Forest Research Branch

SOME FACTORS INFLUENCING JACK PINE REGENERATION AFTER FIRE IN SOUTHEASTERN MANITOBA

by

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Sommaire en français

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Some Factors Influencing Jack Pine Regeneration After Fire in Southeastern Manitoba[1]

by

J. H. CAYFORD[2].

INTRODUCTION

In September 1955 a wildfire burned over an area of 24,000 acres in the northern portion of the Sandilands Forest Reserve, destroying approximately 12,000 acres of merchantable and young growth jack pine[3]. The following summer a fact-finding investigation was begun to determine the amount and distribution of natural jack pine regeneration under the various forest conditions. At the same time, general information was obtained regarding some of the important factors that appeared to have affected germination, survival and early growth. Investigations were carried out annually from 1956 to 1961 with the exception of 1959.

LITERATURE REVIEW

It is well known that most of the present-day jack pine forests owe their existence to the occurrence of forest fires. Jack pine cones, which are generally serotinous, open at temperatures of between 120° and 140°F (Rietz 1937, 1941, Eyre and LeBarron 1944, Cameron 1953) and seeds remain viable even after brief exposure of the cones to temperatures of between 700° and 1,000°F (Beaufait 1960b). Consequently, the usually brief period of heat from a forest fire can bring about cone opening on the trees without killing the seeds. At the same time fires prepare a favourable seedbed as they remove the accumulated organic layers on the soil surface, reduce competing plant growth, kill seed-eating rodents and birds and produce a temporary fertilizing effect (Watson 1937).

The partial shade created by dead standing trees and by fallen logs on burned-over areas provides favourable conditions for jack pine seed germination (Fraser and Farrar 1953) which usually occurs promptly after seed dispersal if conditions of temperature and moisture are suitable. If favourable weather continues during the first growing season a stand of jack pine is likely to be regenerated successfully (Eyre and LeBarron 1944). However, many factors are capable of causing seedling mortality, and regeneration may fail following fire. Areas originally supporting jack pine may thus be converted to brushland (Eyre and LeBarron 1944, Kabzems and Kirby 1956).

Regeneration following slash fires in clear-cut jack pine stands has usually been inadequate because of the destruction of cones in the slash. In the few instances where regeneration has apparently been successful, careful examinations have revealed the seed source to be standing residual trees rather than the slash on the ground (Watson 1937, LeBarron and Eyre 1938).

In partially-cut jack pine stands, regeneration following fire is usually satisfactory, provided an adequate seed source is present. In Michigan approximately 75 cone-bearing jack pine trees, well distributed over an acre, were required to fully restock an area following fire (Watson 1937). In Saskatchewan

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[3] For botanical names of all plant species mentioned in text, see Appendix.

a 70-year-old residual stand of 60 trees per acre was found to be capable of completely regenerating an area after fire (Jameson 1961), while in northern Minnesota as few as ten mature dominant trees per acre, averaging 12 inches in diameter, provided 15,000 to 20,000 seedlings per acre (Ahlgren 1959). However, Beaufait (1960a) reported that prescribed fires in Michigan in June 1958, on areas where 19 and 24 seed trees per acre had been left standing, resulted in first-year stocking of only 18 and 25 per cent and densities of 450 and 1,200 per acre. As the summer of 1958 was very dry, better results might be expected during a more favourable year.

If a second fire occurs before a young stand has produced cones, the forest land may be converted to brush or grass cover. If it occurs after the young stand has produced cones, then the only adverse result may be the delaying of stand replacement by a few years (Eyre and LeBarron 1944).

DESCRIPTION OF STUDY AREAS

The areas lie within the northern portion of the Sandilands Forest Reserve approximately 50 miles southeast of Winnipeg, in the Rainy River Section (L.12) of the Great Lakes—St. Lawrence Forest Region (Rowe 1959).

The climate is characterized by cold winters and cool summers; January and July mean temperatures are 0° and 65°F respectively. Average annual precipitation is 21 inches, of which 12 inches falls during the period April to August (Anon. 1957).

Soils on the examined areas, chiefly sand to loamy sand podzols, were classified as dry, moderately fresh and moist after Hills (1952). The dry site had poorly developed, stone-free soil profiles; the permanent water table occurred below rooting depth. Before the fire, minor vegetation was dominated by an ericaceous low shrub cover of bearberry, low-bush blueberry, and wintergreen; reindeer lichen was widespread. The moderately fresh site was characterized by the presence of numerous surface boulders (Figure 1) and a soil parent material of unsorted morainic origin. Scattered hardwoods—white birch, balsam poplar, and trembling aspen—had been present in the pre-fire jack pine stands. Shrubs were the dominant stratum of minor vegetation; the more abundant species included prairie willow, Bebb's willow, green alder, rose, choke and pin cherry, and Saskatoon. Soils on the moist site were characterized by mottling throughout the B horizon and by the occurrence of a water table approximately three feet below ground level during midsummer. Minor vegetation before the fire was characterized by a feather-moss cover dominated by Shreber's moss. The dry, moderately fresh, and moist soil classes correspond to Jameson's (1961) site groups D, C and B, respectively.

In the selected study areas the fire had crowned, killed the vegetation, consumed the soil organic horizons, and exposed mineral soil (Figure 2). Prior to the fire, the pine stands varied in age from 30 to 80 years; some stands had been cut over, others were undisturbed. Cut-over stands had been logged by various methods including clear-cutting, strip-cutting, seed-tree cutting leaving 10 and 30 trees per acre, and salvage cutting of trees damaged by a windstorm in 1954. Mineral soil seedbeds had been prepared mechanically with an Athens disk plough on portions of some of the cut-over areas. On a number of areas salvage cutting was carried out after the fire. Descriptions are given in Table 1.

Figure 1. A moderately fresh site after fire. Note the presence of numerous surface boulders. The area was cut after the fire

Figure 2. A burned-over stand of jack pine on a dry site. Prior to the fire this area had been cut over by the seed-tree method

TABLE 1—DESCRIPTION OF BURNED-OVER STUDY AREAS

Study area number	Stand age years	Disturbance before fire		Disturbance after fire	Site
		Cutting	Ground preparation		
1	30–35	None	None	None	Dry
2	60	Uncut* strips	None	Cut over	Dry
3	60	Cut* strips	None	None	Dry
4	60	Seed-tree cut	None	None	Dry
5	60	Clear-cut	None	None	Dry
6	60	Cut strips	Disked	None	Dry
7	60	Seed-tree cut	Disked	None	Dry
8	60	Clear-cut	Disked	None	Dry
9	25–35	None	None	None	Mod. fresh
10	50–75	None	None	Cut over	Mod. fresh
11	50–75	None	None	Cut over	Mod. fresh
12	70–80	Windfall salvage	None	None	Mod. fresh
13	60–70	None	None	Cut over	Moist

* Both uncut and cut strips were one chain or less in width.

METHODS

Regeneration was examined annually from 1956 to 1961, with the exception of 1959, on 160 permanent plots each 1/100-acre in size. One hundred and thirty-two of the plots had been established prior to the fire in conjunction with a combined cutting method and seedbed treatment study to regenerate jack pine. Twenty-eight more plots were selectively located in 1956 to provide a greater variety of burned-over conditions. In addition, sixty-five temporary milacre quadrats were examined on a moist site in 1960.

Each plot was divided into ten one-miliacre quadrats. During each examination all seedlings were tallied on one list-count quadrat per plot, while the other nine quadrats were recorded as "stocked" or "not stocked" with jack pine and other species.

In 1956 general notes were made regarding the original forest cover, minor vegetation, shade, seedbed conditions and site. In 1957 and 1958 the height of the tallest seedling on each list-count quadrat was measured and in 1960 the height of the tallest seedling on each quadrat was measured. In 1961 the heights of all seedlings, both living and dead, were measured.

RESULTS AND DISCUSSION

Stocking, Density and Mortality Trends

Stocking and density trends for dry and moderately fresh sites for the period 1956-61 are shown in Figure 3, based on pooled data from all 12 areas regularly examined. Stocking over the period remained constant on the moderately fresh site, whereas on the dry site an initial average stocking of 65 per cent was reduced to 44 per cent by 1957 and to 33 per cent by 1961. Number of seedlings per acre in 1956 did not vary greatly between sites; however, by 1961 there were 5,200 stems per acre on the moderately fresh site as compared with 1,400 on the dry site.

Nearly all seedlings resulted from germination in the spring of 1956. More than 1,100 seedlings were examined during the study; over 99 per cent of them were 1956 germinates, while the remainder were 1955, 1957 and 1958 germinates.

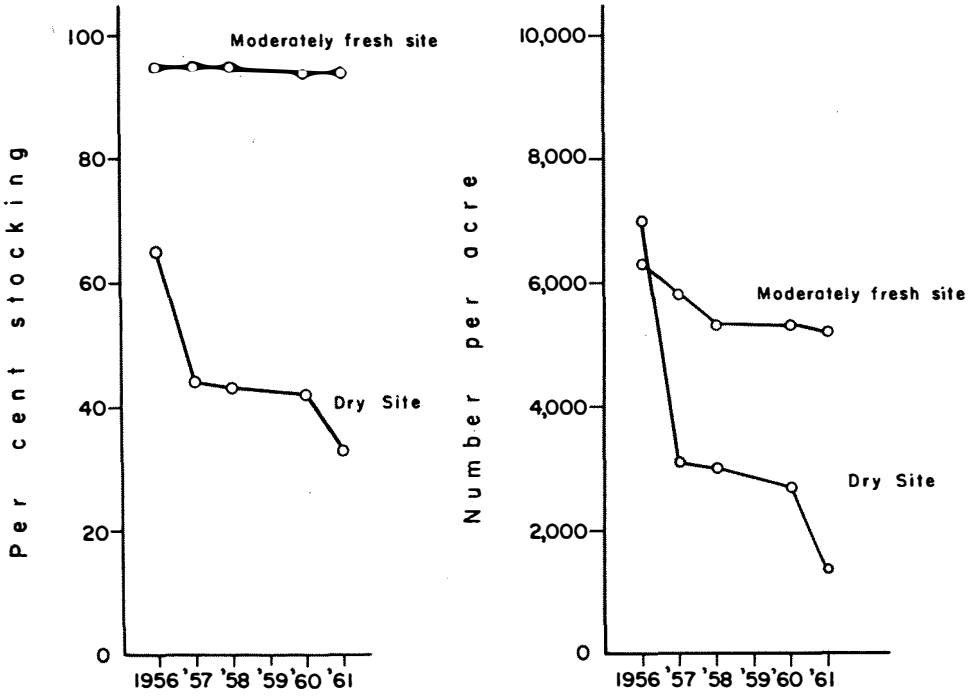

Figure 3. Stocking and density of jack pine regeneration following fire

These findings from a fall fire contrast with results reported for spring and summer fires by Ahlgren (1959) who found in a study in Minnesota that 57 per cent of the seedlings originated the first year, 35 per cent the second year and 8 per cent the third year.

Most seedling mortality occurred in the summers of 1957 and 1961 (Figure 3). Although the 1957 growing season precipitation was probably above average[1], hot dry spells in July and August caused mortality. During the 13 days between July 18 and 30, no measurable precipitation occurred and during the 14 days between August 13 and 26 precipitation amounted to only 0.07 inches. Throughout these periods mortality was also observed among seedlings planted in the spring of 1957 by the Manitoba Forest Service (Anon. 1958).

Seedling mortality in 1961 is attributed to the extreme drought conditions that prevailed in the region during the spring and summer of that year. At Winnipeg precipitation was as follows: April 1.7 inches, May 0.4 inches, June 0.1 inches, July 3.3 inches, August 0.2 inches, and September 2.3 inches. Total precipitation for the period was 8.0 inches as compared with the long-term average of 14.3 inches. In the Sandilands Forest Reserve no rain occurred during the period May 31 to July 10, and growing season precipitation (April to September) was approximately 10 inches.

Effects of Site

Stocking and density of regeneration varied considerably between sites (Table 2). All burned-over areas undisturbed before the fire were well or fully

[1] As shown by weather records for Winnipeg, approximately 50 miles west of the study areas.

stocked[1] in 1956 regardless of whether the sites were dry, moderately fresh, or moist. Little mortality occurred on the moderately fresh and moist sites during the five years subsequent to the fire; in 1961, the areas were fully stocked with from 4,000 to 12,000 stems per acre. Considerable mortality occurred on the dry site; in 1961 an area that had supported a 30- to 35-year old stand was well stocked, and one that had supported a 60-year old stand was understocked. On each area there were just 800 stems per acre.

TABLE 2—EFFECT OF SITE ON JACK PINE STOCKING AND DENSITY

Stand condition before fire	Study area number	Site	Stand age (years)	Per cent stocking		Number per acre		Basis no. of quadrats
				1956	1961	1956	1961	
Undisturbed	1	Dry	30–35	98	75	11,800	800	40
	2	Dry	60	75	33	4,600	800	200
	9	Mod. fresh	25–35	98	100	11,400	9,800	50
	10	Mod. fresh	50–75	92	90	5,300	3,900	120
	11	Mod. fresh	50–75	90	100	4,000	4,000	20
	13	Moist	60–70	—	89*	—	12,100*	65
Cut-over	3	Dry	60	63	26	7,000	800	200
	4	Dry	60	49	38	1,600	1,100	160
	5	Dry	60	24	10	1,000	100	200
	12	Mod. fresh	70–80	94	94	4,600	4,000	50

*Data in 1960.

A stand that had been cut over before the fire, located on the moderately fresh site, was fully stocked in both 1956 and 1961; density in 1961 was 4,000 stems per acre. On the dry site, initial stocking in cut-over stands varied from understocked to well stocked; mortality during the summers of 1957 and 1961 resulted in understocked stands with from 100 to 1,100 stems per acre (Table 2).

The results from the 1961 examination clearly demonstrate the effects of site on mortality. Over 50 per cent of the seedlings on the dry site died in 1961 as compared with only 2 per cent on the moderately fresh site (Tables 3 and 4). Mortality was attributed to unfavourable soil moisture conditions in the upper soil horizons during drought periods, and consequently increased with decrease in seedling size (Table 4).

Height growth of jack pine seedlings varied greatly between sites. In 1960 average heights of the tallest seedling per stocked quadrat for individual areas were from 1.2 to 1.8 feet on the dry sites from 2.9 to 3.6 feet on the moderately fresh sites, and 3.8 feet on the moist site.

TABLE 3—EFFECT OF SITE ON 1961 MORTALITY

Site	Number living per acre 1960	Number living per acre 1961	Per cent mortality
Dry	2,700	1,300	52
Moderately fresh	5,300	5,200	2

[1] Stocking standards are those used by Candy (1951) for miliacre quadrats. Fully stocked, 80 to 100 per cent; well stocked, 60 to 79 per cent; moderately stocked, 40 to 59 per cent; understocked, 20 to 39 per cent; failure, under 20 per cent.

TABLE 4—1962 MORTALITY BY SEEDLING HEIGHT CLASSES

Height class (inches)	Dry site	Moderately fresh site
	Per cent mortality	
1- 6	92	100
7-12	70	14
13-18	62	0
19-24	39	0
25-30	18	0
31+	0	1
All	52	2

Basis: 367 seedlings on the dry site and 128 on the moderately fresh site.

The foregoing results point out the important role played by site in the regeneration of jack pine after fire. On moderately fresh and moist sites, initial stocking was excellent, mortality low, and in 1961 well-stocked six-year old stands of regeneration were present. Provided seed supply was adequate, areas on the dry site were fully or well stocked in the first year after fire. However, mortality occurred in both 1957 and 1961, and by the end of 1961 the areas were generally understocked. It is evident that climate assumes an important role on the dry site, and when weather conditions are favourable well-stocked stands can be expected to follow fire. But, if weather conditions are unfavourable during any of the first few growing seasons, dry sites may not regenerate adequately regardless of density of initial stocking.

Effects of Stand Density Before Fire

Stand density at the time of fire had an important effect on subsequent initial stocking, attributed to differences in amount of seed available. Results from a 60-year old stand on the dry site which had been logged by three different methods showed that best stocking occurred under the densest canopy, and poorest stocking under the lightest canopy. In 1956 both the uncut and cut strips in a strip-cut area were well stocked, an area cut by the seed-tree method was moderately stocked, and a clear-cut area was understocked (Table 5). By 1961, as a result of mortality, all areas were understocked. Amount of mortality did not appear to be correlated with density of the fire-killed stand.

TABLE 5—EFFECT OF STAND DENSITY BEFORE FIRE ON INITIAL STOCKING—60-YEAR OLD STAND ON A DRY SITE

Study area number	Disturbance before fire	Per cent stocking in 1956	Number per acre in 1956
2	Uncut strips	75	4,600
3	Cut strips	63	7,000
4	Seed-tree cut	49	1,600
5	Clear-cut	24	1,000

Results indicate that on the dry site, burning an average of 20 dominant seed trees per acre, plus approximately 150 unmerchantable 1 to 3 inch trees, provided adequate seed to initially restock an area with 49 per cent stocking

and 1,600 seedlings per acre (Table 5). On the moderately fresh site, fire in a stand of approximately 80 trees per acre, resulted in an initial stocking of 94 per cent with 4,600 seedlings per acre, a 57-fold increase in the number of jack pine (Table 2, Area 12). These findings may be compared with those reported by Ahlgren (1959) and by Jameson (1961) who found, respectively, that the burning of 10 and 60 seed trees per acre resulted in satisfactory regeneration.

Effects of Stand Age

Results from the study show that initial stocking was adequate following fire in both non-merchantable stands 25 to 35 years of age and merchantable stands 50 to 80 years of age (Table 6). Even the young stands, with most trees less than six inches in diameter, contained sufficient seed to satisfactory restock burned areas.

TABLE 6—EFFECT OF STAND AGE ON STOCKING—STANDS UNDISTURBED BEFORE FIRE

Study area numbers	Stand description and age	Dry site		Moderately fresh site	
		Per cent stocking			
		1956	1961	1956	1961
1, 9	Non-merchantable, 25 to 35 yrs.	98	75	98	100
2, 10, 11	Merchantable, 50 to 80 yrs.	75	33	92	91

Effects of Topography

Topography of the study areas was flat, with the exception of a dry site from which a 60-year old stand had been strip-cut before the fire (Areas 2, 3 and 6). There, slopes averaged 5 to 10 per cent and both germination and survival were somewhat related to aspect. In 1961 best stocking generally occurred on northerly and easterly aspects (Table 7). On the Nisbet Provincial Forest in Saskatchewan, Jameson (1961) observed jack pine reproduction on clear-cut areas to be more abundant on eastern and northern aspects than on southern and western aspects or on level areas.

TABLE 7—EFFECT OF TOPOGRAPHY ON STOCKING

Topography	Per cent stocking		Per cent reduction in stocking 1956–1961
	1956	1961	
North slope	93	49	47
Northeast slope	73	40	45
East slope	81	30	63
Southeast slope	100	80	20
South slope	30	10	66
Southwest slope	95	60	36
West slope	83	13	84
Northwest slope	76	24	68
Depression	66	30	55
Level	58	17	71
Knoll	54	20	63
Average	73	32	56

Effects of Microhabitat

On all areas examined, the fire had consumed the soil organic horizons. Accumulations of charred organic matter did occur, but were generally confined to depressions in the soil surface or to microhabitats beside burned logs or branches. Many seedlings occurred amidst these accumulations probably because seeds had been blown or washed into the same places as the organic matter (Figure 4).

Prior to the fire, mineral soil seedbeds had been prepared with an Athens disk plough on cut-over Areas 6, 7 and 8. Disking created many depressions which provided favourable conditions for germination; this resulted in better stocking than on Areas 3, 4 and 5, which were logged similarly, but not disked (Table 8).

Mortality in 1961 did not vary between disked and undisked seedbeds. Approximately 76 and 77 per cent of quadrats stocked in 1960 on disked and undisked seedbeds, respectively, were stocked in 1961.

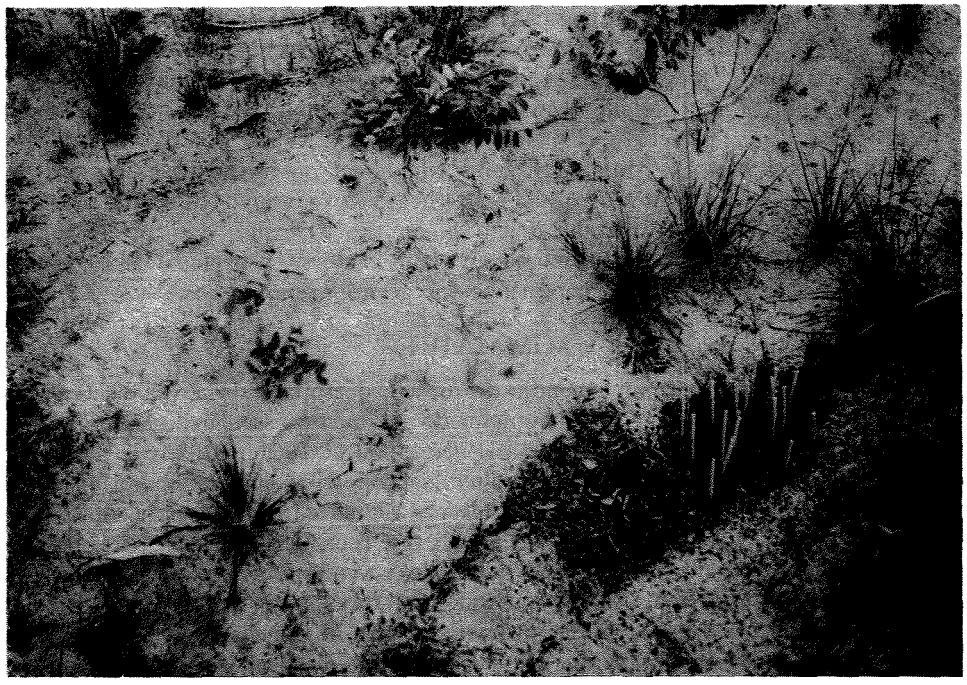

Figure 4. A burned-over area showing the occurrence of approximately 30 jack pine seedlings in a depression amongst an accumulation of organic matter

TABLE 8—EFFECT OF SEEDBED TYPE ON STOCKING

Study Condition numbers	Method of cutting	Disked		Not disked	
		Per cent stocking			
		1956	1961	1956	1961
3, 6	Strip-cut	82	38	63	26
4, 7	Seed-tree cut	92	56	47	38
5, 8	Clear-cut	64	26	24	10

Growth of jack pine seedlings did not differ on the two seedbeds. Heights of the tallest seedlings in 1960 averaged 1.6 feet on both conditions.

SUMMARY

In the fall of 1955 a forest fire burned approximately 12,000 acres of merchantable and young growth jack pine on the Sandilands Forest Reserve in southeastern Manitoba. A fact-finding observational study was carried out between 1956 and 1961 to determine the amount and distribution of natural jack pine regeneration occurring in various forest conditions following crown fire. At the same time, general information was obtained regarding some of the factors that appeared to have affected germination, survival and early growth.

More than 99 per cent of the seedlings resulted from germination in the spring of 1956. Mortality was most pronounced during hot dry periods that occurred during the summers of 1957 and 1961.

Site was one of the most important of the factors that affected survival and early growth of jack pine. On moderately fresh and moist sites, initial stocking was excellent, mortality was low, and by 1961 well-stocked six-year old stands of regeneration were present. Initial stocking on dry sites was generally adequate; however, as a result of mortality most areas were understocked in 1961. Early height growth was best on moist sites and poorest on dry sites.

Stand density at the time of fire had an effect on initial stocking on dry sites; best stocking occurred under the heaviest canopy. Germination and survival were somewhat related to aspect on the dry site, and in 1961 best stocking generally occurred on northerly and easterly aspects. Disking prior to the fire created favourable conditions for germination.

SOMMAIRE

A l'automne de 1955, un incendie de forêt a détruit environ 12,000 acres de pin gris marchand et de jeunes peuplements de même essence dans la réserve forestière de Sandilands, au Manitoba. Entre 1956 et 1961, l'auteur a poursuivi une étude sur le terrain afin de déterminer la proportion et la distribution de la régénération naturelle du pin gris sous divers régimes forestiers à la suite d'un feu de cimes. En même temps, il a recueilli des renseignements d'ordre général ayant trait à certains des éléments qui semblent avoir influé sur la germination, sur la survivance des semis et sur la croissance des jeunes sujets.

Plus de 99 p. 100 des semis proviennent de la germination survenue au printemps de 1956. La mortalité fut plus prononcée au cours des périodes de temps chaud et sec des étés de 1957 à 1961.

Le type de station a été l'un des facteurs les plus importants qui aient influé sur la survivance et la croissance des jeunes semis de pin gris. Dans les stations modérément fraîches et humides, la reconstitution initiale des peuplements a été excellente et la mortalité, faible, puis dès 1961 on observait la présence de peuplements de six ans bien reconstitués. En règle générale, la reconstitution initiale des peuplements dans les stations sèches a été suffisante; toutefois, par suite de la mortalité, la plupart des aires n'étaient qu'en partie repeuplées en 1961. La croissance en hauteur au départ a été la meilleure dans les stations humides, alors qu'elle a été la moins bonne dans les stations sèches.

La densité des peuplements au moment de l'incendie a influé sur leur reconstitution initiale dans les stations sèches; la meilleure reconstitution s'est

produite sous le couvert le plus dense. La germination et la survivance se sont aussi rattachées en quelque sorte à l'exposition dans la station sèche et en 1961, la meilleure reconstitution des peuplements a eu lieu, en règle générale, dans les aires exposées au nord et à l'est. La scarification exécutée antérieurement à l'incendie a créé des conditions favorables à la germination.

APPENDIX

Common and Botanical Names of Plants Mentioned in Text

Alder, green	*Alnus crispa* (Ait.) Pursh
Aspen, trembling	*Populus tremuloides* Michx.
Bearberry	*Arctostaphylos uva-ursi* (L.) Spreng.
Birch, white	*Betula papyrifera* Marsh.
Blueberry, low-bush	*Vaccinium angustifolium* Ait.
Cherry, choke	*Prunus virginiana* L.
Cherry, pin	*Prunus pensylvanica* L.f.
Lichen, reindeer	*Cladonia rangiferina* (L.) Web.
Moss, Shreber's	*Calliergonella schreberi* (Bry. Eur.) Grout
Pine, jack	*Pinus banksiana* Lamb.
Poplar, balsam	*Populus balsamifera* L.
Rose	*Rosa acicularis* Lindl.
Saskatoon	*Amelanchier alnifolia* Nutt.
Willow, Bebb's	*Salix bebbiana* Sarg.
Willow, prairie	*Salix humilis* Marsh.
Wintergreen	*Gaultheria procumbens* L.

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