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Fire Effects in Northeastern Forests: Jack Pine

Cary Rouse

PREFACE

This is the third in a series of papers dealing with fire effects in northeastern forest. 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. In spite of the fact that all forests have some things in common, each responds somewhat differently to fire. Although less is known about fire ecology in the Northeast than in any other region of the country, some information is 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 in a single, bound volume. Other papers available through the North Central Forest Experiment Station in the series to date include: aspen, oak.

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FIRE EFFECTS IN NORTHEASTERN FORESTS: JACK PINE

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

Fire is Important

Fire has played a major role in the forest ecosystems of North America (28). Fire in the jack pine forest type has long intrigued many researchers (from Ellis in 1911 (14) to Abrams in 1984 (1)). Unfortunately, much of the literature lacks the prefire vegetation and fire behavior documentation necessary for predicting fire effects.[1] In this report, we bring together existing information about the effects of fire onthe jack pine forest type in eastern North America and suggest silivicultural uses of prescribed fire in this type.

HISTORY

Origin of Existing Stands

Many jack pine stands of today originated after devastating wildfires (4, 10). These fires, caused either by humans or lightning, burned until they met an obstacle (such as rivers, lakes, or changes in cover type) or until weather changes made fuels less flammable. Plant communities in repeatedly burned areas might evolve to become more flammable to maintain themselves (27). This hypothesis certainly seems true of jack pine communities. Debris breaks down slowly in jack pine, and woody material that falls to the ground remains as fuel available for fire spread for several years. When a stand begins to break up, fuel arrangement and amount enhance the likelihood of a severe fire (20). The probability of a lighning-caused ignition increases until fire does occur. Fuels are reduced with a killing fire, and the stand is often regenerated on favorable seedbeds by seeds released from serotinous cones. Fire in jack pine clearly influences nutrient cycles and energy pathways, thus helping to maintain diversity, productivity, and long-term stability (21). For example, 1 year after the Mack Lake fire, water holding capacity, organic carbon, and cation exchange capacity all remained above pre-fire levels.[2]

Natural Fire Cycle

Fire intervals, the time between fires on the same area (26), have been calculated for jack pine in various locations. In the Boundary Waters Canoe Area of Minnesota, fires burned over the same area an average of every 6.1 years between 1727 and 1972 (21). Before settlement (1727-1868), the average fire interval in this area was 4.3 years with 21 to 28 years between major fire years (21). Eighty-four percent of the 532,000-acre land area burned during these major fire

[1]*To compare fires readily, managers must know the fireline intensity (the product of energy from fuel consumed and the rate of spread expressed in BTU/second/foot) (9). The intensity of a flaming front can be estimated from the actual flame length. The flame length as well as the rate of spread can also approximate heat released. Methods have been devised to estimate both rate of spread and flame length in the field without instruments (29).*

[2]*Cleland, David T. Fire effects summary for all quartzitic sands. Forest Service Memo, June 27, 1984.*

years. Heinselman (19) believes that jack pine barrens on sandy plains experienced light, surface fires as often as once every 15 to 30 years throughout jack pine's range. In lower Michigan, Simard and Blank (32) found a 25-year average fire interval between 1830 and 1980. Before settlement (1830-1849) the average interval was 27 years and dropped to 10 years during settlement (1850-1909). With initial suppression efforts, the period lengthened to 18 years and is now about 30 years. Major fires now occur an average of once every 28 years.

FIRE EFFECTS

Factors

Several factors determine direct fire-caused mortality in jack pine: season; bark characteristics, vigor, form, and size of tree; and specific fire characteristics.

Lethal Temperature

Fire can injure or kill any living tissue, including the cambium and needles of a jack pine tree. When living tissue reaches 147°F (64°C), it dies almost instantaneously (7). This is a good general figure, but death of plant tissue is a function of temperature and time, commonly called residence time.

Season

During the winter, most trees are generally less susceptible to injury because they are dormant (15). In addition, ambient air temperature is lower than at other times of the year, meaning that fire must be more intense to raise the internal temperature of the tree to the lethal point than during other seasons (7).

Bark

Bark insulates and protects the tree's cambium. Differences in bark thickness and thermal conductivity result in differences in the amount of protection the living portion of the tree has from a fire. Bark characteristics are determined by the age of a tree and its growth characteristics. The easiest characteristic to measure is bark thickness. Clearly, the older the tree, the thicker the bark. Jack pine bark is not very thick at any age, but it is less dense and provides more insulation than some hardwood bark.

Form

The form of the tree is also important in determining the extent of damage. If a tree is crooked or leaning, the flame can be directly below the stem, concentrating heat there (34).

Tree Diameter

The same temperature directed at similar-size areas on a large tree and a small tree would usually harm the large tree less than the small one (24, 34). Large trees generally have thicker bark than small trees and a larger area of cambium that can continue to function if a portion is killed.

Fire Behavior

Fire characteristics can differ from fire to fire and even within a fire. Fire behavior is dependent upon several factors, most importantly, the fuel characteristics of the area burned and the fire weather (11). Byram's (9) fire intensity measures fire behavior in terms of heat released per unit time on a foot wide portion of fire line. The greater the fire intensity the more energy is directed at the tree and the higher the probability of injury.

REPRODUCTION AND STAND ESTABLISHMENT

Jack pine regeneration and establishment can be divided into three steps: (1) seed production and dissemination; (2) seedling germination; and (3) seedling survival and growth. Fire can be a factor in each step.

Seed Production and Dissemination

Jack pine trees can produce viable seed when they are only 3 to 5 years old (11), although cone production peaks around 40 to 60 years of age (27). Seeds can remain on a tree for years (2). Fifty percent of 20-year-old seeds may be able to germinate (11). Fire doesn't influence the actual seed production except that fire-stress can cause a jack pine to produce more seeds than without stress (33).

Most jack pine seeds are formed in serotinous cones (18). The serotinous cones are sealed with a resin that melts, liberating the seeds, at 120° to 140°F (49 to 60°C) (27). In jack pine's natural range, these high temperatures can usually only be reached by adding heat to existing air temperature, except on sandy soils where temperatures can reach 170°F at the surface, hot enough to open the cones. Therefore, serotinous cones are an adaptation to fire (22). A "moderately hot" fire can produce enough heat to release the seeds from serotinous cones in the crowns of standing trees (27). If the cones themselves are burned, however, the seed will be destroyed (10, 27). Only in the southern portion of its range does jack pine produce nonserotinous cones (6).

Burning Slash Unsuccessful

Jack pine slash (activity fuels) with cones remaining after a clearcut has been burned in an attempt to prepare a seedbed and liberate seeds in one activity (5, 10, 13). This has not proved very successful probably because fires were not able to consume enough fuel to prepare the site. Even if the fires had been able to prepare the ground, the seeds would probably have been incinerated (10, 27).

Seedling Germination

Once seeds have been released, they germinate best on mineral soil or soil with less than 0.2 inch of organic matter (27). The organic soil layer can be reduced with fire. If a seed source is available, seeds will often germinate soon after the fire. However, seeds are vulnerable to heat and dessication on blackened, dry organic soils and may not germinate or, if germinated, may die (11).

Seedbed

To ensure a good seedbed, slash remaining from a harvest must be reduced because it provides too much shade (25). Slash can be reduced with fire. Some shade, though, appears to favor germination. Standing dead jack pine can enhance establishment of jack pine by providing a slight amount of shade (27).[2] It appears that light shade aids in the regeneration of jack pine on sandy sites by allowing available moisture to be retained longer (2, 6, 27).

Growth and Survival

Once germinated, seedlings require full sunlight (6) and release from competing vegetation. This can be achieved, temporarily, by burning before jack pine establishment (27, 11). In addition to controlling competition, fire can also help protect

jack pine from pests, namely damping-off, Scleroderris canker, and dwarf mistletoe (11). In addition, newly created slash often encourages populations of *ips* beetle (6). This beetle can be checked by burning the slash.

Competition can be Slowed

After the overstory is removed, competition from sedges can be severe enough to prevent jack pine from becoming established Slowed on poor sandy sites in northern lower Michigan. Within 2 years of the removal of the canopy, sedges can fully occupy a site to the exclusion of almost all other vegetation, including jack pine.[3] Fire can slow this process, but only if used before or immediately after removing the overstory. The key to maintaining these areas in jack pine is timing. Jack pine must be established, either naturally or artificially, immediately after removing the canopy.

Rain Necessary

Even with the best of site preparation and release, jack pine establishment and growth, especially on sandy soils, is "heavily dependent upon a capricious growing season rainfall pattern" (5) because jack pine sites can experience drought conditions just 6 years after a 1/2 in. rain.[4]

Fire in Existing Stands

Fire can easily injure or kill an established jack pine stand (6). Jack pine foliage is highly combustible and burns readily when crowns are close to the ground (36). Few trees survive a crown fire. Young to "semi-mature" stands are more susceptible to crown fires than are older stands whose crowns are often thinner and higher (35). Benzie (6) recommends that fire not be used for any purpose in immature stands.

SUMMARY AND MANAGEMENT IMPLICATIONS

Stand Establishment

The best use of fire in the jack pine type is for site preparation in the establishment of a new stand. Fire can provide an economical alternative to mechanical site preparation. Fire can aid in regenerating a stand by preparing an adequate seedbed and sanitizing the site. Fire in an established stand, except at low intensity, is detrimental. Although past wildfires produced many of the jack pine stands of today, there is no guarantee that jack pine will become established after a fire (5). Although Buckman thought, in 1964 (8), that successful regeneration techniques using fire would soon emerge, today there is still no guaranteed method to produce an adequately stocked natural stand with fire. To be able to use fire for vegetative manipulation and to predict its effects, managers must know the following: prefire species composition and dominance, extent of buried seed pool, adequacy of adjacent seed sources, soils information, actual fire intensity and past disturbance history.[4] Although this information has not been recorded in the past, such information would allow managers to compare and refine burning techniques needed to meet specific management objectives.

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[3]*Abrams, Marc D. Early plant succession on clearcut and burned jack pine sites in northern lower Michigan. East Lansing, MI: Michigan State University; 1982. 191 p. Ph.D. dissertation.*

[4]*Ibid.*

Seedbed Preparation

The consensus has been that to get an adequate seed catch, duff must be severely reduced (12, 16). It has been suggested that the best time to burn is 1 month after harvest in the spring (3, 6, 30). But this is the time of most severe fire weather and one day's successful burn could be the next day's escaped fire.[5]

Stand Rejuvenation

Many acres of unmerchantable jack pine in the Northeast are approaching decadence. Van Wagner (5) 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 . . ." In the case of jack pine, lack of cutting will result in decadent stands with much fuel—prime candidates for major conflagrations. Kayll (23) proposes a drastic solution. He recommends that "if a mature forest cannot be harvested then fire may be one way to establish a valuable new forest in its place." He suggests burning under controlled conditions to avoid "silvicultural slums." Many jack pine stands in the Northeast are becoming such slums.

Obstacles

The largest physical obstacle to rapid expansion of prescribed burning in the jack pine region is the limited number of days when fire weather is appropriate to burn (8). For example, during the spring in lower Michigan, fire weather appropriate for prescribed burning rarely lasts more than 1 day (31). In addition to this physical limitation are attitudinal obstacles: remembrance of recent and historic destructive fires such as the Mack Lake fire in Michigan (31); organizational bias—towards control rather than fire use; and the widespread acceptance of other methods—chemical, mechanical, and silvicultural techniques (8). Despite these limitations, some burning in the jack pine type is occurring in Minnesota for site preparation and in Michigan for Kirtland warbler habitat management.

Prediction Is Difficult

Research concerning fire's place and use in jack pine has provided much information but no universal answers. Results of burning on one area are not repeatable on another. As more site-specific information is collected, managers can gain confidence in it and burning will be viewed as an accepted management practice (especially for site preparation).

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The jack pine ecosystem has evolved through fire. Jack pine, although easily killed by fire, has developed serotinous cones that depend upon high heat to open and release the seeds. Without a fire to enable the cones to open, jack pine would be replaced by another species.

Prescribed fire can be an economical management tool for site preparation in either a natural or artificial regeneration system.

KEY WORDS: *Pinus banksiana*, fire ecology, silviculture.

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