoke, **know the laws,** and understand how to burn your forest debris with less smoke. Fill in the Burn Checklist on page 14 and keep it handy for easy reference. **You can** make a difference!

What IS Smoke? It's AIR POLLUTION !

It's A Mixture of Particulate Matter (PM10) and Gases.

Smoke contains carbon dioxide, water vapor and products of incomplete combustion. **The pollutant of concern is "inhalable" particulate matter, PM10,** ten microns in diameter or smaller. **Most smoke particles are VERY small droplets of condensed organic vapors (wood tars and gases)**, unburned fuel which escaped the fire. **Over 90% are smaller than one micron** (one millionth of a meter), light enough to stay airborne for weeks, and to travel easily deep into the lungs, causing irritation and coughing. Smoke particles may be trapped in your lungs for years, contributing to lung changes, chronic lung diseases, and cancer.

Carbon monoxide (CO) is the most abundant pollutant emitted by open burning. Dilution usually occurs rapidly enough to reduce its health hazards. Other pollutant gases include nitrogen dioxide (NO_2) and volatile organic compounds (VOCs, some toxic, see below).

Smoke Contains Toxic Pollutants

Smoke from open burning also contains VOCs which have been changed in the fire into **irritating, toxic and/or cancer-causing substances such as benzene, formaldehyde and benzo-a-pyrene, a polycyclic aromatic hydrocarbon (PAH).** VOCs are concentrated in the tar droplet PM10 particles and also adhere to the surface of soot (unburned carbon) particles.

Why Reduce Air Pollution?

Air pollution affects millions of Californians every day. It damages our health, our crops, our property and our environment. Vehicles and industries produce most of the air pollution in the cities. The chief sources of air pollution emitted in most rural areas are **fugitive dust, residential wood combustion and open burning.**

Ambient Air Quality Standards Violated

Both the federal government and the State of California have established **ambient air quality standards, health-protecting** maximum outdoor concentrations of air pollutants. California's geography, weather, and growing population combine to make our air quality **exceed the standards for PM10, ozone, and carbon monoxide**, frequently in many areas. This means people are subjected to **breathing unhealthful air**.

Every year, every air basin in the State but one exceeds the California 24-hour PM10 ambient air quality standard of **50 $\mu g/m^3$**. **Five air basins also fail to attain the federal 24-hour PM10 standard of 150 $\mu g/m^3$**, their areas totaling more than one-third of the State. Both the Federal and the California Clean Air Acts will be requiring the air districts in these "nonattainment" areas to take action to reduce the current PM10 levels and to stop exceeding the ambient air quality standards (AAQS) for PM10.

Is Forest Management Burning the Culprit?

In most cases forest management burning, when properly conducted, is only the most **obvious** source of air pollution in an area, not the primary source. At some times of the year, however, it is a significant **contributing** source. It takes just one smoky day to cause your area to violate the federal and/or State PM10 ambient air quality standards.

Why Do People Complain?

Odor and reduced visibility are the two chief complaints that people have about air pollution. Smoke from forest debris burning is a high-profile source of both of these complaints. If smoke from your burn intrudes into populated areas, then add the health-related problems caused by inhaling smoke particles to these annoyances.

Because Smoke is Air Pollution....

Forest Management Burning is Regulated Under Agricultural Burning by the California Health & Safety Code and by the Agricultural Burning Guidelines in Title 17 of the California Code of Regulations. Each local air pollution control (air) district has adopted State-required rules for forest burning which help minimize the smoke produced and its impact on air quality. Air districts have primary authority and fire agencies designated authority to issue agricultural burning permits and to enforce State and local air rules.

You Need A Permit (Maybe Two) To Burn

State law **requires** the regulation of all agricultural burning. The Air Resources Board (ARB) declares a Permissive Burn Day when expected weather conditions will provide enough ventilation to disperse the added burden of smoke pollutants. Your Agricultural Burn Permit is valid **only on Permissive Burn days**. Find out if you need a fire protection agency Burn Permit as well. Your air and fire agencies want you to realize that:

- **You must know** the air pollution and fire protection rules **before** you can burn.
- **You have the responsibility** to control your burn and manage your smoke carefully.
- **The fire you are lighting** could become a significant **air pollution nuisance** and/or **a wildfire,** unless you follow the rules and use your common sense.

72-Hour Advance Outlook and 48-Hour Decision

If you must commit a lot of people and equipment to conduct a forest burn below 6000 feet elevation and need to plan ahead, contact the Meteorology Section of the ARB **through your permitting agency** to request an early burn or no-burn day decision.

Up to 72 hours prior to the scheduled burn date, ARB Meteorology will issue an advance outlook and, up to 48 hours prior, a permissive burn or no-burn day decision, based on information you provide about your burn. Without further requests, you will receive an advance notice daily until a permissive burn notice is issued and the burn is completed.

Be aware that any permissive burn decision issued more than 24 hours in advance may be cancelled by the ARB, the air district or by the permitting fire agency, if it becomes necessary to maintain suitable air quality or reduce the risk of wildfire.

When Can You Burn?

On Permissive Burn Days - ARB meteorologists have determined that weather conditions will allow the smoke to rise up and disperse. **Caution:** Get authorization to burn from your local air district; air quality in your immediate area may be poor or other burns may already be scheduled.

NOTE: Your fire agency may declare this a **No-Burn Day** if windy conditions are creating an extreme risk of wildfire.

Not on No-Burn Days - meteorologists have determined that the air will be **stagnant** over a large area, with little movement or ventilation, and it's probably already loaded with pollutants. Smoke will **not** disperse well at all.

To Burn on a No-burn Day, you must apply for a special permit **and** show your air officer that "imminent and substantial economic loss" will result from your **not** being able to burn **TODAY**. Check with your air district office; some districts prohibit such burning.

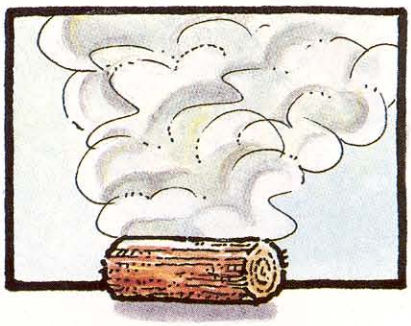
Burn Hours - some air districts and/or fire agencies limit the hours available to start a burn or to add more fuel to an existing fire. Some may stagger ignition times to minimize smoke buildup. You may be required to mop up any residual smoke sources by a specific time. Ask your permitting agency or check your permit(s).

Is Today a Permissive Burn Day?

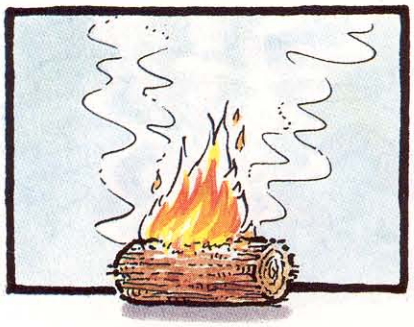
Check with your air district or fire control agency. There may be a local toll-free phone number to call, or a radio station that broadcasts that information at regular times during the day. The phone number may be printed on your burn permit(s).

Stages of Burning and Smoke Production

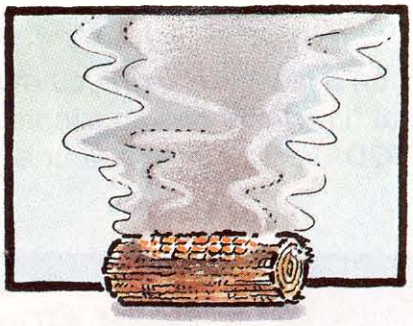
Each piece of fuel goes through the following four stages to burn. **Some stages of burning emit more smoke than others.**



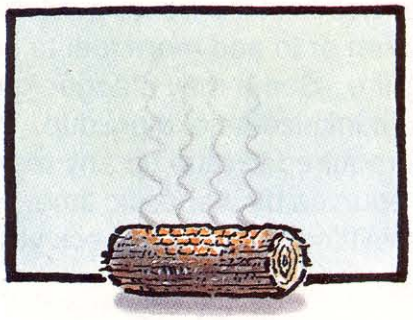
1. Pre-ignition - Smoky - Fuel pieces heat, water vapor moves to the surface and escapes. Pyrolysis (chemical decomposition) begins as fuel temperature rises and VOCs vaporize; steam and the unburned flammable VOCs from pyrolysis stream out of the fuel and condense into smoke.



2. Flaming - Less Smoky - Fuel temperatures rise rapidly, accelerating pyrolysis. The hot flammable VOCs mix with oxygen and ignite, burning (oxidizing) them. Heat, CO_2 and water vapor are emitted, along with some PM10 tar droplets and soot particles (smoke).



3. Smoldering - Very Smoky - VOC production and temperature drop, causing flames to go out. Flammable VOCs continue to stream out and condense into tar droplets less than one micron in size, appearing as smoke. **PM10 emissions are now <u>double</u> those of the flaming stage.**



4. Glowing - Not Smoky - No more flammable VOCs are left to stream out, so more oxygen can reach the fuel surface. Surface of charcoal (solid carbon fuel) now burns, glowing yellow, and CO is the major pollutant emitted.

Some fuel pieces will be drier than others when you burn. Smaller pieces dry out (and get wet again if it rains) more quickly, depending on their size, shape and distance from the soil surface. **Schedule burning when your "targeted" fuel sizes are driest.**

Complete Combustion Cannot Be Accomplished in Open Burning. VOCs need sufficient residence time in the flames, with enough oxygen, to burn completely. In the open, VOCs can escape the flames, to cool and condense into smoke. **The constant heat loss** (to incoming fresh air and to vaporizing fuel moisture) **and fuel loss reduce flaming, encourage smoldering and increase smoke production.**

State Agricultural Burning Requirements

Air districts have adopted the following State rules to help you burn your forest debris with a **minimum of smoke**. The heated air plume from a flaming hot fire helps carry the pollutants high into the air, out of breathing range, and scatters them over a wider area.

The Material Targeted For Burning Should Be:

1. **Free of Non-Agricultural Materials -** *no tar paper, demolition debris, petroleum wastes, tires, tar, metal salvage, plastics, treated wood, trash, household garbage, etc.*

2. **Arranged so as to Allow Air to Circulate Freely.** *Pile loosely. Let that oxygen in there! Fuel pieces should be far enough apart for air to move freely between them, but not so far from each other that they can't sustain flaming.*

3. **Free of Dirt or Excess Surface Moisture.** *Dirt won't burn. It hinders drying, and it keeps air and oxygen away from the fuel. And surface moisture will have to be boiled off before the fuel can heat up enough to burn without any excess smoke.*

4. **Dried For at Least the Minimum Drying Periods.** *If your fuel is too green, you are wasting your time and extra ignition fuel to get it to burn. You are wasting fuel energy to boil off* ***water*** *in the fuel, and you* ***will*** *generate more smoke. For more information, see page 9.*

Smoke Management Strategies

Smoke Management means conducting a forest burn only under predetermined fuel moisture and weather conditions, pacing ignition and using firing techniques that will minimize smoke production and prevent smoke accumulation beyond acceptable limits.

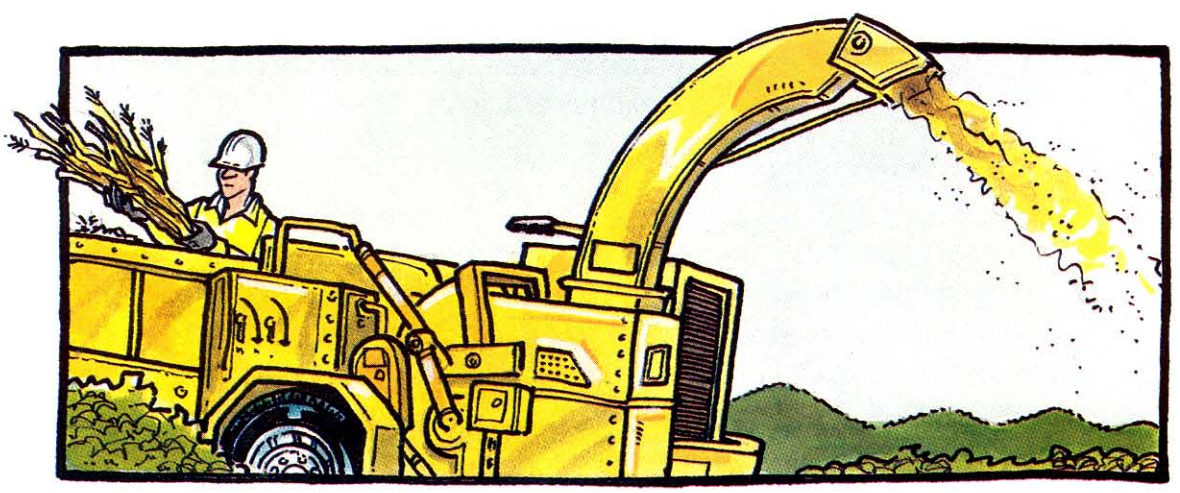
While this may appear tedious and time-consuming, not to mention expensive, in today's world **smoke management must be considered one of the costs of doing business.** Listed below are the four key areas where you can modify your practices to reduce air pollution emissions and minimize your smoke's impact on air quality.

1. **Avoidance - Don't burn** when smoke will not disperse well or will be carried toward **smoke sensitive areas**. These are populated areas, an airport, road or highway, or any place where smoke can adversely affect visibility or the public's health, safety and welfare.

2. **Dilution - Reduce smoke concentration** by staggering ignitions and/or burning when there is good lift and dispersion. Burn some areas at different times of the year, in addition to those burn seasons traditionally chosen. **Cover piles** with waterproof kraft paper when they are dry and burn them when the area is wet or snow-covered.

3. **Emission Reduction - Reduce the amount of pollutants emitted** by burning only the parts of the site needing it, by reducing the fuel loading (remove some fuels prior to burning), or by lowering fuel consumption (burn when some fuels are too wet to ignite). Lower emissions by maximizing the flaming phase during your burn. **Use alternatives to burning**, such as chipping, soil incorporation, and whole tree logging, especially near urban areas.

4. **Schedule Restriction - Honor periods of no burning,** such as overnight, weekends, and especially holidays. In some areas, **protecting good visibility** may be an important public relations goal during certain times of the year.



The Solution to Pollution is Emission Reduction, Not Dilution!

Planning Your Burn

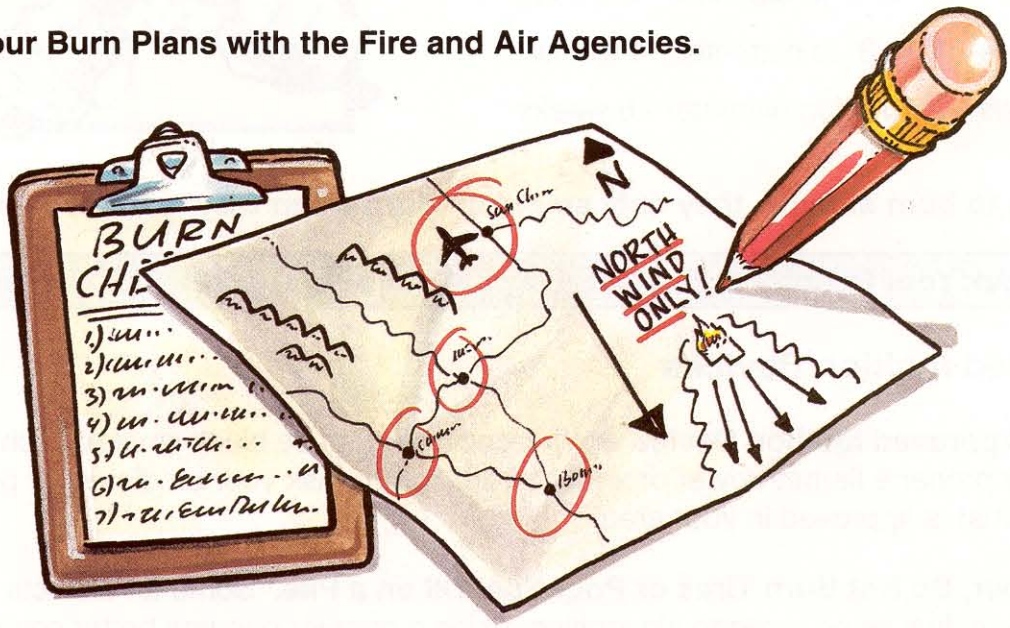
Prepare a Formal Burn Plan, Including:

- specific objectives of the burn,
- location and size of burn site,
- size of fuel to be consumed,
- fuel load per acre,
- type and arrangement of fuel,
- length of fuel drying time,
- ideal fuel moisture and weather to burn,
- direction and distance to smoke sensitive areas,
- estimated length of burn from ignition to mop-up,
- provisions to minimize residual smoke production,
- who to notify before burning and when, and
- contingency plan for escaped fire.

Draw up a Map Showing:

- direction and distance to all smoke sensitive areas,
- smoke drainage patterns,
- high risk visibility areas, i.e. highways and bridges (possible fog formation),
- transport wind allowances,
- ideal local wind speed and direction, and
- planned ignition patterns.

Share Your Burn Plans with the Fire and Air Agencies.



Obtain all necessary permits, and prepare to comply with all permit conditions.

Provide for daily receipt of weather forecasts. Use localized weather information and ask for spot fire-weather forecasts and updates.

Take preliminary measurements of variables such as temperature, relative humidity, and fine fuel moisture content. Keep track of the number of days since rain.

Determine the best weather that will allow you to burn with good smoke management.

Prepare to notify all those interested: public agencies, adjacent landowners, neighbors, and nearby smoke-sensitive institutions, such as schools, of your plans to conduct a burn. This is common courtesy, as well as a requirement in most areas. All those concerned will know that your burn is not a wildfire.

The More Fuel Burned, The More Smoke Produced

Recent research shows that although burning when some fuels are too wet to ignite does increase emissions, **total emissions are greater if all the available fuel is dry** and is consumed in the fire. This is particularly true when the large fuels and the duff layer (forest litter) burn, because these fuels tend to smolder. These two fuel types are wet in California in the spring, and spring burning usually has good smoke dispersal.

Forest fuels range from fines, such as leaves and needles, to huge stumps. If the burn objective is to consume certain sizes of fuel, allow adequate time for drying those sizes, to 20% moisture content or less. The targeted fuels will burn with a minimum of smoke.

Recommended Drying Times

Very fine fuels, less than 1/4" diameter - 10 days

Fine fuels - 1/4" to 1" in diameter - 3 weeks

Small fuels - 1" to 3" in diameter - 4 weeks

Large fuels - 3" to 8"" in diameter - 6 weeks

Don't try to burn stumps, they only smolder. Burn when they're too wet to ignite.

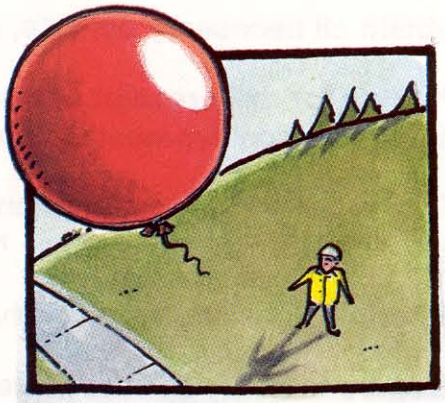
Check Your Permit For The Exact Drying Times Required In Your Air District.

Approved Ignition Devices

Use an Approved Ignition Device which does **not** produce black smoke, such as a butane or propane flamethrower or a fuel oil drip torch. Ask your air district or permitting agency what is approved in your area.

Remember, Do Not Burn Tires or <u>Pour</u> Fuel Oil on a Pile. Some air districts allow you to spray fuel oil on a pile to aid ignition; using a sprayer ensures better coverage of the fuels and less ground contamination.

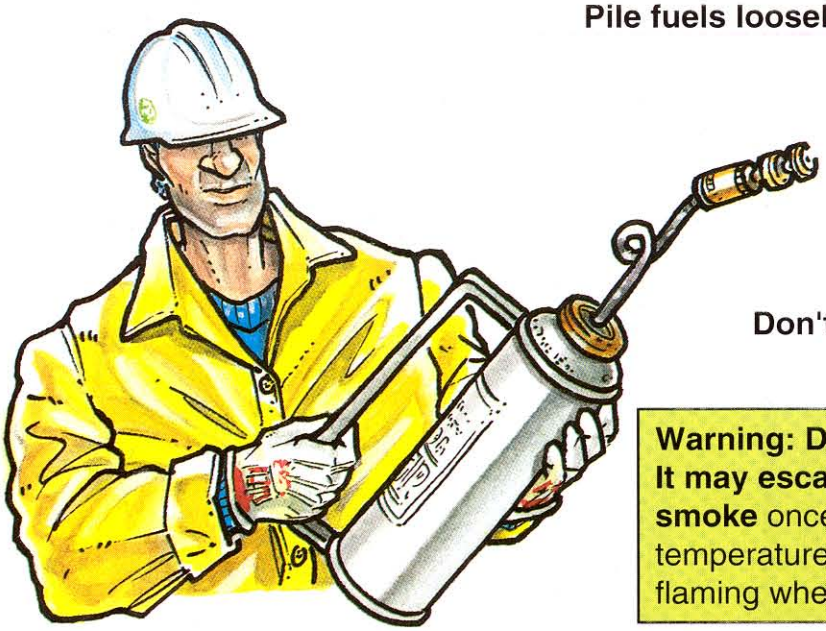
Before Ignition



Release a Helium-filled Balloon and/or light a test fire, away from roads and other "edge" effects, to assess upper level **transport winds.** Watch how well the fire burns and where the balloon (or smoke) goes. Quit for now if the fuel is too damp or the smoke moves toward smoke sensitive areas.

Notify the fire control and air agencies, the neighbors, and the newspaper, radio and television stations that you will be burning today!

Pile Igniting Techniques



Pile fuels loosely and allow ample **air spaces**.

Ignite many spots around the **base** of the pile.

Avoid pushing dirt into the pile if using heavy equipment.

Don't make the pile **too large,** include only what will burn before dark.

Warning: Don't Leave Your Fire Unattended: It may escape, or smolder and emit more smoke once the finer fuels burn and the fire temperature drops. Reform the pile to promote flaming when burning is partially completed.

Broadcast and Understory Burn Ignition Patterns

To burn an area with a continuous fuel cover (broadcast or understory burn) you must weigh many factors. The ignition patterns below are listed from least emissions to most.

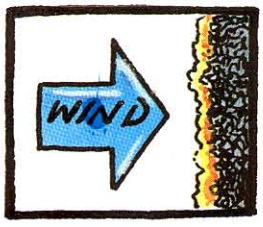
Backing Fire creeps into the wind or downslope. It spreads slowly, with short flames and longer residence time, consuming more fuel in flaming than in smoldering. Produces less smoke emissions, spread over more time, but only if the duff layer is too wet to burn.

Flanking Fire is lit walking with the wind; the fire line angles over into the wind. It moves at a moderate pace, producing emission amounts between backing and heading fires.

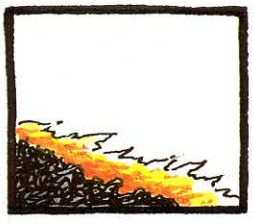
Spot Fire is one of a number of fires ignited along a line or in a pattern, each having backing, flanking and heading sides. It may produce more emissions than a flanking fire.

Heading Fire runs with the wind or upslope, moving rapidly, with long flames and high fire intensity. It emits the most pollutants, as the entire acreage ignites quickly and the flame front moves on before all the VOCs are consumed, causing excess smoldering.

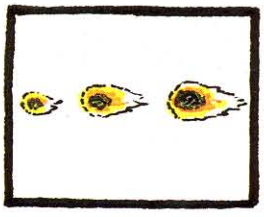
----------> Wind or Upslope Direction ----------->



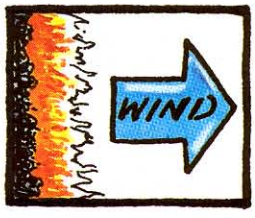
Backing Fire



Flanking Fire



Spot Fires

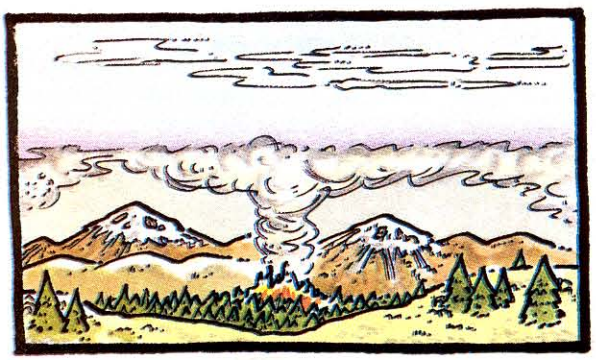


Heading Fire

Weather & Terrain Effects on Winds

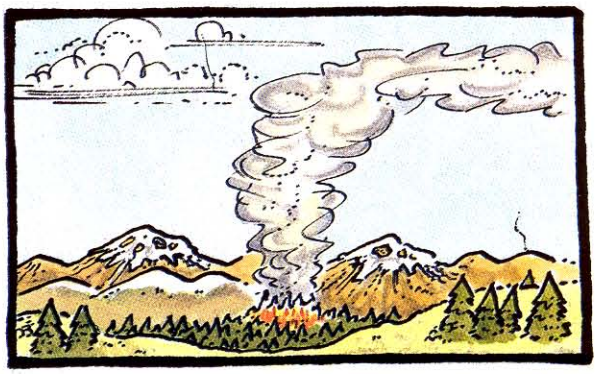
Predicting wind (and smoke) behavior accurately may take years of study and field experience. Be sure you learn about the local, small scale daily wind patterns in your area, their relation to surface features, and how various weather fronts can affect them.
NOTE: The following weather conditions are generalizations that may not apply in your local area.

POOR Smoke Dispersion Likely...



High Pressure Area - Atmosphere Stable
Clear Skies, or Layered, Flat Clouds
Weak or No Winds, Hazy Conditions
Temperature Inversion, Shallow Mixing layer

GOOD Smoke Dispersion!

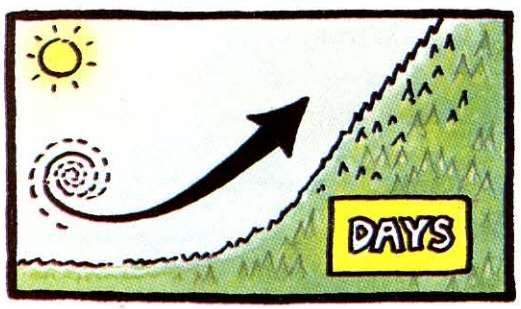


Low Pressure Area - Unstable
Tall, Puffy Cumulus Clouds
Strong, Gusty Winds, Good Visibility
Good Lift and Deep Mixing Layer

Surface winds are strongly affected by the shape of the underlying ground and by local day and night heating and cooling differences. **Caution: Upper level transport winds** may be blowing horizontally in another direction entirely, limiting plume rise by wind shear, or moving smoke into sensitive areas.

Learn about your local, small scale weather patterns. Understand that they can't be predicted using only the widely spaced regional forecasts that are available.

Heating & Cooling Effects on Wind Direction



Upslope

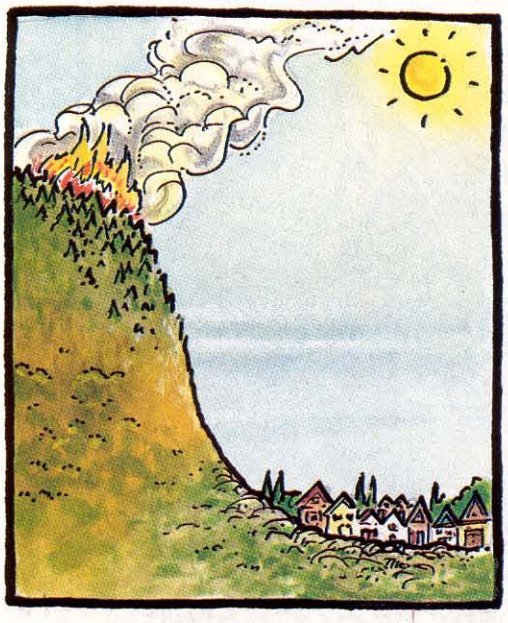
Downslope

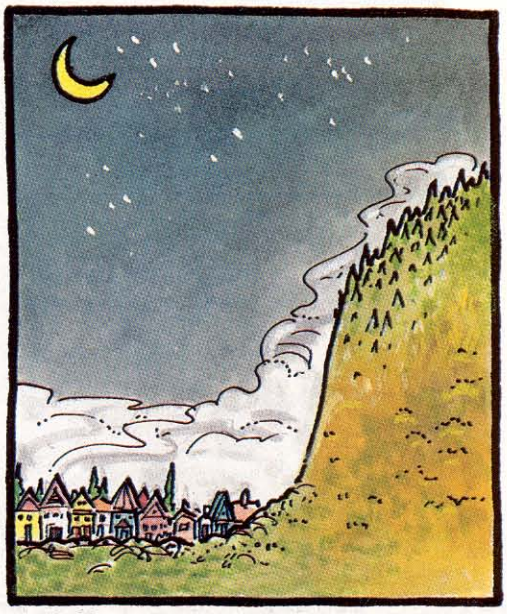
All sloping ground will have local changing winds. Warm air flows upslope by day on sun-heated slopes. Downslope winds begin soon after the first slopes go into shadow and surface cooling begins; by sundown cooling air is flowing down all slopes.

Avoid Burning - and Smoke - After Dark

Air temperature normally decreases with height above ground level, allowing heated air and smoke to rise. **A temperature inversion is an increase of air temperature with height**, which inhibits vertical air movement and mixing. Unfortunately, these inversions are very common in California's many natural air basins, which are often formed by mountains surrounding valleys.

Night inversions will form in sheltered basins, given little wind and clear night skies. The ground cools first at night, cooling the air in contact with it, while the air aloft may remain near daytime temperatures. The cooled surface air (with any **smoke** in it) gets dense and flows downslope as it cools further. It collects on the valley floor, leaving shallow cold air layers on the slopes and deep, cold (and smoky?) air layers and a temperature inversion in the valley.





By late afternoon any residual smoke coming from your burn will stay at ground level, cool, and begin to drain downhill. **Time your burn** early enough in the day so that it won't still be smoldering as night falls and impacting sensitive areas.

But don't burn too early in a basin! After sunrise, surface heating of the valley wall by the sun warms the cold air next to the ground. As surface heating destroys the inversion on the slope, upslope winds begin, pulling the inversion lid down on the valley as the warmed air flows upslope. Your smoke will stay under the inversion lid and will not rise until the sun warms the valley floor and lifts the inversion.

Don't Be A Public Nuisance !

If you manage a burn which emits enough smoke into the air to cause people downwind to complain, you will be subject to Section 41700 of the Health & Safety Code of California, which prohibits the *"discharge from any source whatsoever such quantities of air contaminants or other material which cause injury, detriment, nuisance, or annoyance to any considerable number of persons or to the public..."*. You may be cited by your local air district if your smoke causes visibility or other problems at ground level. It's far better to plan your burn carefully and curtail burning if the weather is not cooperating.

Develop a Good Communication Habit: Keep the public, your neighbors, and your local regulating agencies informed about your intentions to burn, so the burn won't be an unwelcome surprise.

Get Specialized Training, or be sure that your contractor has the training, credentials and the expertise to conduct a controlled burn safely and with a minimum of smoke.

Violating California Law Can Be Very Costly!

Violating burning regulations can be expensive! Penalty fees for not complying with air pollution regulations can be as much as **$50,000 per day.** You may **also lose** your Agricultural Burn Permit and have to **reimburse** the fire protection agency for any wildfire suppression costs (which often exceed **$50,000 per hour**), not to mention paying your neighbors for any valuable property your fire consumes. Use the checklist on the next page - obtain all the permits and information you will need to protect yourself, your neighbors, and your community!

Regulations of agencies other than the air district may apply to your operation as well. Remember, the benefit of keeping your burns within legal limits is not simply avoiding penalties, but also **being a good neighbor, and helping to provide a more healthful environment for everyone.**

Name_____ Date_____

Burn Checklist

State Agricultural Burning Requirements:

You must have a valid Agricultural Burn Permit.
No non-agricultural materials may be burned.
Waste materials are to be arranged loosely for good air circulation.
Material to be burned must be free of dirt and surface moisture.
Material must be dried for the minimum drying times.
Avoid burning when wind direction is toward populated area.

Acres_____ **Tons/Acre**_____ **Type of Burn**_____

Location_____

Fuel Type_____ **Fuel Arrangement**_____

Target Fuels_____ **Time Dried**_____

Smoke Sensitive Areas Within 20 miles:

_____ Distance_____ Direction_____
_____ Distance_____ Direction_____
_____ Distance_____ Direction_____
_____ Distance_____ Direction_____
_____ Distance_____ Direction_____

Estimated Time Needed To Complete Burn_____

Burning Hours_____ **Ideal Fuel Moisture**_____

Mop-Up Equipment, Personnel_____ **Begin Mop-Up By**_____

Ideal Wind Direction, Ignition_____ **Wind Direction, Mop-Up**_____

Approved Ignition Devices _____

Approved Ignition Techniques _____

I Need Permits From:

APC District_____ Fire Station _____

Fire Protection Agency_____ Fish & Game _____

I Need to Contact _____ **Before Burning.**

Burn Day Status Information _____

Need More Information?

Air Resources Board (800) 952-5588 **District: _____**

Multi-County Districts

1 - Bay Area (415) 749-5000
2 - Feather River (530) 634-7659
3 - Great Basin (760) 872-8211
4 - Monterey Bay (831) 647-9411
5 - North Coast (707) 443-3093
6 - Northern Sierra (530) 274-9360
7 - South Coast (909) 396-2000
8 - Yolo-Solano (530) 757-3650
9 - San Joaquin Valley (559) 230-6000

County Districts

Amador (209) 257-0112
Antelope Valley (661) 723-8070
Butte (530) 891-2882
Calaveras (209) 754-6504
Colusa (530) 458-0590
El Dorado (530) 621-6662
Glenn (530) 934-6500
Imperial (760) 482-4606
Kern (661) 862-5250
Lake (707) 263-7000
Lassen (530) 251-8110
Mariposa (209) 966-2220
Mendocino (707) 463-4354
Modoc (530) 233-6419
Mojave Desert (760) 245-1661
No. Sonoma (707) 433-5911
Placer (530) 889-7130
Sacramento (916) 874-4800
San Diego (858) 650-4700
San Luis Obispo (805) 781-4247
Santa Barbara (805) 961-8800
Shasta (530) 225-5789
Siskiyou (530) 841-4029
Tehama (530) 527-3717
Tuolumne (209) 533-5693
Ventura (805) 645-1400

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