SEEDSPOTTING SEVERAL SPRUCE SPECIES ON BURNED LAND IN WESTERN NEWFOUNDLAND

by

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FOREST RESEARCH LABORATORY
ST. JOHN'S, NEWFOUNDLAND
INFORMATION REPORT N-X-48

CANADIAN FORESTRY SERVICE
DEPARTMENT OF FISHERIES AND FORESTRY
JUNE, 1970

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Introduction

Burned cutovers often do not regenerate naturally in Newfoundland, primarily because a seed source is lacking. If such areas are to be maintained in a productive state, new stands must be established artificially by seeding or planting.

In 1958 a large-scale seedspotting experiment was established in western Newfoundland on a non-reproducing burned cutover. The purpose was to determine which of a number of species would be most suitable for seeding burned cutover areas using the seedspotting method.

The establishment of the experiment was reported by Wilton[1]. Remeasurements in the fall of 1961, in 1963, and in 1966 have been reported by van Nostrand and Wilton[2], Wilton (1964), and van der Pas[3]. The present report contains the results of a final remeasurement carried out in 1968, ten years after establishment. As well as comparing the results for the different species, an attempt has been made to show how site conditions have influenced their development.

Description of Area

The experiment lies on a low ridge at an elevation of about 650 feet, in the vicinity of Birchy Lake at 49°20'N and 56°53'W. It is in the centre of a triangular area bounded by Sandy Lake, Birchy Lake and the former Trans Canada Highway (Figure 1). This area is in Forest Section B28b (Rowe 1959), but forest conditions appear more like those in Forest Section B28a.

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[1] Wilton, W.C., 1958. Establishment Report. Direct seeding on burned-over land at Birchy Lake. NF-48. Can. Dep. Northern Aff. Nat. Res., Forest. Br., For. Res. Div., St. John's, Nfld.

[2] van Nostrand, R.S. and W.C. Wilton, 1961. Progress Report. Direct seeding on burned-over land at Birchy Lake, central Newfoundland. Can. Dep. Forest., Forest. Res. Br., St. John's, Nfld.

[3] van der Pas, J., 1966. Results of experimental spruce seeding on burned-over land at Birchy Lake, Newfoundland. Can. Dep. For., For. Res. Br., File Report, 22 p.

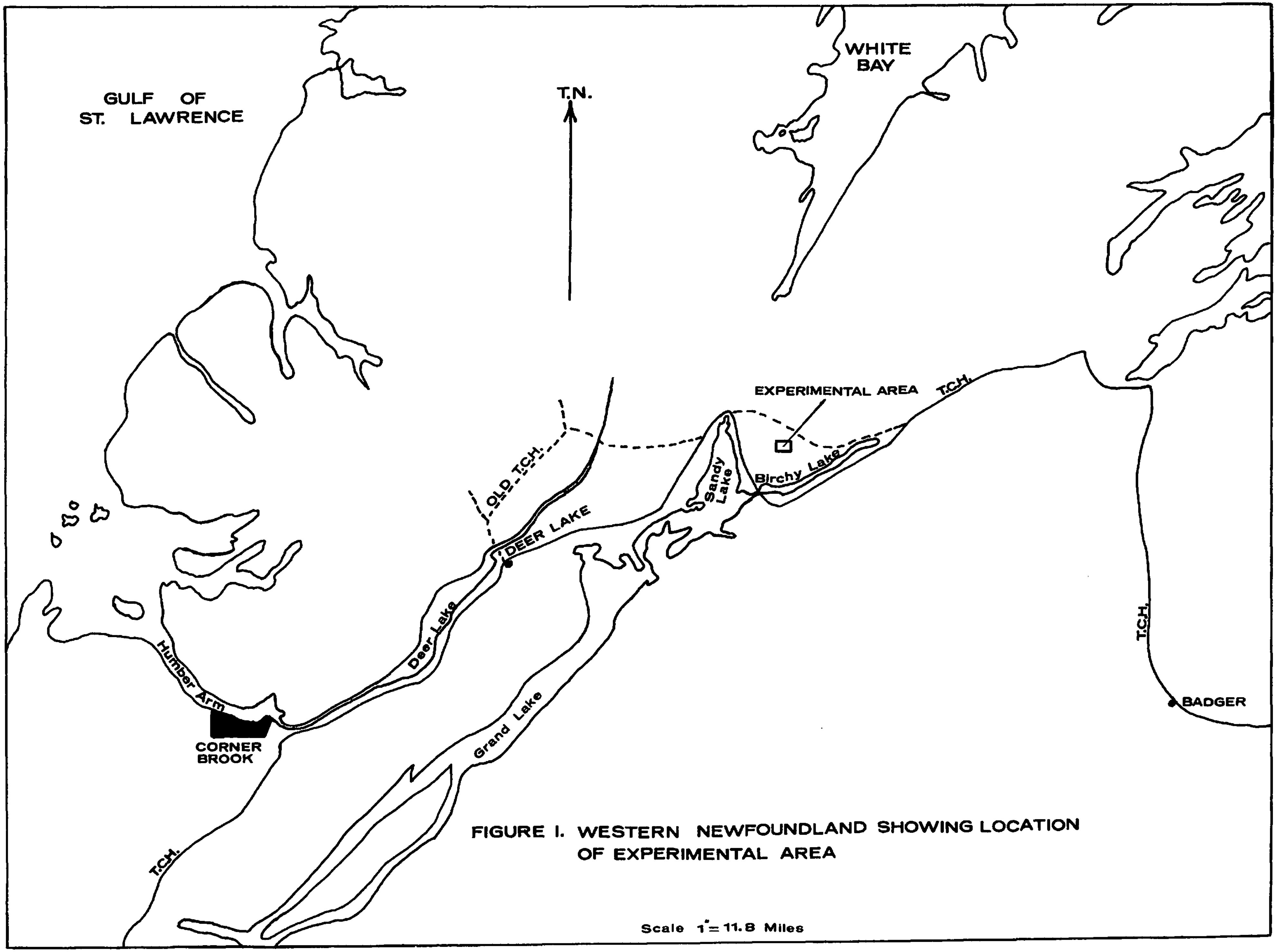

FIGURE I. WESTERN NEWFOUNDLAND SHOWING LOCATION OF EXPERIMENTAL AREA

The original stands were balsam fir (Abies balsamea (L.) Mill.) and black spruce (Picea mariana (Mill.) BSP.) with scattered large white pine (Pinus strobus L.) throughout. Fir was found mostly on the better drained sites while black spruce predominated on the poorly drained sites. Between 1955 and 1957 the area was cut over for pulpwood. During a hot dry period in August 1957 a fire burned over 1000 acres and in many places consumed most of the organic mantle.

Five site types, based essentially on soil moisture and drainage conditions, were recognized in 1968. These are:

I. Somewhat dry to fresh gentle upper slopes with well-drained sandy loam soils (in some places stony) in which rooting conditions are good; the organic layer is thin, generally less than one inch in depth and not matted; ground vegetation is dominated by a carpet of Cornus canadensis L. with Epilobium angustifolium L., Aralia nudicaulis L., Anaphalis margaritacea (L.) C.B. Clarke, Rubus idaeus L., and occasional non-vigorous patches of Dicranum and Polytrichum moss; the shrub layer is dominated by six- to eight-foot-tall white birch (Betula papyrifera Marsh.) regeneration.

II. Fresh to moist moderately steep upper slopes with well-drained sandy loam soils which are relatively thin over rock; the organic layer is thin, between one and two inches and not matted; ground vegetation is mainly moss and herbs as in I; the shrub layer is mainly ten-foot-tall white birch regeneration.

III. Moist to very moist gentle lower slopes, with fairly well-drained loamy soils, receiving drainage water from above; the organic layer is thick, at least four to six inches, and sometimes matted; the ground vegetation is primarily a carpet of Polytrichum and Dicranum moss with Cornus canadensis, Clintonia borealis (Ait.) Raf. and other herbs as in I; occasional patches of Kalmia angustifolia L., Vaccinium and other ericaceous dwarf shrubs occur on the very moist sites; four- to six-foot-tall birch regeneration is present.

IV. Wet lower slopes and valley bottoms, with gleyed sandy clay soil, in which water is not stagnant; the organic layer is thick, at least six inches; the ground vegetation which is very vigorous is mainly Sphagnum and Polytrichum moss with Equisetum, Carex spp., Clintonia and other herbs; four-foot-tall birch regeneration is present.

V. Very wet sphagnum bogs in poorly drained upland hollows with thick humus, apparently not burned by the fire; the ground cover is kalmia and other ericaceous dwarf shrubs, and stunted black spruce.

The distribution of the different site types over the experimental area is shown in Figure 2.

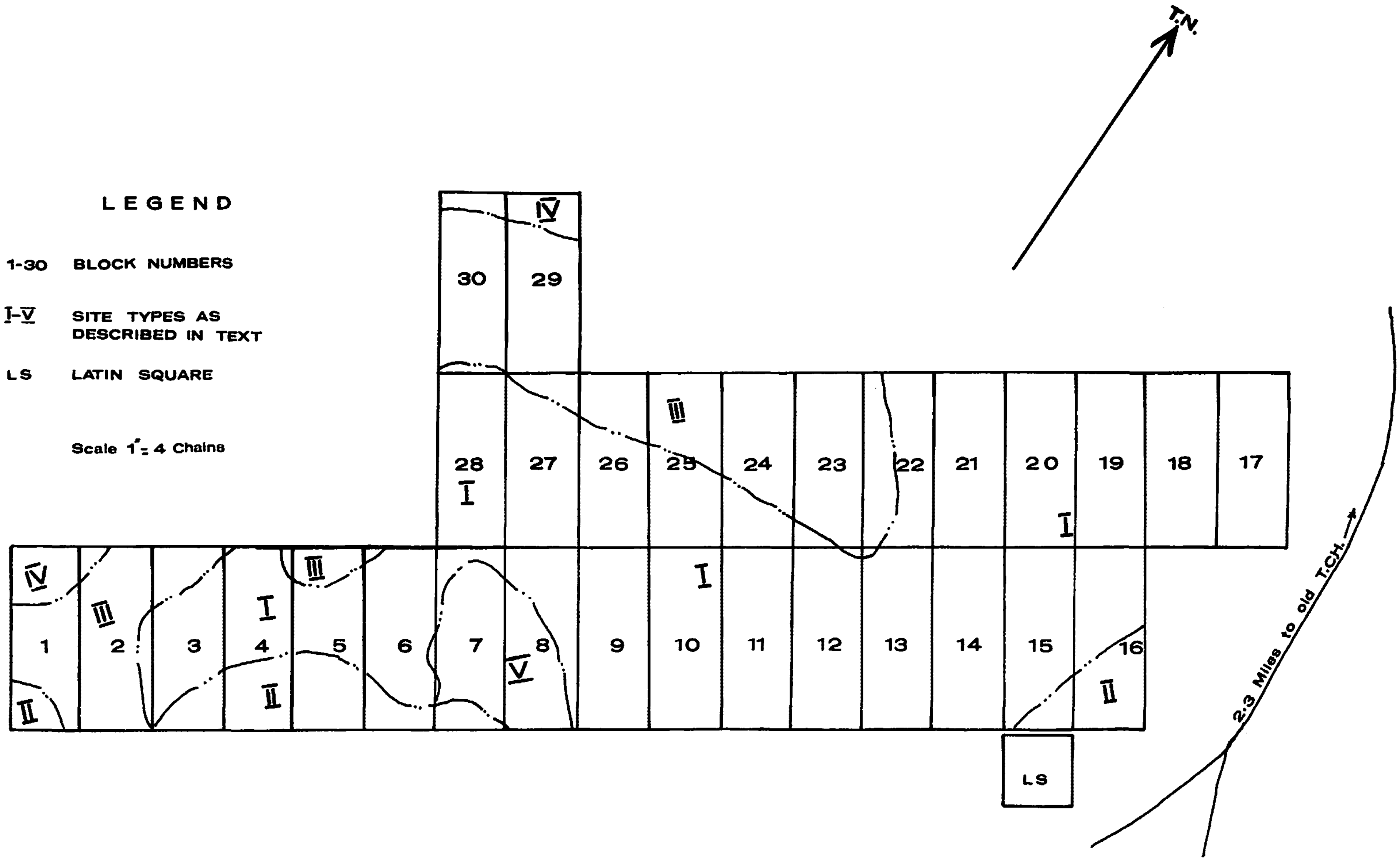

FIGURE 2 DISTRIBUTION OF SITE TYPES ON EXPERIMENTAL AREA

Experimental Design

The main experiment consists of 30 one-acre blocks each measuring two chains wide by five chains long. Alternate blocks were seeded as shown in Figure 3. Because of limitations in seed supply, some blocks were seeded with more than one species.

Seeding was performed during late May and early June in 1958. Spots were prepared at five-foot intervals by scuffing the surface with the foot; about ten viable seed were deposited by hand on each spot, then pressed into the seedbeds by tramping with the foot. The overall seeding intensity was approximately 17,000 viable seed per acre. On plot 30, freshly picked black spruce cones were sown instead of seed. Five cones were placed on each scuffed spot and tramped into the seedbed.

A smaller experiment utilizing a latin square design was established with nine of the species used in the main experiment. As shown in Figure 2, the latin square was situated entirely on site type II. The arrangement of species is shown in Figure 4. In each plot of the latin square nine seedspots each containing ten viable seed were sown at five-foot intervals as in the main experiment. The purpose of establishing the latin square was to permit statistical comparisons among all species which the design of the main experiment did not permit.

Table 1 gives a comparative listing of the species sown in the main experiment and the latin square experiment.

Remeasurement and Analysis

In August 1968 the main experiment was remeasured by means of a milacre quadrat survey. Two independent systems of establishing quadrats were used. One consisted of a series of 50 contiguous quadrats established on a diagonal line across each block from northeast to southwest. The second consisted of three lines of 20 quadrats established across each block starting at random points along one side. In blocks containing more than one species, sufficient lines were established so that each species or combination was sampled.

For each quadrat the following information was recorded: total number of seedlings by species (including all softwood species), number of stocked seedspots, number of seedlings in each seedspot, and height of the tallest seedling of each softwood species. Depth of humus was measured on one out of five quadrats in the diagonal remeasurement and on one out of ten quadrats in the random line remeasurement, the quadrats being selected systematically. Humus depths were related to the presence or absence of regeneration and its height growth.

On the latin square experiment each stocked seedspot was examined and the number of stems and height of the tallest were recorded.

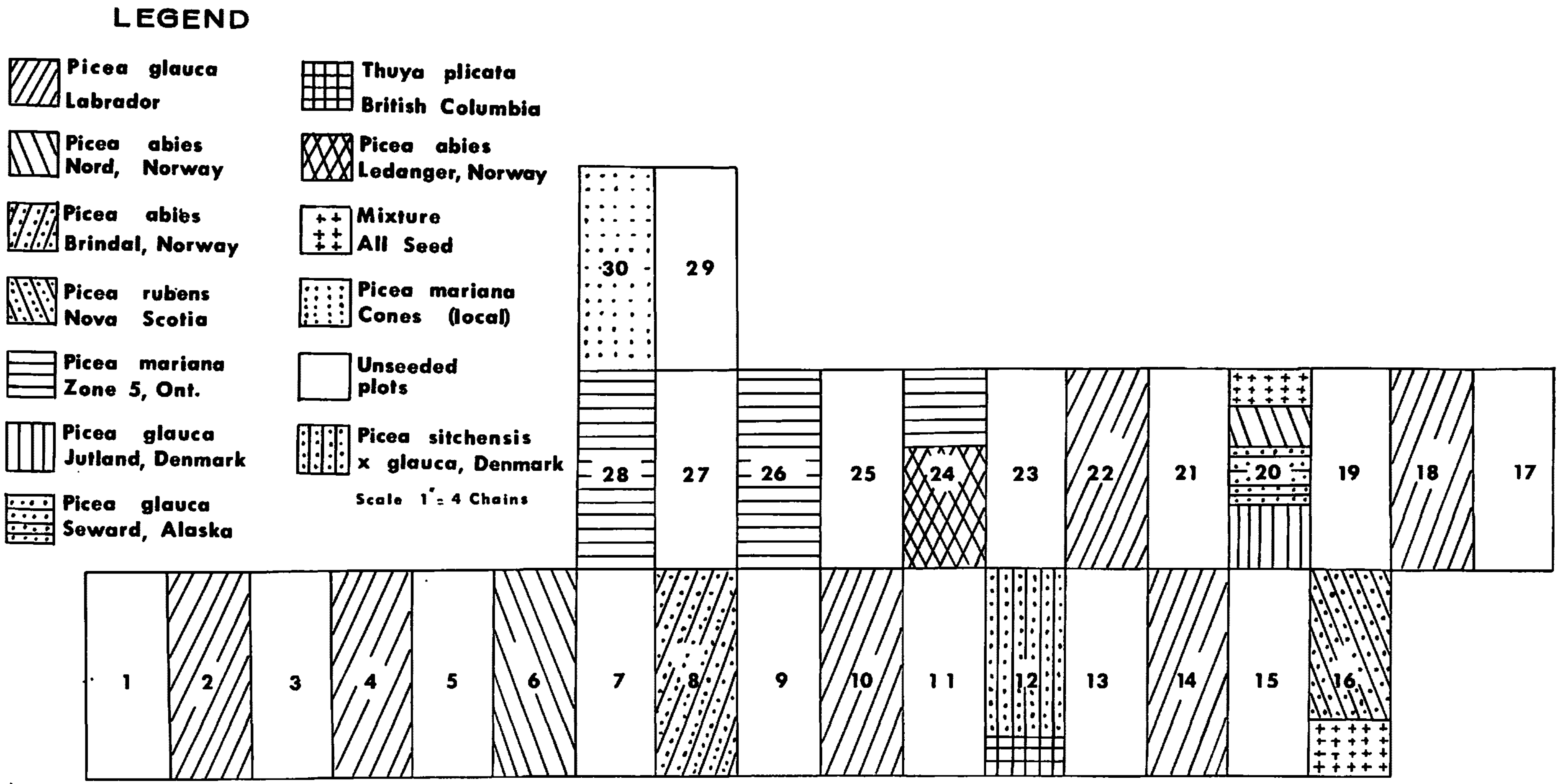

FIGURE 3. ARRANGEMENT OF SPECIES

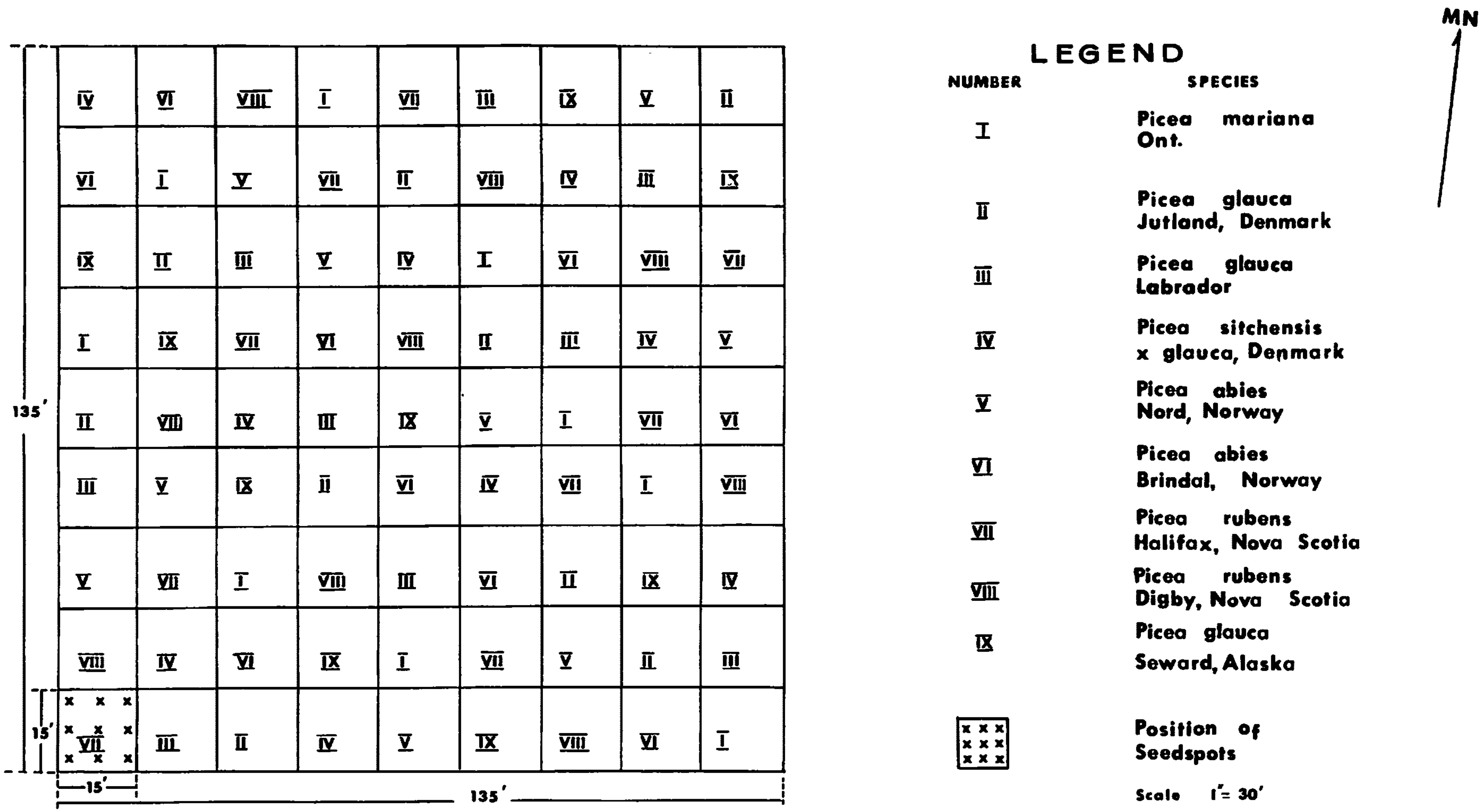

FIGURE 4. ARRANGEMENT OF SPECIES IN LATIN SQUARE EXPERIMENT

Table 1

Species and Strains Sown in Main Experiment and Latin Square

Species	Origin	Main Experiment	Latin Square	Common Name*
Picea abies (L.) Karst.	Brindal, Norway	X	X	Norway spruce (Nord)
Picea abies (L.) Karst.	Ledanger, Norway	X		Norway spruce (Ledanger)
Picea abies (L.) Karst.	Nord, Norway	X	X	Norway spruce (Nord)
Picea glauca (Moench) Voss	Seward, Alaska	X	X	White spruce (Alaska)
Picea glauca (Moench) Voss	Jutland, Denmark	X	X	White spruce (Denmark)
Picea glauca (Moench) Voss	Labrador	X	X	White spruce (Labrador)
Picea mariana (Mill.) BSP.	Zone 5, Ontario	X	X	Black spruce (Ontario)
Picea mariana (Mill.) BSP. (cones)	Central Newfoundland	X		Black spruce cones (local)
Picea rubens Sarg.	Digby, Nova Scotia		X	Red spruce (Digby)
Picea rubens Sarg.	Halifax, Nova Scotia		X	Red spruce (Halifax)
Picea rubens Sarg.	Nova Scotia	X		Red spruce
Picea sitchensis x *glauca*	Denmark	X	X	Sitka-white spruce hybrid
Thuya plicata Donn	British Columbia	X		Cedar
Mixture, all seed		X		Seed mixture

*These are the names used to identify the species throughout the remainder of this report.

In the analysis of the main experiment the results of seeding the various species were compared on the basis of percent stocking by milacre quadrat and number of seedlings per acre, as well as average height. The data obtained by the two sampling systems used in the remeasurement were compared by means of t-tests. These showed no significant differences (at the 0.01 level) between the mean values obtained for percent stocking and average height by the two sampling systems. Therefore the data were pooled for the remainder of the analysis. Because of the lack of replication of most species, an analysis of variance of the experiment could not be conducted. However, t-tests were used to compare the results on seeded plots and on unseeded plots.

For the latin square experiment the data were analyzed by standard analysis of variance techniques. Duncan's New Multiple Range test was used to determine the significance of differences between individual means.

Because of the design of the main experiment and the site and stand conditions several modifications of procedure were required in the analysis. On blocks seeded to black spruce, artificial regeneration could not always be distinguished from natural regeneration. However, an estimate of black spruce stocking due to artificial regeneration was obtained from the difference in total black spruce stocking between seeded and adjacent unseeded blocks. A large proportion of the black spruce stems on site V consisted of advance growth which had not been destroyed by the fire. For this reason, data on black spruce stocking on this site were not included in the analyses.

Results

a) Latin Square Experiment

The mean number of stocked spots, the mean number of seedlings per plot, and the mean height of the tallest seedling per spot are shown by species in Figure 5. With respect to stocking and number of seedlings per acre, the species fall into three groups. Red spruce (Halifax) and black spruce (Ontario) performed best; white spruce (Labrador), Norway spruce (Nord) and the sitka-white spruce hybrid performed the poorest; and red spruce (Digby), Norway spruce (Brindal), white spruce (Denmark) and white spruce (Alaska) were intermediate. Differences in height growth between species were not so marked but black spruce (Ontario), red spruce (Digby) and white spruce (Denmark) were the tallest; white spruce (Alaska), Norway spruce (Nord) and the sitka-white spruce hybrid were the shortest.

b) Main Experiment

(i) Performance of individual species

Percent stocking and number of stems per acre by species are shown in Figure 6. Average stocking of all species on the seeded plots (21.4 percent) was not significantly better than that of natural black spruce on

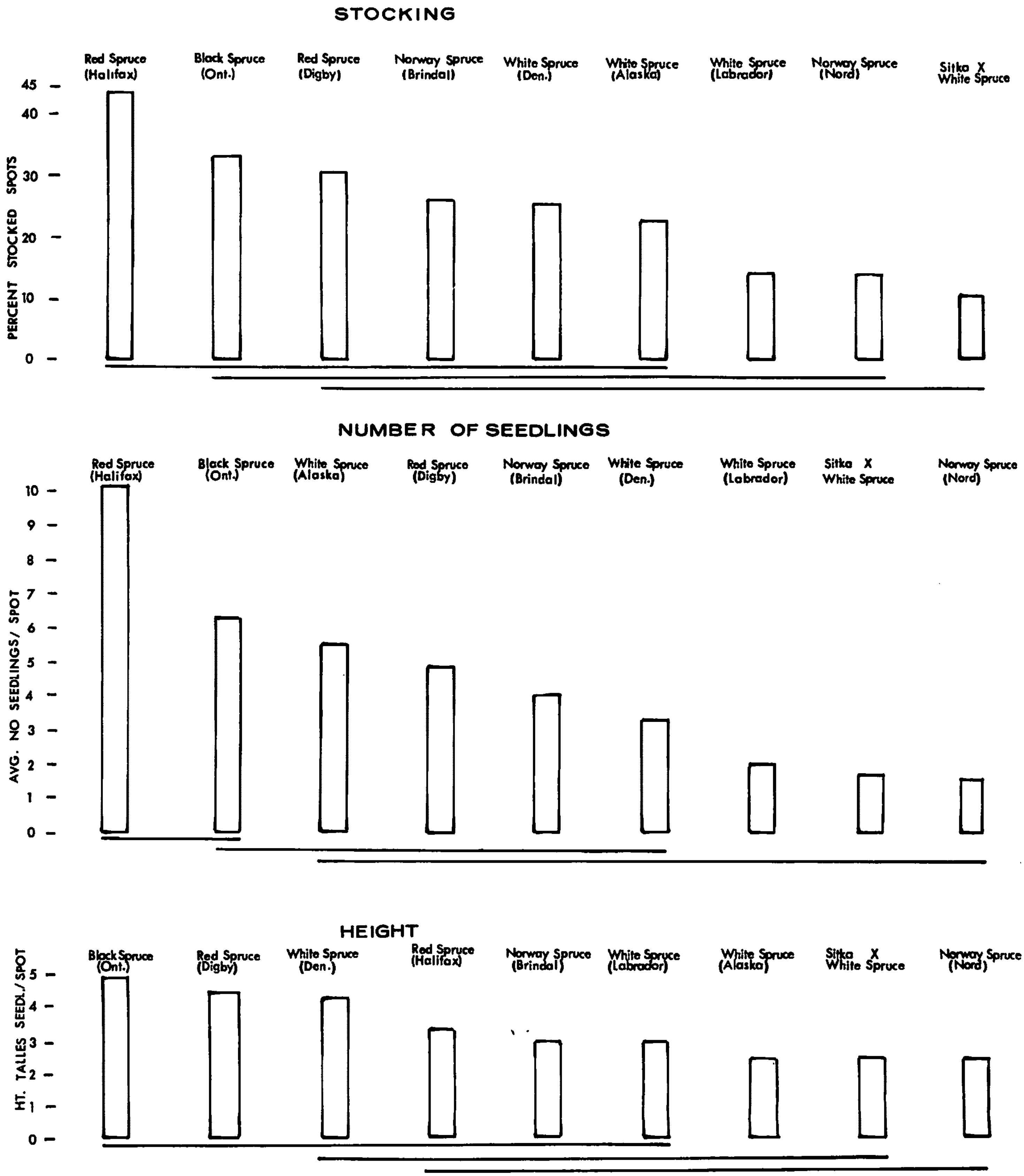

FIGURE 5. STOCKING, NUMBER OF SEEDLINGS, AND HEIGHT OF NINE SPECIES AND STRAINS SEEDSPOTTED IN LATIN SQUARE EXPERIMENT

There is no significant difference at the 0.01 level (0.05 level for height data) between means represented by columns underlined by the same straight line.

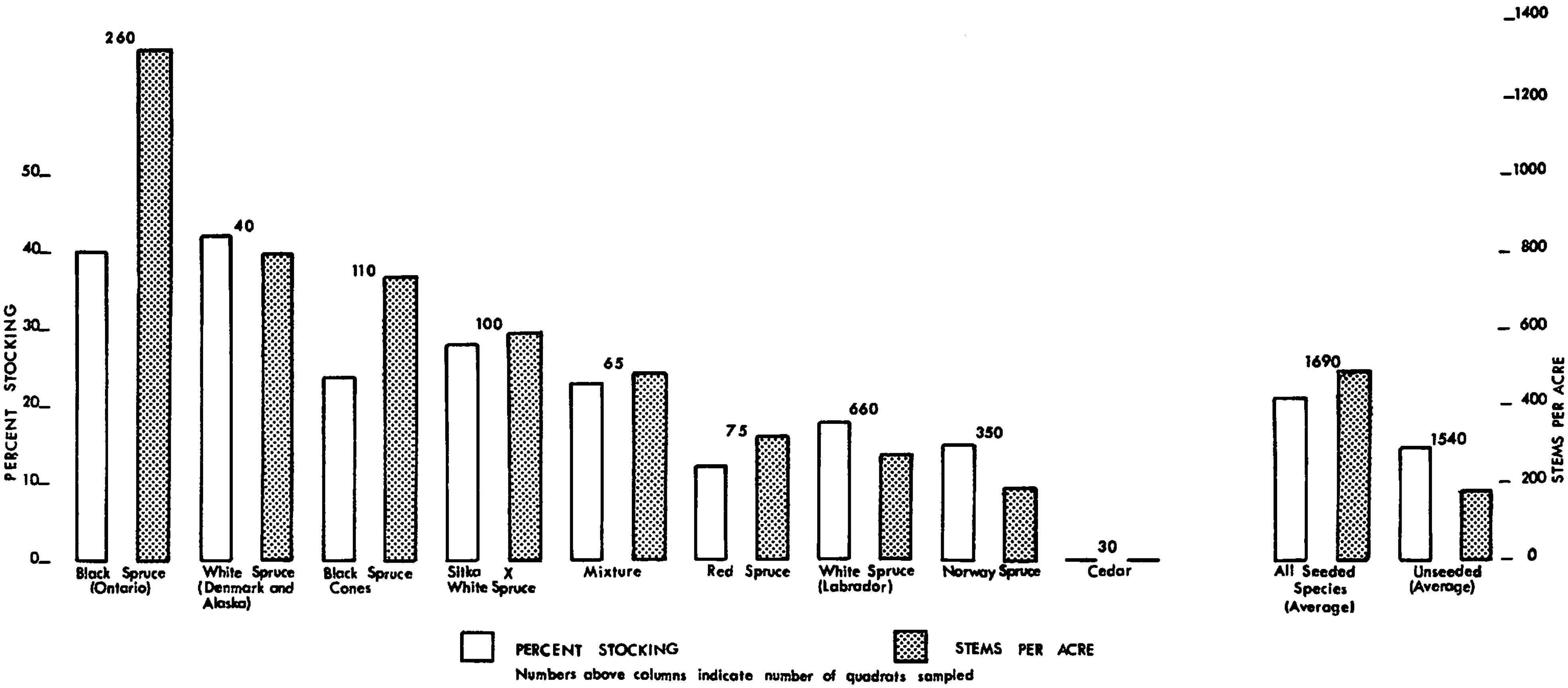

FIGURE 6. PERCENT STOCKING AND NUMBER OF STEMS PER ACRE BY SPECIES

unseeded plots (14.4 percent). However, the number of stems per acre was significantly greater on the seeded plots (490) than on the unseeded (180).

Black spruce (Ontario) and white spruce (Denmark and Alaska) produced the best stocking and number of seedlings per acre; red spruce, white spruce (Labrador), Norway spruce and cedar, which failed completely, performed the poorest; and black spruce cones, the sitka-white spruce hybrid, and the seed mixture were intermediate.

The average number of stems per seedspot for all species except black spruce are shown in Table 2. Few seedspots had more than three seedlings; spots seeded with red spruce, and the sitka-white spruce hybrid contained more than one seedling more often than those spots seeded with other species.

Table 2

Seedling Densities in Seedspots

Species or Strain	Average number of stems per seedspot
White spruce (Labrador)	1.3
Norway spruce	1.2
Sitka-white spruce hybrid	1.9
Red spruce	2.0
White spruce (Denmark and Alaska)	1.5
All species	1.5

The average height of all seeded species (4.2 feet) was greater than that of the natural black spruce regeneration (3.1 feet) though the difference was not statistically significant (Figure 7). White spruce (Denmark and Alaska) and the sitka-white spruce hybrid grew best; black spruce originating from cones had the poorest growth, but again none of the differences were statistically significant.

(ii) Effects of site conditions

Percent stocking and average height of all species are shown by site types in Table 3. On the unseeded plots natural black spruce was better on sites III and IV than on sites I and II. On the seeded plots stocking to all species was best on sites I and III, intermediate on site II and poorest on site V.

Height growth of natural black spruce did not vary greatly with site, although seedlings on sites I and III grew a little better than those on other sites. Average height growth of all seeded species was much greater on sites I, II and III than on site V. For any given site, the height of the seeded species was greater than that of the natural black spruce.

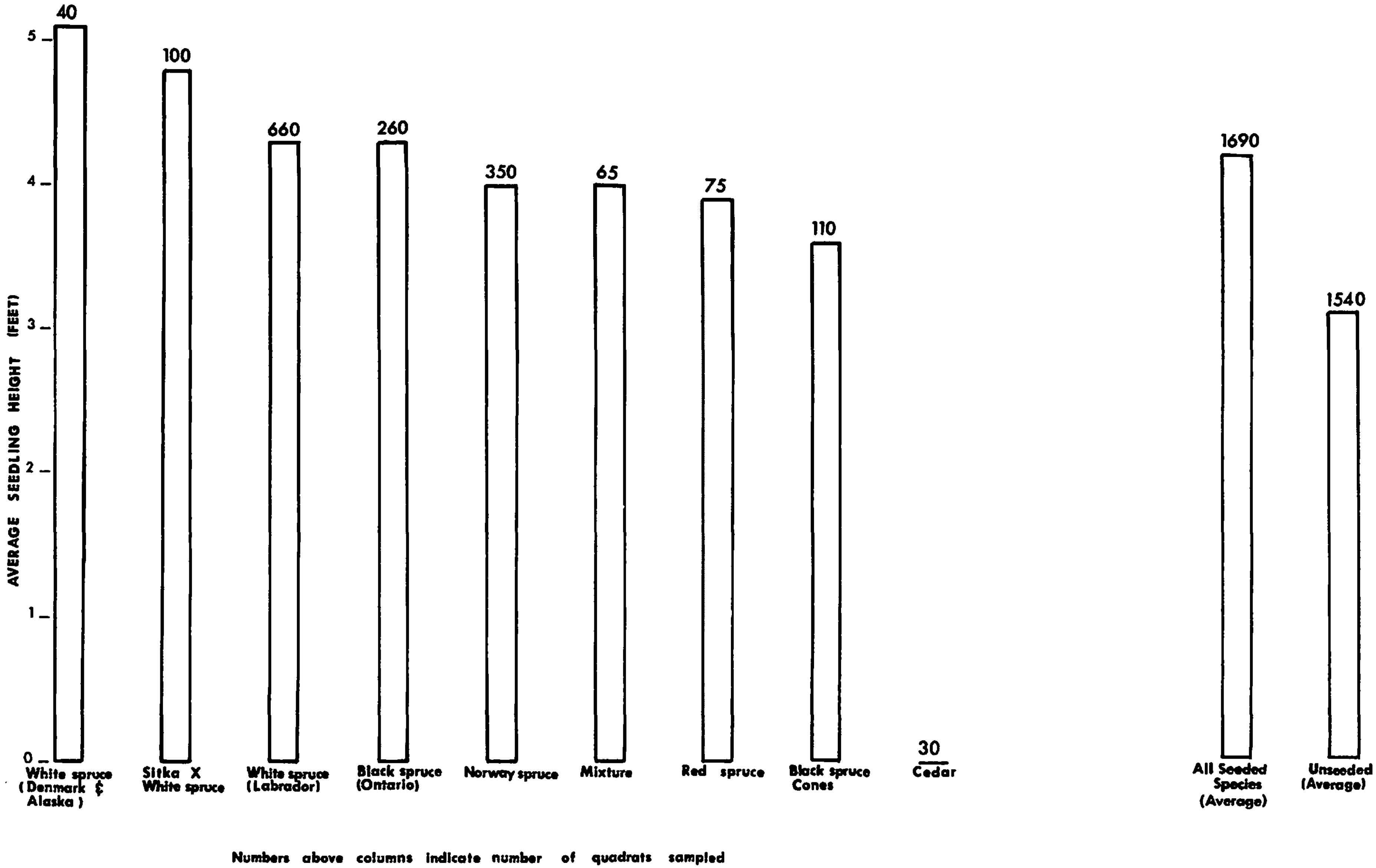

FIGURE 7. AVERAGE HEIGHT GROWTH BY SPECIES

Table 3

Percent Stocking and Average Seedling Height of all Species by Site Type

Site	Seeded			Unseeded		
	No. of Quadrats sampled	Percent Stocking	Average height (ft.)	No. of Quadrats sampled	Percent Stocking	Average height (ft.)
I	1158	23	4.3	1066	13	3.3
II	109	17	3.9	91	11	2.5
III	350	20	4.2	342	20	3.1
IV*				41	20	2.4
V	70	4	2.4			

*Only 3 quadrats in seeded blocks fell on site IV, so they are not included.

Stocking was generally better on shallow humus than on deep humus. This is illustrated by the data for white spruce (Labrador) (Table 4) which show that the best stocking occurred on humus which was one inch deep or less. Seedlings grew best on humus about one-inch deep and poorest on humus less than one-half inch deep; growth was intermediate on humus more than one-inch deep.

Table 4

Percent Stocking and Average Height of White Spruce (Labrador) On Different Humus Depths

Humus Depth (ins.)	No. of Quadrats Sampled	Percent Stocking	Average Height (feet)
0-½	23	26	3.9
¾-1	31	26	5.8
1¼-2	19	16	4.4
2¼-4	16	19	4.5
5	8	12	5.0

(iii) Mortality

In the course of the remeasurement it was noticed that a significant proportion of the softwood regeneration was dead or dying, or that the foliage had an unhealthy yellowish colour. Most of the affected trees were about the same size as neighbouring healthy trees. The percentage of stems of different species which were dead or dying is shown in Table 5.

Table 5

Mortality of Different Species

Species	Number of Stems Sampled	Percentage Dead or Dying
White spruce (Labrador)	180	2.2
Norway spruce	66	10.6
Sitka-white spruce hybrid	59	13.6
Red spruce	24	0.0
White spruce (Denmark & Alaska)	32	0.0
Black spruce (Ontario)	345	1.8
Black spruce cones	82	1.6
Natural black spruce	280	1.1

Norway spruce and the sitka-white spruce hybrid were the species most severely affected and it was estimated that at least half of all stems of the latter showed some discoloration of foliage. Examinations carried out by regional pathologists revealed that mortality resulted from infection by the fungus Armillaria mellea (Vahl ex Fr.) Kummer.

Discussion

Considering all seeded species and natural regeneration together, the overall softwood stocking on the seeded plots of the main experiment (39.5 percent) is barely satisfactory. Nevertheless, some species performed quite well.

Percent stocking and number per acre for black spruce (Ontario) were good in both the latin square experiment and in the main experiment. White spruce (Labrador) and the Norway spruces had poor stocking. In the main experiment the sitka-white spruce hybrid had better than average stocking but in the latin square it had poor stocking. Red spruce was one of the best-performing species in the latin square but one of the poorest in the main experiment. White spruce (Denmark and Alaska) had medium to good stocking in both experiments. No cedar was observed in sample quadrats or elsewhere. Some of these discrepancies between the two experiments are believed to be due, at least partially, to the confounding effects of site, since the latin square was located entirely within site type II while the main experiment covered a wide range of site types.

Although natural and artificially seeded black spruce could not be distinguished, seeding definitely played a major role since stocking on plots seeded to this species was much greater than on the unseeded plots.

In the main experiment white spruce (Denmark and Alaska) and the sitka-white spruce hybrid were taller than average while in the latin square black spruce (Ontario), red spruce (Digby) and white spruce (Denmark) were the tallest. Black spruce from cones were smaller than average. Wilton (1964) attributed the comparatively small size of these black spruce in 1963 to delayed germination as a result of slow cone opening. Although an attempt was made to assist cone opening by heating the cones prior to sowing, it is believed that germination of this seedlot may not have occurred until at least one year after the other species had germinated.

Stocking obtained in the 1968 remeasurement is compared in Table 6 with the figures obtained by Wilton (1964) in the 1961 and 1963 remeasurements.[4] The stocking figures shown here differ from those shown in Figure 6 since natural black spruce, as well as the seeded species, is considered in every quadrat; also data for only the diagonal method, which was the system Wilton used, is included. These figures show that the stocking of most species was more or less the same in 1968 as it was five years earlier. The average stocking of the unseeded plots shows a steady increase; this is probably due to seeding in from black spruce stands which surround and extend north and west of blocks 29 and 30. However, there is no corresponding increase in average stocking on the seeded plots even though natural regeneration of spruce was also included. This suggests that there has been a net decrease in stocking of artificial regeneration over the last five years.

A casual examination of the experiment was made in October 1965, at which time the sitka-white spruce hybrid was considered to be the most promising strain. It appeared healthy and vigorous with excellent height growth and stout leaders. In 1968 its total height was still above average but because of Armillaria attack it seems unlikely that the early promise will be fulfilled. Several specimens over six feet tall were measured on which the 1967 leader length was only half of the annual average for the last five years, even though weather conditions in 1966 and 1967 were quite favourable for good growth.

Fairly clear relationships exist between site type and results in both seeded and unseeded blocks. On the unseeded areas the percent stocking of natural regeneration was best on sites III and IV probably because of the moist seedbed conditions. Growth was best on sites I and III most likely because these sites had optimum rooting conditions. On site II the shallow soil may have tended to be alternately dry and wet making it unsatisfactory for seedling survival. On site IV competition from dense ground vegetation, which flourishes on this site probably restricted growth.

On the seeded areas where the seedspotting technique caused some improvement in seedbed conditions, percent stocking and height growth was good on sites I, II and III, but poor on site V. The latter site has very wet, poorly drained conditions with peat development under sphagnum moss and ericaceous dwarf shrubs. Although sphagnum moss is generally a good seedbed medium, the presence of the cold wet peat and the shrub competition make this site highly unfavourable for subsequent seedling development.

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[4] The data from the 1966 remeasurement are not included since they are on the basis of stocked seedspots rather than stocked quadrats.

Table 6

Percent Stocking of Spruce Species* 3, 5 and 10 Years After Seeding

Species	Area Seeded (ac)	Percent Quadrats Stocked 1961	1963	1968
White spruce (Labrador)	6.0	28	35	33
Norway spruce (Norway)	2.8	24	32	30
Black spruce (Ontario)	2.4	45	48	50
Black spruce cones	1.0	42	56	56
Sitka x white spruce	0.8	28	37	37
Red spruce	0.7	29	31	31
Seed mixture	0.5	16	28	28
White spruce (Denmark & Alaska)	0.6	40	43	43
Red cedar	0.2	0	0	0
Average stocking:				
Seeded plots	15.0	31	38	36
Unseeded plots	15.0	10	12	17

*All spruce species, both natural and artificially regenerated, were considered in each quadrat.

Stocking was best on thin humus on all sites but especially so on site I where vegetative competition was at a minimum. Even in 1968 a considerable proportion of the ground surface on this site was still almost bare of vegetation. The depth of humus measurements tend to confirm the superior nature of thin humus sites, especially for white spruce (Labrador). This is in agreement with the results of the 1966 remeasurement which showed that only 8 percent of stocked seedspots were found on humus more than 0.5 inches thick, although 60 percent of the seeded area had humus depths greater than 0.5 inches. It is now generally appreciated that the thickness of deep humus layers must be reduced by scarification or other means in order to produce satisfactory seedbeds (Richardson 1970).

Conclusions

Based on the results of these experiments at Birchy Lake, it can be concluded that black spruce (Ontario) and white spruce (Denmark and Alaska) will produce satisfactory regeneration when seedspotted on burned cutover sites similar to those on the experimental area. Sowing black spruce cones will also produce reasonably good stocking though germination may be delayed. Results with red spruce were good on the shallow soils but were poor elsewhere. Other species tested cannot be recommended for seedspotting under similar conditions in Newfoundland. However if seedbed conditions were improved by scarification some of the other species might prove satisfactory. At any rate better stocking than that achieved in this study could be anticipated.

The case of the sitka-white spruce hybrid deserves special mention. Although its stocking was not outstanding, in the first five to eight years its vigour and height growth were very promising. However, it has now suffered worse than any other species from attack by *Armillaria* root rot and therefore cannot be recommended for use. Because of the severity of the *Armillaria* attack in this and other plantations in Newfoundland, a program is being developed by the Canadian Forestry Service to provide practical methods for prevention and control.

Site conditions had an appreciable effect on the results of the experiment. Stocking to most species was best on the dry to fresh gentle upper slopes with well-drained sandy loam soils on which thin humus and absence of vegetative competition were important factors. On the other sites stocking was poorer mainly because of unsatisfactory seedbed and drainage conditions. Unless pre-sowing site treatments (to reduce the depth of the organic mantle and improve drainage) are contemplated only the dry to fresh sites with a shallow humus layer should be seeded.

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