CHAPTER 10

The Ecological Role of Fire in Jack Pine Forests

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ABSTRACT

Jack pine (Pinus banksiana Lamb.) is a species well adapted to fire in the boreal forest environment. Cone serotiny and an ability to survive harsh environmental conditions permits jack pine to regenerate successfully after fire. Indeed, without the periodic occurrence of fire the species would disappear from the boreal forest. Fire in the jack pine forest is a highly variable phenomenon; behaviour characteristics are dependent largely on the fuel characteristics of individual stands and on fire weather. Prescribed fire is being used successfully in the jack pine forest as an economical site-preparation tool for regenerating logged-over sites. It can aid in slash removal, seedbed preparation, hazard reduction, and competition reduction. Because of the vast complexity of the variables involved in the jack pine forest fire ecosystem, continued research in this field is warranted.

10.1 INTRODUCTION

Of the 105 pine species discussed by Mirov (1967), seven may be considered as northern circumpolar species. Four of these occur in North America: jack pine (Pinus banksiana Lamb.) is both an eastern and a western North American species, white pine (Pinus strobus L.) and red pine (Pinus resinosa Ait.) are eastern species, while lodgepole pine (Pinus contorta Dougl.) is a western species. The other three northern pines are found in Eurasia. Scots pine (Pinus sylvestris L.) is the most widely distributed of all pines, occurring from Scotland in the west to the Pacific coast of Siberia. Two other pines are found in Siberia, Pinus sibirica Mayr and Pinus pumila Regel, the latter a very small tree and more often a creeping shrub.

Forest fire plays an important role in the ecology of pine forests. By exposing favourable seedbeds for germination, it often enhances pine-regeneration. Lodgepole and jack pine are particularly well adapted to regeneration after fire. They are characterized by serotinous cones that do not normally open until they are exposed to high temperatures. Because of
their unique ability to disperse seed following fire, they are a widely distributed species. This chapter will deal only with jack pine.

Jack pine is the most widely distributed Canadian pine, ranging from Nova Scotia and New Brunswick westwards to northern British Columbia, the Yukon Territory, and the Northwest Territories. In the United States it is most abundant in the states of Michigan, Minnesota, and Wisconsin. The value of jack pine was not recognized until after the extensive stands of eastern white pine and red pine were harvested. Indeed, Roth (1902) referred to it as 'that frugal scrub among the stately race of northern evergreens'. The tree is now an important commercial species used for pulpwood, construction timber, hydro and telephone poles, fence posts, mine timbers, railway ties, and Christmas trees.

The species is capable of growing on the driest and poorest sites within its range, and its ability to produce merchantable stands where other species can scarcely survive is one of its outstanding values. The characteristic jack pine sites are dry sand plains developed on glacial outwash, morainic, aeolian, and beach deposits. Jack pine is also found on fresh to moist sands, on tills, and on relatively thin soils overlying rock outcrops (Chrosćiewicz, 1963; Cayford, 1971).

Extensive areas of jack pine are generally considered rather unattractive, but less extensive stands that lend diversity to the landscape, or occur on rock-outercrop ridges, have high visual appeal (Ohmann et al., 1978). Jack pine areas provide opportunities for blueberry picking, and pine is generally considered to be a deer food of medium preference. Groups of young trees with branches reaching the ground provide nesting sites for the endangered Kirtland’s warbler in Michigan’s Lower Peninsula (Benzie, 1977).

To a considerable extent, jack pine stands are consolidated into large areas of flat to rolling topography in situations where they can be utilized efficiently, and operated and managed on a year-round basis. Commercial operations are seldom in direct conflict with recreational use of the forest. Multiple-use values are normally enhanced by access provided by road construction, and the harvesting and regeneration of old-growth jack pine contributes to a varied habitat for wildlife (Yeatman, 1979).

Jack pine is generally a short-lived species and is intolerant of shade. On dry, sandy sites jack pine tends to be a climax type, whereas on other sites it is a temporary type that is replaced by more shade-tolerant species as long as natural succession is not interrupted by fire (Fowells, 1965; Cayford, 1971; Benzie, 1973).

### 10.2 FIRE AND JACK PINE

It has long been recognized that fire is a particularly important ecological factor responsible for renewing jack pine forests. Indeed, as early as 1911,
Ellis reported that jack pine in Ontario grew primarily on burned-over areas. He also noted that the extensive stands of jack pine were due to past fires; in fact, the periodic occurrence of wildfire is considered by all authorities to be an indispensable phase in the natural life cycle of the species (Heinselman, 1973; Ahlgren, 1974; Day and Woods, 1977).

Boreal jack pine forests are especially prone to fire, particularly on dry sites and at high densities where living undergrowth is sparse (Rowe and Scotter, 1973). The foliage of jack pine is highly combustible and burns readily when the tree crowns are sufficiently closely spaced to carry the fire (Van Wagner, 1967). Jack pine trees of almost any age are usually girdled and killed by wildfire and relatively few survive a crown fire (Mitchell, 1954; Frissell, 1973; Day and Woods, 1977).

In the southern portion of its range, on the xeric glacial outwash sand plains of central Wisconsin and Lower Michigan, many jack pine stands have been subjected to surface fires of moderate intensity that kill only portions of stands. These periodic fires have created the open, patchy, multi-aged pine stands that characterize the 'pine barrens' (Heinselman, 1981).

Rowe and Scotter (1973) in discussing fire in the boreal forest have summarized some of the autecological characteristics of the dominant conifers, indicating in a relative way their degree of adaptation for successful regeneration following fire. A total 'index of success' showed that jack pine is best adapted to fire, whereas balsam fir (Abies balsamea [L.] Mill.) is least adapted. Jack pine ranked high in relation to seed retention on the tree, earliness of seed production, seedling growth rate, seedling frost hardiness, and seedling growth response to full light exposure.

10.2.1 Cone Serotiny

Without doubt the single most important characteristic of jack pine that makes the species ideally suited to regeneration after fire is the serotinous habit of its cones. Serotinous cones are common over most of the range of the species (Eyre and LeBarron, 1944) and only in the southern portion of the range in the Lake States do non-serotinous cones occur to any extent (Schoenike, 1976). It may be postulated that the serotinous habit is perpetuated by fires which are most prevalent in northern and western stands (Schoenike, 1976). A fire regime in which fires are spaced to allow for tree maturation, as occurs in the boreal forest, should favour serotiny; too frequent fires could eliminate the species, while less frequent fires, as in the Lake States, would select open-cone individuals whose seed would cause the genotype to increase its representation in the stands (Rudolph et al., 1959; Hendrickson, 1972).

Jack pine is an early and proficient seed producer and trees may begin to bear cones at 3 to 5 years of age, with significant seed production attained by
age 10. Light to medium cone crops are produced annually, with good crops at intervals of 3 or 4 years (Eyre and LeBarron, 1944; Roe, 1963). Seeds in the tightly closed serotinous cones accumulate on the trees for 25 years or longer (Ellis, 1911); the cone scales are held together with a bonding material that melts at about 50°C (Cameron, 1953). Seed in closed cones remains viable for a long period of time. High viability is maintained for at least 5 years, and seeds 20 years of age may average as high as 50% germination. Even seeds from the oldest cones play their role in natural regeneration (Schantz-Hansen, 1941; Eyre and LeBarron, 1944).

10.2.2 Cone Opening and Seed Dissemination

Forest fires provide the heat necessary to open the large number of cones that are present in jack pine crowns. Although a fire may generate very high temperatures, the seeds within the cones are well insulated and can survive brief periods in flames (Eyre, 1938; Eyre and LeBarron, 1944). In detailed studies, Beaufait (1960b) found that seed viability was unaffected when cones were exposed to 900°C for 30 s; at 700°C viability did not decrease until cones were exposed for a 3-min interval. Even though most trees are killed by fire, cones are opened and provide an abundant seed supply. Following a fire, up to 5 million seeds per hectare may be disseminated from the newly opened cones in the scorched crowns of standing trees (Eyre, 1938).

10.2.3 Germination and Seedling Development

Requirements for seed germination and early seedling growth are often ideally created by fire. Fires remove loose organic matter such as surface litter or moss, and expose mineral soil or decomposed organic matter, which are generally favourable seedbeds for germination (Ahlgren, 1959, 1960; Chrosniewicz, 1959, 1974, 1978d; Ahlgren and Ahlgren, 1960; Cayford, 1963). Complete exposure of mineral soil is seldom required, and a mixture of exposed mineral soil and thin humus may provide optimum conditions (Chrosniewicz, 1970, 1974). On moist sites, suitable seedbeds may result from burning only the loose surface litter and the feathermoss, leaving the compacted, lower organic strata intact (IZ. Chrosniewicz, 1979, personal communication).

Fires normally kill most of the overstorey trees, but dead standing trees permit much of the solar radiation to reach the ground. Moreover, the partial shade created by dead standing trees as well as by logs on the ground surface creates suitable conditions for jack pine seed germination (Fraser and Farrar, 1953) which normally occurs promptly after seed dispersal if temperature and moisture conditions are favourable. If such conditions continue during the
first growing season, a stand of jack pine is likely to be regenerated successfully (Eyre and LeBarron, 1944).

Fire temporarily eliminates competing vegetation, and the intensity of the fire affects regrowth. While certain herbs and shrubs may provide a shady, cool microenvironment which is beneficial for germination and early growth, a dense cover, especially of hazel (*Corylus cornuta* Marsh.), may retard growth of jack pine seedlings. The additional nutrients released by the fire may aid in the reestablishment of jack pine, sustain its growth, and stimulate the growth of herbs which will provide the beneficial cool, moist microclimate (Ahlgren, 1960, 1963, 1970; Beaufait, 1960a).

Ahlgren (1959), Cayford (1963), and Chrosciewicz (1970) have observed that most germination occurs promptly after fire. Ahlgren reported that, in Minnesota, 57% of the seedlings originated the first year and 35% the second year. Cayford found in one study that 99% of more than 1000 seedlings germinated the first year after wildfire.

### 10.2.4 Post-fire Successional Patterns

A number of investigators have carried out comprehensive fire ecology studies in areas in which jack pine is an important component of the forest. The earliest comprehensive work was undertaken by Ahlgren in northeastern Minnesota (Ahlgren, 1959, 1960; Ahlgren and Ahlgren, 1960). More recently, Day and Woods (1977) have carried out a detailed study in northwestern Ontario, while Heinselman (1973, 1981) has done similar work in Minnesota. These investigations have all been carried out in the Great Lakes–St. Lawrence Forest Region (Rowe, 1972). In the Boreal Forest, Rowe and Scotter (1973) have investigated fire ecology in northern Canada, while Alexander (1978) is currently carrying out studies in Ontario. In New Brunswick, MacLean and Wein (1976) have investigated post-fire jack pine stands in the Acadian Forest Region.

Day and Woods (1977) have presented a detailed description of five post-fire jack pine stands ranging in age from 14 to 160 years. The results from this study confirm the fact that the Quetico Provincial Park forest in northwestern Ontario is composed of a mosaic of early and late successional stands originating from large wildfires. The results also indicate that, in the absence of wildfire, jack pine would be replaced by stands of more shade-tolerant species. In the same paper, Day and Woods present the following hypothetical model for post-burn succession in the jack pine–aspen (*Populus tremuloides* Michx.) community.

In the first phase (15 years), a dense, vigorous, even-aged jack pine–aspen stand dominated the burned-over area. Jack pine at 10000 stems per hectare were twenty times as abundant as aspen; beneath the overstorey was a black spruce (*Picea mariana* [Mill.] B.S.P.) understorey. In the second phase (45
years), the fire-initiated jack pine and aspen still formed an even-aged canopy that dominated a spruce and shade-tolerant hardwood [sugar maple (*Acer saccharum* Marsh.)/white birch (*Betula papyrifera* Marsh.)] understory. Neither pine nor aspen had regenerated because of low light levels, severe root competition, and an increasing depth of pine needle litter. In the third phase (75 years), the jack pine and aspen still formed an even-aged canopy, but their crowns had declined in size and the canopy was beginning to show signs of decadence. The understory of black spruce, balsam fir, and shade-tolerant hardwoods was developing and was beginning to become the main stand canopy. In the fourth phase (105 years), the jack pine and scattered aspen were decadent and dying. Black spruce, fir, and shade-tolerant hardwoods were in the process of replacing the overmature jack pine-aspen stand. In the fifth and sixth phases (135 and 165 years), the original jack pine and aspen had been almost completely replaced by the understory. At 135 years, only scattered jack pine remained, while at 165 years, only a few large ancient and decadent specimens remained. The original jack pine-aspen forest had been replaced by an all-aged spruce-balsam fir-tolerant hardwood stand.

Heinselman (1973) has reported that in the Boundary Waters Canoe Area of Minnesota, jack pine-dominated communities where black spruce is significant may eventually be succeeded by a black spruce-feather moss (*Pleurozium schreberi*) community. Where balsam fir is significant in association with jack pine, the succession will be towards a balsam fir-white birch-white spruce type with a tall shrub layer. However, Heinselman found that these successions were never entirely completed, and in 1970 he found a few scattered living jack pine in a stand that had burned in 1727. In the same year he found numerous 215-year-old jack pine in a stand burned in 1755. Thus it is evident that individual jack pine can persist as a scattered over-storey for at least 210 to 250 years without fire.

### 10.3 FIRE EFFECTS

Forest fires have a profound effect on the jack pine ecosystems. The tree component and all other physical and biological processes are directly affected. Changes caused to any one of these processes will ultimately affect most other processes.

Scotter (1964) noted that soil temperatures in burned-over areas were normally higher than in similar unburned areas. This temperature difference decreased as soil depth increased. The increase in temperature in the burned-over area was attributed to the blackened surface, which readily absorbed solar energy, to the removal of unincorporated organic matter (duff) which acts as an insulator, and to the absence of shade from the forest canopy. Scotter believed that many of the fire-induced species in the early
eral stages of succession would benefit from the increased soil temperature which is ecologically favourable for the germination and growth of some plants.

In northeastern Minnesota, the litter component of the soil was found to increase rapidly within one or two months after fire through needle fall from killed trees (Grigal and McColl, 1975). Needle fall decreased after this period but continued for up to two years after the burn. Needles in the burned-over areas fell prematurely with higher nitrogen, phosphorus, and potassium and lower calcium concentrations than in the unburned areas.

In the first year after fire, the woody component of the litter layer was increased by the breakdown of small branches and twigs of the trees killed by the fire (Grigal and McColl, 1975). During the second year, the component was augmented by the breakdown of tree crowns and the felling of complete trees. Sloughing of large quantities of tree bark which accumulated at the base of the dead trees was evident. By the third year, woody litter fall returned to unburned levels. Litter buildup by cones and seeds was reduced by fire because of loss of reproductive organs. Litter increases caused by the woody components of trees, fruits, and seeds after fire did not affect nutrient concentrations of the litter component of the soil.

Fire also has an effect on soil nutrients. Ahlgren (1960, 1963, 1970) observed higher concentration of nitrates, ammonia, potash, phosphates, calcium, and magnesium in upper soil levels than on comparable unburned areas. The higher concentrations of nitrates and ammonia diminished rapidly after fire; those of potash, phosphates, calcium, and magnesium were undoubtedly caused by the residual ash, and they prevailed to some extent in the soil for at least five years after the fire. However, the actual soil type is a key factor in determining the effect of fire on nutrient cycling. McColl and Grigal (1977) observed that nitrogen fixation, litter decomposition, and mineralization were enhanced by certain types of fire. They felt that the increased soil pH was the reason. In Saskatchewan, Scatter (1964) found that exchangeable hydrogen decreased and exchangeable calcium increased following fire. On these same burns he found that soil pH increased because of the fire but that increases were less at greater soil depths. He considered that increased pH was due to the destruction of unincorporated organic material and the addition of wood ash to the soil; the addition was naturally greatest at the soil surface.

Vegetation response to fire is a complex matter involving many factors (Ahlgren, 1960) including ‘preburn condition of the land, season of burn, seed supply, (fire) intensity, ash concentrations, subsequent mineral-nutrition, soil moisture, rainfall, humidity, soil and air temperatures, animal populations and plant competition’.

In Minnesota, Ahlgren (1960) observed three categories of plants in fire-killed stands: those that were found on unburned land, those that were
found only on burned-over land, and those that occurred on both burned and unburned land. Few species occurred only on unburned land. Most species found only on burned-over land reproduced by seed and the majority were wind or animal disseminated. The third category, occurring on both burned and unburned areas, contained a number of vegetatively reproduced species which survived the fire. Vegetative parts of several species were remarkably fire tolerant and were equally distributed on unburned, lightly burned, and severely burned areas. In general, the occurrence of vegetatively reproduced species depended primarily on the resistance of the reproductive parts to fire or their escape from it.

In the boreal forest Rowe and Scotter (1973) have noted that a number of subordinate plant species commonly associated with jack pine are able to regenerate promptly from basal or underground sprouts. Still other species frequently invade burned areas. These are fast-growing species, adept at rapid invasion by seed or by vegetative means, which develop in full light. Similarly, various bryophytes and lichens appear soon after an area is burned. In northern Alberta, Carroll (1978) has studied the successional trends following fire in jack pine–lichen woodlands, noting in particular the changes in occurrence of lichen species over time.

Caribou show a preference for stands over 50 years of age which contain their preferred food source (Scotter, 1964). Fires which alter the jack pine forest from mature to immature reduce the food source for caribou. Scotter found that a mature forest can produce 614 kg/ha of high-value lichen forage for the caribou winter supply while an immature forest 1–10 years of age supported only 2 kg/ha. In terms of total forage available to caribou, recent burns provided only a third of the forage provided by mature forest. Peek et al. (1976), in discussing the need to reintroduce fire into the Boundary Waters Canoe Area of northern Minnesota for successful moose management, found that vegetation located on ‘hotter’ burns was higher in proteins than that on ‘cooler’ burns. Nutrient quality of plants following fire appeared to depend on available soil moisture as well as on the ‘intensity’ of the burn.

10.4 WILDFIRE CHARACTERISTICS
The role of fire as a factor in the ecology of the boreal forest has been well documented by numerous investigators (Kayll, 1968; Komarek, 1968; Kiil and Chrosiciewicz, 1970; Rowe and Scotter, 1973; Methven et al., 1975; Burgess and Methven, 1977; Woods and Day, 1977). The increased buildup of forest fuels after early logging activities resulted in wildfires that increased the extent of jack pine in the logging sectors of the boreal forest (Benzie, 1977; Burgess and Methven, 1977). The major source of ignition for wildfires in the boreal forest before the arrival of man was lightning and even after man's arrival it contributed significantly to wildfire ignitions (Kourtz, 1967;
Komarek, 1968). Komarek (1968) viewed the role played by lightning in the boreal forest ecology as very significant, and refers to the boreal forest as a lightning fire bioclimatic region. Boreal forest species such as jack pine, lodgepole pine, black spruce, trembling aspen, and white birch are all well adapted to reproducing after fire. Heinselman (1971) found that 80-90% of the virgin forest in the Boundary Waters Canoe Area in northern Minnesota has resulted from fire.

Before man’s intervention, intervals as short as 5 years and as long as 100 years between fires were documented for the boreal forest (Heinselman, 1969, 1971, 1973; Shafi and Yarranton, 1973; Swain, 1973; Burgess and Methven, 1977; Cwynar, 1977; Woods and Day, 1977). Heinselman (1971) found an interval of 300 years in some instances. Heinselman (1973) estimated that the fire cycle, i.e., the number of years required to burn over an area equal to the whole area of the forest (Van Wagner, 1978), in the Boundary Waters Canoe Area was between 70 and 100 years. Van Wagner (1978), analysing Heinselman’s (1973) data, theorized that 50 years was a more realistic figure. Woods and Day (1977) showed that, in western Ontario, fires now occur on the average every 870 years because of improved fire suppression techniques.

As determined with the aid of the Canadian Forest Fire Weather Index, the major proportion of the jack pine range lies in a low to moderate fire weather zone while the remainder is classed as a high fire weather zone (Simard, 1973). Fire in most of this jack pine region will occur at the rate of 0-3.9 fires/1000 km²/year with smaller portions of the region having up to 7.7 fires/1000 km²/year (Simard, 1975). In areas near urban centres, fires may occur at a rate of 27/1000 km²/year.

Increased interest in quantitative data has resulted in the in-depth documentation of wildfires in the jack pine forest (Van Wagner, 1965; Walker and Stocks, 1971; Stocks and Walker, 1973; Stocks, 1975). Description of the aerial fuel components of the jack pine forest (Brown, 1965; Quintilio et al., 1977; Walker and Stocks, 1975) has enabled investigators to estimate crown fuel consumption during wildfires. The estimation of crown fuel consumption makes it possible to predict the frontal fire intensity (kW/m), which is synonymous with Byram’s fire intensity (Byram, 1959), and total heat release (kJ/m²).

Fire researchers at the Great Lakes Forest Research Centre in Ontario are investigating fire behaviour in a mature jack pine stand with a black spruce understorey originating from a fire in 1899 and in an immature jack pine stand originating from a fire in 1948. Since the inception of this study, 13 and 17 burns, respectively, have been conducted under various fire weather conditions. Descriptions of the two fuel types are contained in Walker and Stocks (1975). Fire rates of spread in the mature stand have ranged from 0.5 to 15 m/min with frontal fire intensities of 108-6308 kW/m. The immature stand
has had rate of spread measurements averaging 11–68 m/min with associated frontal fire intensities averaging 672–59596 kW/m. Less intense fires occurred in the mature stand because it was difficult for the fire to crown without the aid of any ladder fuels. Only at a wind speed of 32 km/h was the fire able to torch in this mature stand (B. J. Stocks, 1979, personal communication).

Quintillo et al. (1977) conducted seven experimental burns in open, mature jack pine stands in northern Alberta in which fire spread rates averaged 0.6–6.1 m/min. They observed that fuel moisture was the controlling factor in the fire’s rate of spread when the wind was constant. Other factors which were found to affect the rate of spread were wind speed and direction, ground vegetation, and quantity and continuity of surface fuel. In these burns, as a reflection of fire weather conditions, fuel consumption (kg/m²) was 43–57% for woody fuels and 36–76% for the duff. The duff depth was reduced by 28–62%.

The study in Ontario supports remarks by Van Wagner (1977) who found that young to semi-mature stands were more susceptible to crowning than were older stands whose crowns are higher and thinner. Such mature stands generally support only surface fires. Normal daily convection activities produce irregular winds with gusts interspersed with lulls. Van Wagner (1977) observed that variations in wind speed in combination with stand structure and topography can produce intermittent active crowning. Such intermittent crowning can be readily observed from the air where it produces a ribbon effect of burned and unburned crowns in the landscape.

Fuel moisture, an important factor in fire behaviour, is strongly affected by atmospheric conditions such as temperature, relative humidity, wind speed, and precipitation. Van Wagner (1967) found foliar moisture content of eastern Canadian conifers including jack pine to be at their lowest in the spring. Stocks (1970) observed that evaporation from the surface of the forest floor is important in the duff-drying pattern of various duffs including jack pine.

Van Wagner (1973) has predicted fire spread rates for standing jack pine and for jack pine slash using the fuel moisture codes and fire behaviour indices of the Canadian Forest Fire Weather Index. On the basis of their experimental burns, Quintillo et al. (1977) predicted the rates of spread for similar jack pine stands in northern Alberta, using a simplified version of Van Wagner’s model.

### 10.5 PRESCRIBED FIRE

A forest manager may employ either wildfire or prescribed fire as a management tool to meet a specific objective. Wildfires have seldom been used in the past because of the inherent difficulty of controlling them and
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because of the common attitudes towards total fire suppression by the personnel responsible for their control. While prescribed fire has been used in North America, it has not found widespread application.

Jack pine regeneration silviculture began in the 1930s when it became evident that the species would not regenerate adequately after harvest cutting unless special silvicultural practices were undertaken. Reasons for failure of jack pine to regenerate on the cutover sites have included non-receptive seedbeds, insufficient moisture, inadequate seed supply, insufficient light, and excessive plant competition (Eyre, 1938; Eyre and LeBarron, 1944; Rudolf, 1946; Farrar et al., 1954; Beaufait, 1959, 1960a; Chrosiewicz, 1959, 1967, 1974, 1978d; Adams, 1966; Cayford, 1966b; Cayford et al., 1967; Foster et al., 1967). Research into the use of prescribed burning as a management tool in jack pine regeneration silviculture began in Ontario and Michigan in the 1940s and 1950s (Beaufait, 1959; Chrosiewicz, 1959) and initial results indicated that the technique had potential. Further research was conducted in the 1960s and early 1970s in Minnesota, Ontario, Manitoba, and Saskatchewan (Adams, 1966; Cayford 1966a; Cayford et al., 1967; Chrosiewicz, 1967, 1970, 1974, 1978a, b, c, d; Foster et al., 1967; Ahlgren, 1963, 1970). The results are still being evaluated in terms of jack pine regeneration (Chrosiewicz, 1978d), but practically no new experimental work has been undertaken in recent years.

At the same time operational prescribed burning has found relatively little support largely because of the availability of alternative mechanized methods of site preparation (Cayford, 1971). However, by the late 1970s, an increasing backlog of non-regenerated jack pine land, increasing costs of mechanized site preparation, and an increasing awareness of fire management have placed prescribed burning in a more favourable light as a silvicultural practice (McRae, 1979b).

The major use of prescribed fire in jack pine slash today is for silvicultural purposes, namely site preparation for planting and seeding. Other minor uses of prescribed fire are for fire hazard reduction and wildlife management.

Direct seeding has been shown to be successful on sites that have undergone prescribed burning (Ahlgren, 1970; Chrosiewicz, 1970, 1978d; Johnson, 1974). Following a successful series of burning and seeding treatments, Chrosiewicz (1970) compared results from scarified and unscarified seedbeds and reported that pre-burn scarification was unnecessary for burning and seeding treatments to be effective. He also stressed that determination of the amount of seed required for broadcast seeding depends on many factors including seed viability, quality of fire-produced seedbeds, mineral soil materials present, and anticipated losses to birds and rodents.

Chrosiewicz (1970) observed that, to secure the desired number of seedlings per hectare at more or less uniform spacing, the intensity of seeding must be inversely adjusted in relation to the quality of post-burn seedbed
conditions as defined by the average depth of residual duff and the exposure and texture of mineral soil materials. In his opinion, provided that seed is more than 70% viable and is treated with bird- and rodent-repellent chemicals, this type of adjustment would probably range from 70 to 700 g of seed per hectare. Ahlgren (1970) found that 385 g of viable seed per hectare gave a well-distributed stand of trees if seeding was done in the autumn when mouse activity was low.

Spring plantations on areas that have undergone prescribed burning were observed to have a higher survival rate and a greater height growth than autumn plantations. It was also found that plantations survived severe drought better than direct seeded areas (Cayford, 1966a; Walker and Dobbs, 1968). Chrosniewicz (1978d) considered that the duff depth need be reduced only moderately during a prescribed burn for planting. Planters can easily get the seedling roots into direct contact with mineral soil even through a moderate duff depth. This observation is true only on sites where hardwood species, including deciduous shrubs, are absent and will not resprout to compete with planted seedlings.


The behaviour of prescribed fires must be understood by both fire and silvicultural specialists if the objectives of burning are to be attained. Each prescribed fire is unique and its behaviour depends on many factors including fuel conditions, weather, and topography. The need for more quantitative fire behaviour data is now recognized (McRae 1979a,b) and a handbook has been produced to enable the adequate documentation of fuel and fire behaviour characteristics on prescribed burns in northern Ontario slash complexes (McRae et al., 1979).

Relationships between fire behaviour in jack pine slash and fire weather conditions in Ontario as expressed by the Canadian Forest Fire Weather Index Tables (Anon., 1978) were developed by Stocks and Walker (1972). Their work on producing a Fire Behaviour Index for the jack pine logging slash fuel type has aided the planner of prescribed burns in choosing codes or indices of the Canadian Forest Fire Weather Index to meet burn objectives. Frontal fire intensity, rate of spread, and fuel consumption parameters (total fuel consumption, slash consumption, depth of burn) were found to be strongly related to the Fire Weather Index, Initial Spread Index, and Buildup Index, respectively. Chrosniewicz (1978a,b) found that the Duff Moisture Code was sufficient for predicting duff-depth and duff-cover reductions by
burning when used with the pre-burn duff depth and cover in Manitoba and Saskatchewan.

10.6 CONCLUSIONS

The unique ecological role played by wildfire in the jack pine forest must be considered carefully when fire ecology and silviculture in this forest ecosystem are being studied. It must also be recognized that one cannot generalize from the ecological changes brought about by fire in one situation and expect the same result in another situation. Each fire may create a different forest succession, the existence of which depends largely on conditions prevailing before the fire and the characteristics of that particular fire. Because of the variability which may be encountered, further research is needed to fill gaps in our knowledge, particularly about the specific fire effects over the entire range of jack pine ecosystems. One must not neglect Grigal and McColl's (1975) warning that: 'Every fire is an individual event, and until a number of the possible types of fires are studied, extrapolation must be done cautiously.'

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