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Fire effects in northeastern forests: aspen

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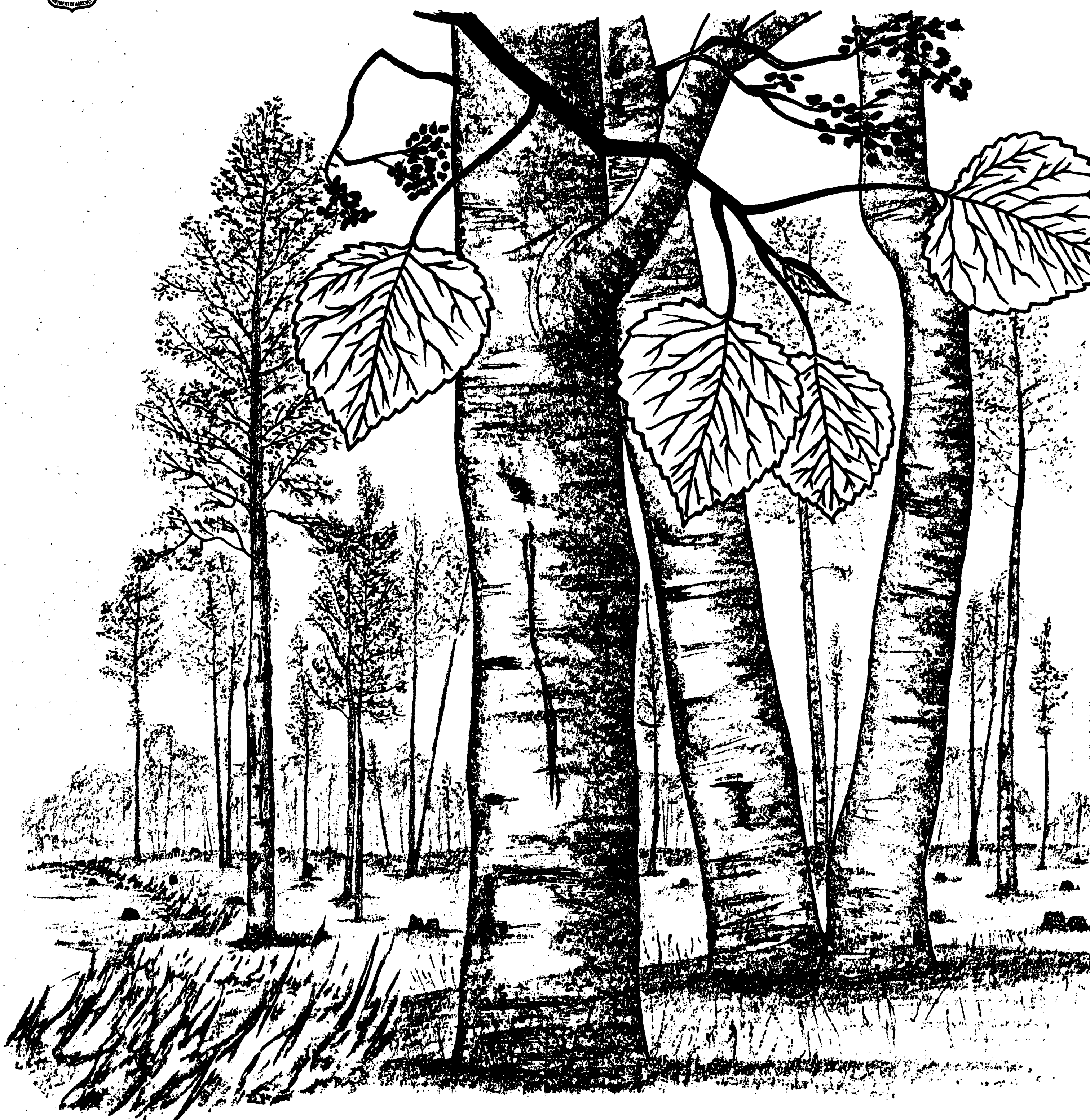

PREFACE

This is the first in a series of papers dealing with fire effects in northeastern forests. The 21-State region incorporates many diverse ecosystems—the northern hardwoods of New England, the boreal forests of Minnesota, the oak-hickory forests of Missouri, and fine hardwoods in the Central States. Although some things are common to all forests, each responds somewhat differently to fire. Although less is known about fire ecology in the Northeast than in any other region of the country, there is a small body of information scattered throughout the literature. The purpose of this series is to compile what we know today and make it readily available to managers. Each paper in the series will summarize the literature; detailed information on specific topics can be obtained from the accompanying references. When the series is complete in several years, the individual papers will be updated and republished as a single, bound volume.

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FIRE EFFECTS IN NORTHEASTERN FORESTS: ASPEN

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". . . almost every forest climax of North America displays a fire subclimax . . ." (17).

Aspen is Important

Quaking aspen (*Populus tremuloides*) is the most widely distributed tree species in North America (13). Bigtooth aspen (*P. grandidentata*), although not as widespread, is likewise an important species (18). The aspen commercial timber type, consisting of both quaking and bigtooth, is important in the northeastern quarter of the United States. In the Lake States alone, 41 industrial plants used 2 million cords of aspen in 1981 (4). Although much aspen is used, a tremendous amount is still on the stump. In Michigan, the amount of aspen biomass is second only to that of the maple group (30).

Observations Not Quantified

Although fire has been prevalent in the East since before settlement, little has been written about its role in hardwoods. As long ago as 1930, it was noted that although available literature generally described immediate postfire effects, it did not quantify them (14). Further, most fire effects literature lacks prefire vegetation documentation (37). Without this information, real comparisons among fires become questionable.[1] Our purpose here is to bring together existing information about the effects of fire on the aspen timber type in the eastern United States and to suggest silvicultural uses of fire in this type.

NATURAL FIRE CYCLE

"The search for stable communities that might develop without fire is futile and avoids the real challenge of understanding nature on her own terms" (19).

Fire Interval

Fire intervals for many areas in the eastern aspen range have been estimated from fire scars, fire reports, and lake sediments (44). Natural fire rotation periods range from 26 to 100 years (19, 44). During presettlement, " . . . large acreages burned at rather long intervals when weather and fuels combined to create peak burning conditions" (20). Presettlement fires probably occurred most often in the fall because forest fuels, including those under bigtooth aspen stands, are more prone to burn in the fall than at any other time of the year (27).

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[1] *In order to compare fires readily, the fire intensity (the product of the available fuel energy and the rate of spread) must be known (7). The intensity of a flaming front can be determined from the actual flame length. The flame length as well as the rate of spread can also give an approximation of heat released. Methods to estimate both rate of spread and flame length in the field without instruments have been devised (34).*

Aspen and Fire

Many large upland ridges that burned frequently or intensely are now dominated by aspen (20). It has been hypothesized that on repeatedly burned areas, plant communities, in order to maintain themselves, may have evolved to be more flammable than plant communities on less frequently burned areas (29). The aspen community might fit in this category. It is not very flammable when young (32) and has even been advocated for use in fuel breaks (12). However, once aspen starts to break up, fuel builds up (45). If this fuel dries, it will easily burn. Smaller material, especially, can become airborne even at low windspeeds and travel great distances while still smoldering. Thus, the fire can be spread quickly, enhancing an entire stand's propensity to burn. Most eastern aspen stands of today originated from destructive logging practices and large, severe fires of the logging/settlement era (6, 16). Repeated fires killed young pine trees and destroyed what pine seed was left while the aspen continued to sprout (16).

FIRE EFFECTS

"Fire is not a perturbation or a disturbance, but a recycling agent and an ecosystem stabilizer" (43).

Lethal Temperature

Fire can injure or kill the cambium, buds, and leaves of aspen trees. When living tissue reaches 147°F, death occurs almost instantaneously (6). Although this is an upper limit, death of plant tissue is a function of temperature and time. For example, the cambium layer exposed to 120°F for more than one hour will be killed (6). To produce such temperatures at the cambium layer, there must, of course, be more heat or a longer heating time at the bark surface.

Root Survival

Most fires in the Northeast do not kill the entire aspen tree—both above and below ground. In aspen stands, low intensity surface wildfires are most common (22). Severe fires may kill the aerial portions of a tree, but leave the roots intact (22). Although root tissue is more susceptible to heat-induced mortality than above ground tissue (23), the insulating quality of the soil and the heat release characteristics of most fires allow roots to remain viable (22). In contrast, cured slash piles ("activity fuels") may burn so intensely that aspen sucker growth is reduced (31). The main fire adaptive trait of aspen, in fact, is its ability to sprout from roots. Aspen roots can range in depth from about 39 to 60 inches but most sprouts are produced from roots that are within 3 to 4 inches of the soil surface (13). Lateral roots of aspen may be 80 feet long enabling sprouts to occur at some distance from the parent (18). More commonly, however, new sprouts are within 30 feet of the parent (31).

Factors

Several factors that determine direct fire-caused injury or mortality in an aspen tree are: season, bark characteristics, size, vigor, form and clone of tree, and fire intensity.

Winter

During winter, most trees are dormant and therefore less susceptible to injury by fire (15). In addition, ambient air temperature is lower than at other times of the year, requiring higher energy release rates (i.e., more intense fire) to raise the internal temperature of the tree to the lethal level (6).

Bark

Bark insulates and protects the cambium of the tree. Differences in bark characteristics determine the amount of protection the tree has from a fire. Bark characteristics are determined by the age and vigor of the tree. The easiest characteristic to measure is thickness. Although the older the tree the thicker the bark, aspen has thin bark at any age, making it susceptible to fire-induced injury and mortality (39).

Tree Diameter

Most large trees can usually withstand the same temperature directed at the same sized area better than smaller trees (26, 38, 40) because they have more cambium that can continue to function if a portion is killed. Also, with age, the tree's insulating bark thickens.

Vigor

Aspen of low vigor (e.g., those that have been burned or defoliated repeatedly or are growing on poor sites) do not sprout well and may not be able to heal as quickly as more vigorous trees after they have been injured by fire (9).

Form

The form of the tree is also important in determining the extent of damage. If a tree is crooked or leaning, the flames may be directly below the stem, thereby increasing heat at the bark surface (38). The growth characteristics of aspen, however, usually make for a straight-boled tree (18) if it is undamaged by insects, diseases, storms, or past wildfires.

Clones

Some characteristics differ greatly among clones (16). In the West it was found that although most clones sprouted more vigorously after a fire than in a similar unburned area, some did not (3). Although aspen in the West lives longer and grows slower than that in the East (3), different clones probably respond to fires in different ways in the East as well.

Fire Intensity

Fire intensity is markedly different from fire to fire and even within a fire (31). The greater the fire intensity the more energy is directed at the tree and the greater the likelihood of injury (22). Although low intensity burns may only kill part of the aspen overstory, burns of moderate intensity may kill all the aspen in the canopy (22).

Secondary Effects

The direct loss due to fire may be but a small percentage of the trees lost later to disease. For example, *Armillaria mellea* may attack weakened aspen (5). In addition, fires after the establishment of an aspen stand may reduce site index by 6 to 25 feet due to retarded height growth (41). Early stand senility and breakup may also result from fire due to mechanical injury and/or attacks by insects and diseases that physically weaken trees (41). And fire may increase the likelihood that some tree species will frost crack (25). This may be true for aspen, especially since other weather-related mechanical injuries (e.g., sunscald) are common (16).

Growth Stimulations

In some instances, fire may stimulate the growth of aspen trees, as reflected by increases in height, diameter, and/or number of trees. In Canada, a stand originally containing no aspen had nearly 4,800 aspen stems per acre after logging and burning (36). In Minnesota, fall burning stimulated aspen suckering (34, 9). Soil heat was found to be the key to aspen sprouting (44).

Temperature and Light

Increased temperature and light after a fire increase aspen sprouting (35, 31). The removal of insulating litter and vegetation as well as the blackening of the soil surface may alter the temperature of the soil for some time after a fire (2). In the summer, burned areas are hotter than unburned adjacent areas, but in winter, they are colder. The effects of temperature differ with types of soil (2). For example, water infiltration rates in some soils are decreased after burning, increased in others (2). For aspen to produce root sprouts, soil temperature at the roots must be 64°F to 95°F (28). Fire can increase the amount of light reaching the forest floor through destruction of the overstory. During the growing season, however, the period of increased light is short because herbaceous growth often quickly fills in the open places (9).

Associated Vegetation

After most fires in aspen stands, herbaceous growth increases. Invading grasses and weeds fill in and "...appear to prevent optimum stand development" (41). Repeated burns stimulate hardwood and shrub sprouts (*Quercus* spp., *Corylus* spp. and *Cornus* spp.) (32, 9). If jack pine is present it will also often seed in after a fire (2), as will paper birch, pin cherry, and mountain ash (1). Hazel may dominate sites after fire due to deer browsing other species (1).

MANAGEMENT IMPLICATIONS

"Fire is one of the oldest tools of man, and one of the most powerful (10)."

Regeneration

Aspen regeneration is readily obtained in even-aged stands provided the aspen is not decadent (33). The sprout aspen stands that originated after earlier pine logging and sweeping wildfires are now deteriorating (16). Without a concentrated effort to regenerate aspen, pine and/or slower growing hardwoods or brush will occupy these sites (33). After a final harvest cut, a prescribed fire can be a " . . . great aid to the establishment of the aspen type" (41). Fire helps insure adequate temperatures for aspen root suckers which are more effective in regenerating a stand than seedlings (33). Although natural regeneration by seed is possible after a fire (46), the seeds require an open but moist seedbed (33). Fires often produce open seed beds but rarely moist ones. To establish aspen regeneration, prescribed fire can be used after logging to kill all remaining aspen (9, 31), although this is not a widespread practice. If the objective is not accomplished, a second prescribed fire, 2 to 3 years after the first should be used, if enough fuel remains.

Timber Stand Improvements

Fire will favor aspen over seed-reproducing conifers (1). Thus, if a change in species composition from conifers to aspen is desired, prescribed fire can be used. Usually, any fire in an established aspen stand will damage the aspen crop trees and should be discouraged (41, 22). If a thinning is needed, it should be done manually, mechanically, or chemically (33).

Integrated Pest Management

Aspen is susceptible to many fungi that cause cankers and root rots (11, 21). Burning can change insect populations, especially when insects are overwintering in the duff. For example, cut worms in destructive numbers may inhabit leaf litter (16); removing the litter (by fire) virtually eradicates these insects. To date, however, little work has been done on the effect of fire on insects and diseases in this region.

CONCLUSIONS

Stand Establishment

The best use of prescribed fire in the aspen type is either to establish a new stand after cutting or to regulate an unmerchantable stand. Almost any fire in an established aspen stand is detrimental to silvicultural goals, but it may further other goals such as wildlife-species diversity.

Stand Rejuvenation

It has been suggested that "if a forest is not going to be completely regulated by logging and silviculture, then presumably natural regulating forces must be allowed some free rein. . ." (42). In aspen, this means stands that are nearly decadent and cannot be harvested due to poor access, poor markets, or other reasons. Others are more blunt, recommending that "if a mature forest cannot be harvested then fire may be one way to establish a valuable new forest in its place" (24). Burning may avoid "silvicultural slums." Aspen stands of the East are rapidly becoming such "slums."

Barriers

The greatest physical deterrent to rapid expansion of prescribed burning in the aspen region is the limited number of days when fire weather is suitable for burning aspen (8, 31). There are also attitudinal obstacles: remembrance of infrequent but terribly destructive fires; an organizational bias towards control rather than prescribed fire use; and the widespread acceptance of other silviculture techniques (chemical and mechanical), even though they are more expensive (8). Without disturbance, aspen—"the phoenix tree" (16)—cannot reproduce and will be replaced by other species (35, 33, 16, 18). Fire provides such disturbance.

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Fire has been a natural component of the aspen ecosystem. Any fire in an established aspen stand will cause injury. Aspen is easily top-killed but the roots remain viable. A fire's heat can stimulate sprout growth from these roots, aiding natural regeneration.

KEY WORDS: Fire ecology, fire management, silviculture.

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