Environmental Effects

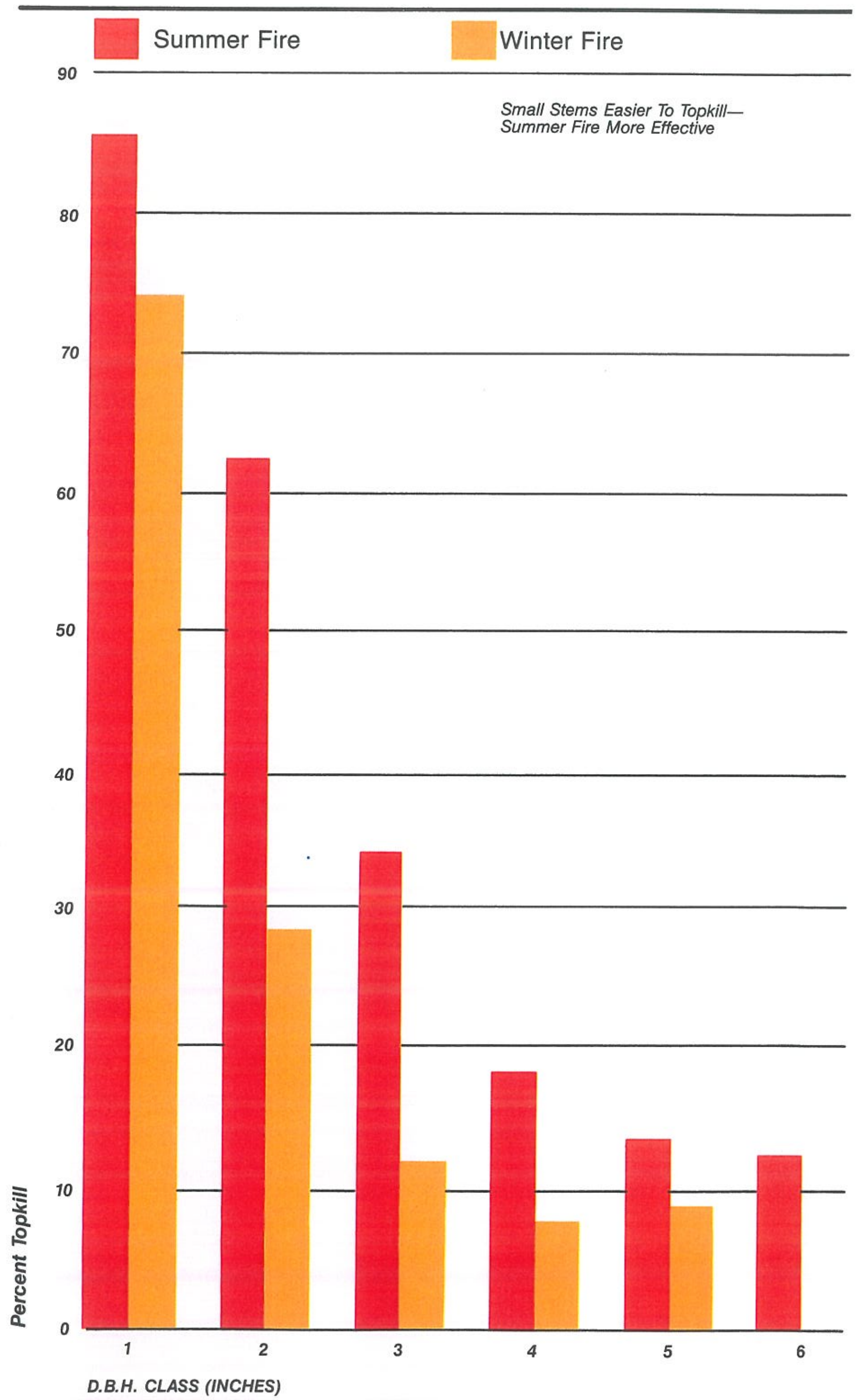
Prescribed burning has direct and indirect effects on the environment. Proper use of prescribed fire, and evaluation of the benefits and costs of a burn require knowledge of how fire affects vegetation, wildlife, soil, water, and air. Burning techniques and timing of burns can be varied to alter fire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

Effects on Vegetation

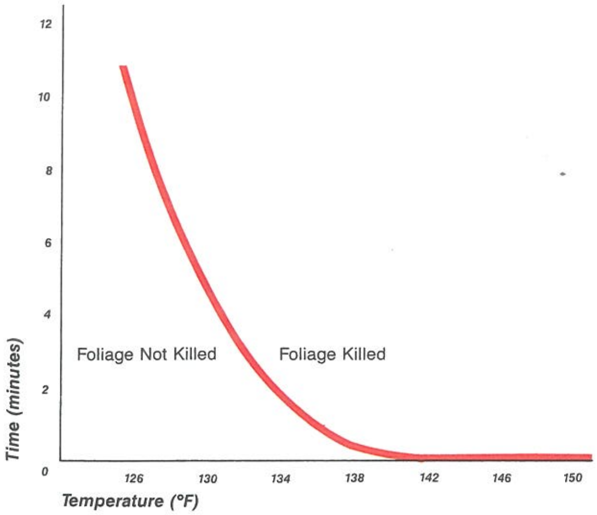
Fire may injure or kill part of a plant or the entire plant, depending on how intensely the fire burns and how long the plant is exposed to high temperatures. In addition, plant characteristics such as bark thickness and stem diameter influence the susceptibility to fire. Small trees of any species are 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 3 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 135°F. Pine needles will survive exposure to 130°F for about 5 minutes, while similar needles exposed to 145°F for only a few seconds will die.

Very high temperatures are produced in the flames of burning forest fuels. Fortunately, the hot gases cool rapidly above the flame zone and are back to a few degrees above normal air temperature a short distance from a prescribed fire unless the wind is calm. Adequate wind should be present to help dissipate the heat and slow its rise into the overstory canopy. Wind is also important in cooling crowns heated by radiation from fire. Southern pines generally survive complete crown scorch as long as there is little needle con-



Hardwood topkill



Lethal time - temperature curve

Differential fire effects

sumption. Severe needle scorch will, however, retard growth for a year or more after damage and, in this weakened state, the trees are more susceptible to drought and beetle attack.

Temperatures of the air and vegetation at the time of burning are critical factors. When the air temperature is 40°F, it takes twice as much heat to kill the foliage in a tree crown at any given height above a fire than when it is 90°F. The effect of high air temperature is recognized in using fire to control understory hardwoods. Although winter burns will topkill hardwoods, summer burns are generally required to kill hardwood rootstocks. Less heat is needed to raise plant cells to their lethal temperature during the summer, and as a general rule, plants are more easily damaged by fire when they are actively growing. In areas with scenic values, a special effort should be made to keep needle scorch and bark char to a minimum.

Even though pine bark is a good insulator, cambial damage can occur from the extended smoldering of duff around the root collar. Such damage is expecially likely in previously unburned, mature trees where a deep organic layer has accumulated. Whenever heat penetrates into the soil, feeder roots and beneficial soil organisms are likely to be killed. Damaged pines are more susceptible to bark beetle attack, especially if adverse weather conditions (e.g. drought) after the burn compound any loss in tree vigor. However, many observers report less insect damage in stands that undergo periodic prescribed burns than in stands where fire has been excluded.

Prescribed fire generally is not used in the management of hardwoods intended for harvest once a stand is established. Fire may not kill large-diameter hardwoods outright, but it will often leave fire scars. Such scars render the lower portion of the bole unmerchantable and provide entry to insects and disease.

Many benefits from prescribed fire, such as reduced hardwood competition, increased forage for grazing, and improved conditions for wildlife, depend on changes in the vegetation. Unwise use of fire may also alter species composition, but with adverse results, particularly when relying on natural regeneration.

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 underburns 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 soil clays.

Leave some duff to protect the soil

Exposing mineral soil in hilly terrain can cause erosion

As a stand matures, an increasing proportion of the nutrients on the site become locked up in the vegetation and are unavailable for futher use until plants die and decompose. Low-intensity fires speed up this recycling process, returning nutrients back to the soil where they are again available to plants. Under many conditions, burning may increase nitrogen fixation in the soil and thus compensate for nitrogen loss to the atmosphere that results from burning the litter layer. When duff layers are not completely consumed, changes in soil pore space and infiltration rate are very slight. If mineral soil is repeatedly exposed, rain impact may clog fine pores with soil and carbon particles, decreasing infiltration rates and aeration of the soil.

A major concern of the forest manager is how fires affect surface runoff and soil erosion. On most Lower and Middle Coastal Plain sites, there is little danger of erosion. In the steeper topography of the Upper Coastal Plain and Piedmont, some soil movement is possible. However, if the burn is under a timber stand and some duff remains, soil movement will be minor on slopes up to 25 percent. The amount of soil movement will be greater after site preparation with heavy machinery than after prescribed burning.

Care must be taken when clearcut logging slash is burned on steep slopes. Until grass and other vegetation cover the site, surface runoff and soil erosion may occur. The burning phase of the "fell and burn" site-preparation technique commonly used in the upper Piedmont and mountains should be completed by mid-September. This timing allows herbaceous plants to seed in and provide a winter ground cover. Burning should not be done if exposure of highly erosive soils is likely.

Soil should be wet or damp at the time of burning to ensure that an organic layer will remain after a prescribed burn. Moisture not only protects the duff layer adjacent to the soil, but also prevents the fire from consuming soil humus. If the forest floor is completely consumed, the microenvironment of the upper soil layer will be drastically changed, making conditions for near-surface tree roots very inhospitable. Damp soil also aids mopup after the burn.

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.

Rainwater leaches minerals out of the ash and into the soil. In sandy soils, leaching may also move minerals through the soil layer into the ground water. Generally, a properly planned prescribed burn will not adversely affect either the quality or quantity of ground or surface water in the South.

Effects on Air

Prescribed fires may contribute to changes in air quality. Air quality on 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 a 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 deter-

Protect streamside zones

Backing fires produce less smoke than heading fires

mined by timing and type of firing technique used. Rate of smoke dispersal depends mainly on atmospheric stability and windspeed.

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 windspeed 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.

Nighttime burning should be done with additional care because a temperature inversion may trap the smoke near the ground. This smoke can create a serious visibility hazard, especially in the presence of high humidities (which occur on most nights). In particular, smoke mixing with existing fog will drastically reduce visibility. Cool air drainage at night will carry smoke downslope, causing visibility problems in lowlands and valleys. On the Coastal Plain, nighttime air drainage often follows waterways. Conditions can be especially hazardous near bridge crossings because of the higher humidity there. Of course, the earlier in the day a fire is completed, the less likely it is to cause nighttime smoke problems. More complete mopup following daytime burning and nighttime burning only under very stringent prescriptions can minimize the occurrence of these problems. Your local State forestry office can help with planning nighttime burns.

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 judgement. The probability of this happening on a prescribed fire is, however, virtually nonexistent.

Over 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 and cancer. But, the risk of developing cancer from exposure to prescribed fire has been estimated to be less than 1 in a million.

Although the use of herbicides in forest management has increased all chemicals are now tested before being approved for use, and we are more careful than ever to minimize their potential danger. Many of them break down rapidly after being applied. Moreover, both theoretical calculations and field studies suggest that prescribed fires are hot enought to destroy any chemical residues. Minute quantities that may end up in smoke are well within currently-accepted air quality standards. Threshold limit values (TLV's) are often used to measure the safety of herbicide residues in smoke. Expected exposure rates of workers to various brown-and-burn combinations have been compared with TLV's. They showed virtually no potential for harm to workers or the general public.

There is at least one group of compounds carried in smoke that can have an immediate acute impact on individuals. When noxious plants such as poison ivy burn, the smoke can cause skin rashes. These rashes can be much more widespread on the body than those caused by direct contact with the plants. If you breathe this smoke, your respiratory system can also be affected.

Smoke sensitive areas can be impacted by prescribed fire

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 deleterious 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 underburning. It also results in unnecessary tree damage as the flame fronts merge in the interior of the area.

Management of the endagered red-cockaded woodpecker presents a special problem because of the copious amounts of dried resin that stretch from the nest cavity toward the ground. The bird requires habitat historically maintained by fire, even though these pitch flows can be ignited, carrying fire up to the cavity. This is unlikely, however, if short flame lengths are prescribed. Fuel can also be raked from around cavity trees as an added precaution.

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.

Prescribed burning attracts wildlife

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 postive 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, topkilled 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.

Some important points are: 1) The apparent size of a burn can be reduced by leaving unburned islands to create a mosaic pattern of burned and unburned area. 2) Where hardwood inclusions are retained, make sure they are large enough to be relevant to the observer. 3) Observer criteria must be understood if reactions to a burn are to be predicted. Personal reactions will depend on observer distance, duration or viewing time, and aspect.

Aesthetics can be enhanced by prescribed fire