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ASSESSMENT OF RECENT PLANTATIONS OF PINE AND SPRUCE IN THE BATHURST AREA OF NEW BRUNSWICK, 1975-1976

by E.L. HUGHES

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Fredericton, New Brunswick

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ABSTRACT

About 26 operational plantings established between 1968 and 1974 in the Bathurst area of New Brunswick were assessed in 1975-76 using temporary sampling locations. The plantations occupy about 3000 ha (7400 acres) in which about 5.5 million seedlings were planted with various species, mainly jack pine, red pine, white spruce, black spruce, and red spruce.

Seedling survival in the plantations, in 1975, ranged from 23 to 89%. About 72% of the plantations, representing 85% of the plantation area, were rated as successful or highly successful. Mortality in the first year after planting was about 10% and was attributed mainly to poor quality seedlings and planting methods. Root deformities resulting from faulty planting, competition from other vegetation, snow damage, species planted 'off-site', and combinations of these damaging conditions are cited as the main reasons for mortality in plantations after the first year. Some recommendations to improve the success of large-scale plantings in this region of New Brunswick are included.

RESUME

On a evalue en 1975-1976 environ 26 plantations operationnelles etablies entre les annees 1963 et 1974 dans la region de Bathurst au Nouveau-Brunswick, en choisissant des placettes provisoires d'echantillonnage. Les plantations occupent a peu pres 3000 ha (7400 acres) dans lesquelles on a plante environ 5.5 millions de semis d'especes diffetentes, surtout de Pin gris, Pin rouge, Epinette blanche, Epinette noire et Epinette rouge.

En 1975, la survie dans les plantations a varie entre 24 et 89%. Environ 72% des plantations, representant 85% de la superficie totale, furent classees comme reussites ou grandes reussites. Dans la premiere annee suivant le plantage, on nota une mortalite de quelque 10%, que l'on attribua principalement a la qualite mediocre des semis et des methodes de plantage. Parmi les principales causes de mortalite dans les plantations apres la premiere annee, il faut citer les difformites des racines (resultat d'un plantage inadequat), la concurrence de la vegetation amibante, les degats causes par la neige, les especes plantees en stations inadequates, ainsi qu'un melange de ces mauvaises conditions. L'auteur formule quelques recommandations utiles a l'amelioration du succes des plantations de grande envergure dans cette region du Nouveau-Brunswick.

CONTENTS

INTRODUCTION

In 1968 the New Brunswick Department of Natural Resources (D.N.R.) started a pilot project of multiple-use management of crown land in the Bathurst area of New Brunswick. One objective of this project is to increase the volume of quality timber through silvicultural practices on the land allocated primarily for timber production. This can be achieved by (i) ensuring that adequate regeneration occurs after clear felling or by artificial reforestation; (ii) improving natural conditions of stand density either by fill-planting in open areas or by cleaning and thinning dense young stands of regeneration; and (iii) increasing soil fertility. The Department opted for the first two ways and requested that the Canadian Forestry Service, Maritimes Forest Research Centre (M.F.R.C.) evaluate this silvicultural program.

The evaluation and assessment of survival and height growth of about 5.5 million planted seedlings were carried out in the fall of 1975 and the spring of 1976 on 26 plantations covering about 3000 ha (7400 acres). Plantations established after 1974 are being assessed by the Department of Natural Resources.

This report gives the results of the evaluation of the planting program to 1974 and recommends methods for improving this program. Information from establishment reports and data gathered during the 1975-76 field assessment are included.

DESCRIPTION OF AREA

The Bathurst Pilot Project Area covers about 405,000 ha (1 million acres) of crown land in Restigouche and Gloucester counties, previously licensed mainly to Consolidated-Bathurst Limited. The land is located in three ecoregions as mapped by Loucks (1962): the New Brunswick Highlands, the Restigouche - Bras d'Or, and the Maritime Lowlands. Most of the plantations established between 1968 and 1974 are located in the Sevogle and Allardville Forest Districts of the last two ecoregions, respectively.

The predominant soils in the planted areas are stony sandy loams, silt-loams, and sands. Bedrock or some other impermeable layer underlies most of these relatively permeable soils. Because the depth to this impermeable layer is variable and sometimes relatively shallow, surface soil moisture varies widely over short distances.

Wildfire has been widespread and frequent in much of these districts but particularly in the Allardville District. Consequently, many of the plantations established from 1968 to 1974 are located either in old or in recently burned areas. Vegetation on these burns varies widely from ericaceous shrubs on the deep sandy soils to relatively dense young hardwoods on the better soils. Generally, the burns are lightly to moderately stocked with hardwood species such as wire birch, pin cherry, red maple, white birch, trembling aspen, and mountain ash. Additional species, such as sugar maple, beech, striped maple, and mountain maple occur on the better soils, mainly on slopes and hilltops, where raspberry and hazelnut are also common.

METHODS

A complete description of the temporary sampling scheme used by the Maritimes Forest Research Centre in 1975-76 to assess the results of the project is contained in Appendix II. Briefly, each sample consisted of several counts of 30 seedlings, measurements of their total height and height increment in 1975, observations on overtopping competition, and reasons for mortality in each plantation.

The starting point for each sample count was located randomly near points established by travelling systematically throughout each plantation. Living, dead, and missing seedlings in each total count of 30 were recorded. Attempts were made to identify and record the reasons for the dead specimens but it was impossible to give reasons for the missing specimens, particularly in those plantations established two or more growing seasons before field assessment.

Total height at the end of the 1975 growing season and height increment in 1975 were measured for five or less seedlings in each sample of 30; the number measured being the number living at the first five locations in each seedling count. Competitive vegetation overtopping the measured seedlings was classified according to species, height, and distance from the planted seedlings. Type of soil, soil moisture conditions, general vegetation, snow damage, etc. were recorded as required.

This method allowed one person to work alone at the time of the field assessment. Thus two people could do the required travel, counts, and measurements in about half the time that would have been required if a sample plot system had been devised.

The method had weaknesses: perhaps the most glaring being that estimates of numbers of seedlings per acre could not be compiled directly from the field assessment records because no plots were established and no measurements of spacing were collected. Such figures were compiled using information from the D.N.R. establishment reports, along with estimates of survival obtained by the M.F.R.C. counts.

The establishment reports prepared by staff of the New Brunswick Department of Natural Resources contained the following basic information and/or compiled records for each plantation:

(a) Number and name
(b) Location and map
(c) Year, season, and dates of planting
(d) Planting tool and/or method
(e) Total number of trees planted by species and stock type
(f) Total acres planted and approximate spacing
(g) Site preparation and date
(h) Number of planters, foremen, and wages paid
(i) Cost per 1,000 and per acre
(j) Quality of stock
(k) Miscellaneous information on soil conditions, special difficulties encountered in access to the planting site, storage conditions and/or facilities near the outplanting site, etc.

A summary of the information in the establishment reports is contained in Appendix I, Table 2. Field data collected in 1975 and 1976 by staff of M.F.R.C. are summarized in Appendix I, Table 3. The reported number of total acres planted and total number of seedlings planted appear reliable with a few exceptions for which footnotes have been added to Tables 2 and 3. Records of spacing were not always reliable, so, compilations of number of seedlings planted per acre for a particular area were usually made using total acres and total numbers planted. Also, estimates of the number of survivors per acre are rough approximations, since these figures were compiled using survival percentages and the estimates of number planted per acre.

Nevertheless, the counts appear to provide fairly reliable estimates of the proportions of living, dead, and missing seedlings. The data on the 1974 summer and autumn plantations, collected in 1975, (one growing season after planting) show that seedlings identified as either living or dead, make up about 90% of the total count, while only 7 to 11% are listed as missing.

Some tests of accuracy have been compiled for three plantations where 18, 20, and 30 counts of 30 seedling locations were obtained. These calculations reveal the following:

(i) Plantation P-1-71 (white spruce) with 18 counts, the mean survival value is 67.3 ± 7.5% at the 95% level of probability;
(ii) Plantation P-2-72 (jack pine) with 20 counts, the mean survival rate is 62.3 ± 7.9% at the 95% level of probability; and
(iii) Plantation P-8-74 (jack pine) with 30 counts, the mean survival rate is 66.7 ± 7.0% at the 95% level of probability.

Where survival rates are uniformly high, a much smaller number of samples provides better estimates of mean survival rate, for example: Plantation TP-13-72 (jack pine in tubes), with 7 counts, the mean survival rate is 88.6 ± 2.2% at the 95% level of confidence.

The data and information collected serve to identify gross, but not minor, differences in degree of success achieved and suggest possible reasons for success.

RESULTS

Survival

Survival to autumn 1975 in the 26 plantations varied widely from 23 to 89% (Appendix I, Table 3). In one plantation (P-6-71) it was impossible to conduct the formal assessment because of extremely low survival. Plantation success was higher in the younger plantations and appears to be related to the type of stock used, the introduction of mechanical site preparation, and planting methods. However, one would expect higher survival rates for the most recent plantings because these plantations have been exposed to mortality-causing agents for a shorter time.

The degree of improvement was assessed by using a series of weighted-average survival rates compiled for (i) years, (ii) type of stock used, (iii) site preparation methods, and (iv) planting methods (Fig. 1). Admittedly, 26 plantations do not display the full range of all the possible confounding variables, such as species, site, type of seedlings used, etc. Nevertheless, the information and data at hand have been used

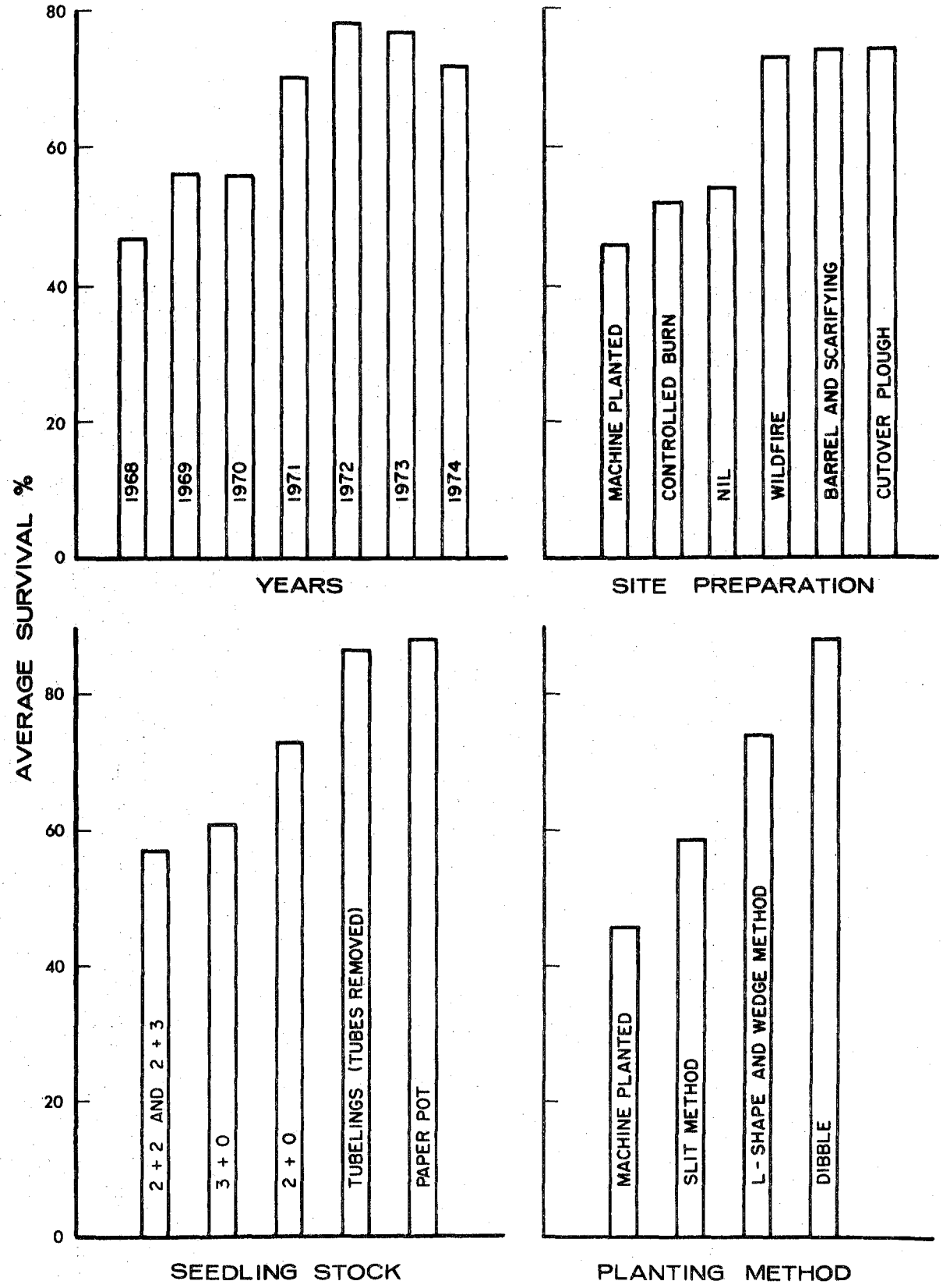

Figure 1. Weighted average survival by (a) years, (b) site preparation, (c) seedling stock, and (d) planting method.

to advance the following reasons for improvement in the plantations over time:

(i) The use of site preparation machinery such as ploughs and barrel scarifiers, beginning on a large scale in 1971.

(ii) The introduction of 2-0 and 3-0 seedlings and of container-grown seedlings in place of 2-2 transplant stock. This coincided generally with the mechanical site preparation.

(iii) Seedlings were trucked to the planting site, as required, beginning about 1970.

Regardless of species, the highest survival rates are for seedlings which were grown in tubes or paper-pots and planted in late summer on prepared sites. Bare-root stock (whether transplant or seedling) either deteriorated between the time of lifting at the nursery and outplanting, or was not as well planted as container-grown seedlings. Both factors appear to have affected the planting success of bare-root stock. Poor quality stock was recorded in one instance (P-4-74), and this undoubtedly contributed to the low survival rates (43, 52, and 58%) found for three different species in this plantation.

To place the survival data on the various plantations in perspective, each species rated in each plantation has been classified according to one of the following arbitrarily-chosen categories:

I Highly Successful:- survival above 80% and/or >600 survivors per acre.

II Successful:- survival from 61 to 80% and/or 401-600 survivors per acre.

III Low Success:- survival from 41 to 60% and/or 201-400 survivors per acre.

IV Inadequate:- survival from 21 to 40% and/or <200 survivors per acre.

V Failure:- survival 20% or less, and/or <200 survivors per acre.

In 70% of the plantations, success of individual species was class I or II. There were instances of low or inadequate success for every species planted, but complete failures were few (Table 1).

The successful plantings represent about 85% of the area planted between 1968 and 1974. Undoubtedly, some of the plantations rated as successful or highly successful in 1975-76 will suffer further mortality.

Some plantings in late September and early October had high survival rates, but the results are not consistent.One planting (Plantation P-11-74) established between 1-10 October, showed very poor survival one year later. The soil in this plantation was frozen some mornings during the planting. Probably, planting should cease before the end of September.

The most successful appearing plantations were those established on prepared sites in the area of the 1971-Mud Lake fire where competing vegetation was largely controlled by the wildfire and site preparation. In contrast, nearly all the plantations established in the area of the 1962-Allardville-Tilley Road fire, where vegetation was only partly controlled, are expected to suffer further mortality caused by competing vegetation.

Mortality

Probable reasons for mortality were recorded for all dead seedlings. Missing specimens could not be assessed; however, on the basis of the assessments of the 1974-plantations, at least 10% of the seedlings died shortly after planting (the missing specimens). Most of this early mortality can be attributed either

Table 1. Species success in 26 plantations

Success class (See text)	Jack pine	White spruce	Black spruce	Red spruce	Red pine	Mixed species or other	All species
I Highly Successful	11	3	1	1			16
II Successful	2	4	1		3	3	13
III Low Success	2	2			1	1	6
IV Inadequate	1			1			2
V Failure	1	2	1				4
All classes	17	11	3	2	4	4	41

to poor quality seedlings or to poor planting techniques (loosely planted, deeply planted, planted in deep humus or rotten wood, or techniques that result in deformed roots). Other reasons were frequently noted, the more important being, smothering by heavy competition from lesser vegetation (mainly grass, hazlenut, raspberry, and bracken) or by snow, browsing by rabbits, broken by snow, frost heaving, or slumping soil (in recently ploughed areas), and flooding. A few dead seedlings had been infected with ***Armillarea mellea***, but most of these also showed deformed root systems suggestive of poor planting techniques (Fig. 2a).

Mortality in the 3- and 4-year-old plantations is mainly attributed to severe competition from other vegetation often combined with snow damage.

In the 5- to 7-year-old plantings, most of the mortality resulted from species planted off-site (e.g. white spruce and red spruce planted on ericaceous barrens and jack pine planted on moist and wet sites), snow damage, root-collar weevil damage, and combinations of these factors coupled with seedlings having deformed root systems. Perhaps the most striking mortality found in an older plantation was in Plantation P-9-68, a red pine plantation on an old fire barren mostly covered with ericaceous vegetation. Poor quality planting of the 2-2 stock resulted in upturned root systems, which in turn probably contributed to the generally low vigor in these red pine. In 1974-75, this plantation was badly damaged by snow, became heavily infested with root-collar weevil, and many seedlings died Significantly, every dead seedling pulled from the ground in this plantation exhibited a "Shepherd's Crook" root system (Fig. 2b).

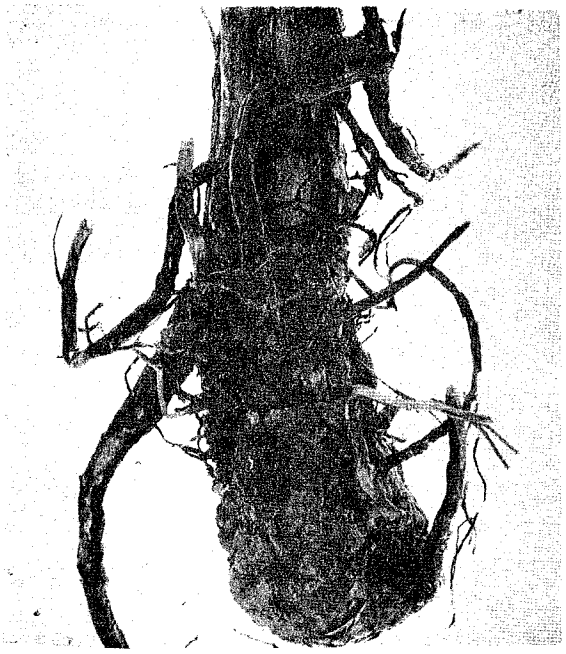

Fig. 2(a) Lower stem and root of a jack pine seedling from plantation P-9-72, showing severely balled root system. This seedling died in 1975, four years after planting having been attacked by shoestring root rot (***Armillarea mellea*** (Vahl.) Quel.)

Fig. 2(b) Lower stems and roots of two red pine seedlings from Plantation P-9-68, showing severely deformed, "Shepherd's Crook", root systems. These seedlings died in 1975, seven years after planting, having suffered severe snow damage and an infestation of root collar weevil (***Hylobius radicis*** Buch.).

Height Growth to 1975

For each plantation, total height of individual seedlings to the end of the 1975 growing season has been expressed as (a) average total height for all living specimens and (b) average total height of the tallest 20% of the living seedlings (Figs. 3-5; Appendix 1, Tables 5-7). Notes on these figures indicate some reasons for success or failure, for instance: P-9-68 and P-2-69 were spruce plantations on ericaceous barrens.

Average height increments in 1975 revealed only that the older tallest plantations were generally growing at the fastest rates (Appendix 1, Table 3). Some jack pine plantations, in particular, grew rapidly in 1975, four of them showed average height incre-

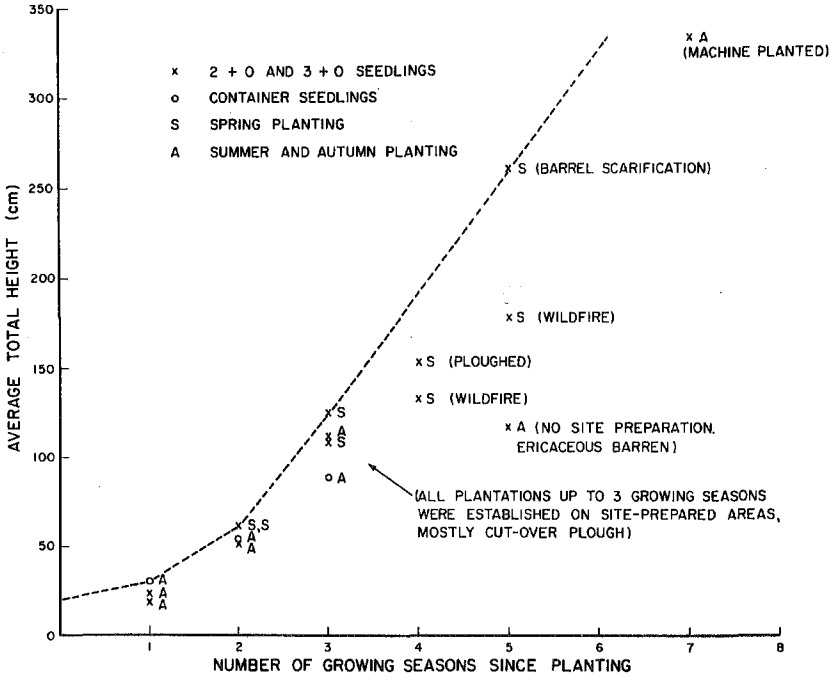

Figure 3. Average total height of tallest 20% of Jack pine seedlings.

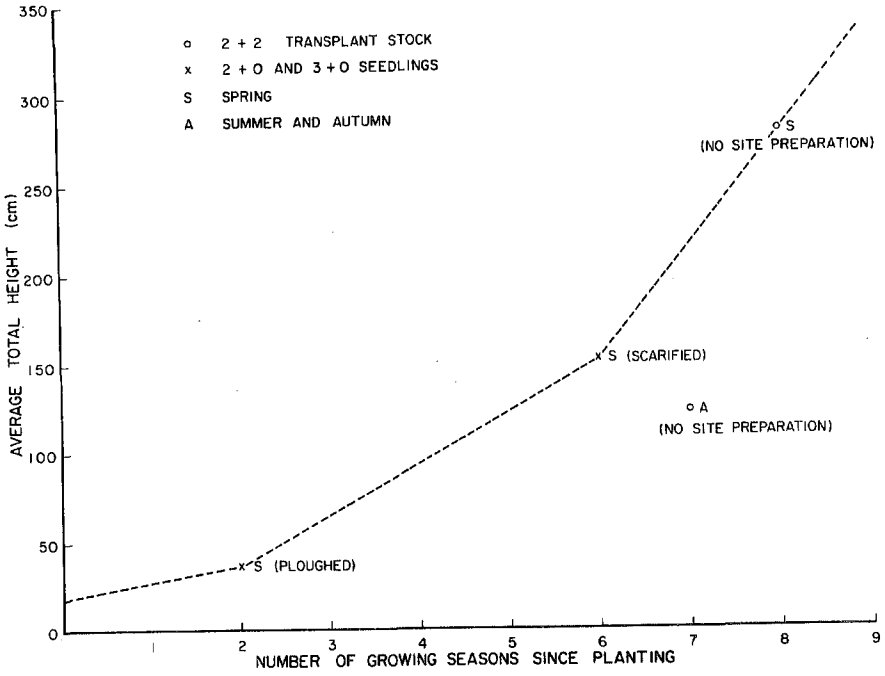

Figure 4. Average total height of tallest 20% of red pine seedlings.

ments of more than 40 cm (16 in). All of these plantations were in their fourth or older growing season.

Single jack pine seedlings showed much greater height increment than the average figures for the tallest 20%; the greatest height increment recorded being 69 cm (27 in) for a jack pine in Plantation P-9-72.

Costs

Planting costs per 1,000 and per acre (Appendix I, Table 2) were much less for machine-planted and container-grown seedlings than for hand-planted bare-root stock. Cost per acre of hand-planted bare-root stock increased directly with the number planted per acre (Fig. 6), and varied from about $28.00 per acre for 500 trees to about $69.00 per acre for 1200 trees. But variation around the mean regression line appeared relatively large. Average cost to hand plant 800 seedlings per acre (2-0 and 3-0 seedlings or 2-2 and 2-3 transplant stock) was about $45.00.

Minimum cost of planting by machine was $12.00 per acre for 870 seedlings, but all the appropriate costs may not have been included in the establishment reports. Minimum planting cost for container-grown seedlings was $14.00 per acre for 910 tubelings.

No other relationships could be established. Too much variation existed between plantations, mostly because of the variation in number of seedlings planted per acre but also because of factors such as (i) distance from the planters' homes to the planting site, (ii) relative ease of access from the motor road to all parts of the planting area, (iii) whether or not sites were prepared and the quality of the site preparation, and (iv) planting difficulty experienced because of stoniness or amount of wood debris in the site. Although such factors are frequently mentioned in the establishment reports, there is no way of objectively rating them.

The outplanting cost represented only part of the total cost of conducting this kind of artificial reforestation. Cost of transporting the seedlings, the cost of site preparation, and overhead need to be added to establish the total cost of the artifical reforestation program. No attempt was made to estimate the total cost because estimates of the cost of seedlings, the cost of site preparation, or the cost of overhead were not usually included in the establishment reports.

Whether the costs are justified in relation to degree of success achieved cannot be determined until specific objectives of the planting program have been established. Moreover, the plantations are not old enough to indicate final biological success rates. Thus, this report covers biological results to date rather than cost effectiveness.

DISCUSSION

Many of the plantations established from 1968 to 1970 can be considered experimental and some problems encountered in these early plantations led to improvements in the larger plantings conducted in 1971 and later. However, this study shows that further improvements will be required in plantation establishment. Successful plantings account for 72% of the 26 plantations; only about 40% were classed as highly successful in 1975. Additional mortality is expected in parts of nearly all plantations due to overtopping competition, snow damage, and the effects of deformed root systems. Improvements needed include: more complete site preparation (or more control of natural vegetation); improved quality of bare-root planting stock; more selectivity in matching species to site conditions; and more attention to stand tending treatments as may be required.

The extent of root deformity in the planting of bare-root jack pine seedlings is unknown and should be investigated, since damage and mortality from this cause is unlikely to be evident in the early years after planting. In fact, if the development of jack pine with deformed root systems follows the trend exhibited by Scots pine as reported by Bergman ***et al.*** (1975), height growth in the early years after planting may be greater for seedlings with deformed roots than for those that are planted properly.

Only one plantation (P-9-68) provides any clues as to the amount of mortality that might be expected from root deformities caused by faulty planting. Red pine planted in the autumn of 1968 on an ericaceous barren which was not given site preparation, displayed unusually high mortality in 1975. Anyone visiting this plantation from the time of establishment until 1973 would probably have rated this as a successful planting. By 1975, survival had dropped to an estimated 41% and mortality in 1975 alone, was estimated as about 15% of the original planting stock. Deformed root systems had led to specimens of low vigor which suffered much snow damage in 1974-75 (and in earlier years). Many seedlings were weakened by an infestation of root-collar weevil and died in 1974 and 1975 but the cause of death is attributed to deformed root systems, not to snow damage or root-collar weevil.

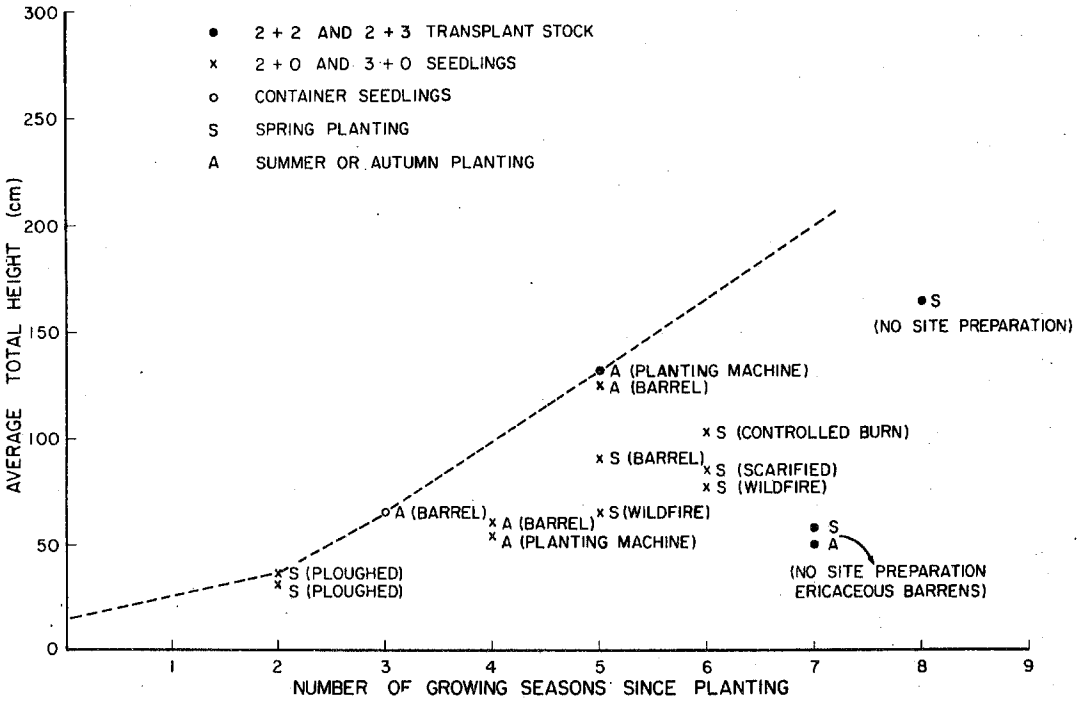

Figure 5. Average total height of tallest 20% of spruce seedlings.

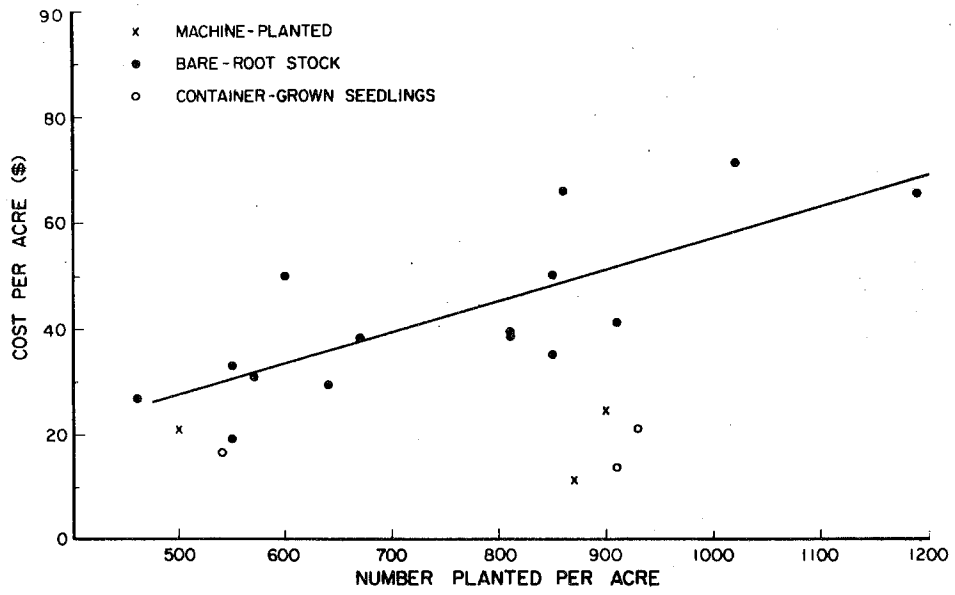

Figure 6. Cost per acre related to number planted per acre.

RECOMMENDATIONS

1. Detailed information should be included in the establishment reports so that costs can be reliably evaluated, and causes of mortality established. Some items in addition to those usually recorded in establishment records are:

(i) Number of days between lifting the seedlings at the nursery and outplanting (or number of days between shipment from cold storage and outplanting);
(ii) Detailed maps to show locations of different species and area planted each day;
(iii) Number of days that seedlings, planted in any one day, were held in temporary storage;
(iv) Detailed weather record, day by day, during the course of plantation establishment;
(v) Cost of seedlings delivered to the planting site;
(vi) Source of seed used;
(vii) Comments on the quality of planting and on the quality of planting conditions; and
(viii) Site preparation costs.

Collecting and reporting this information, plus conducting improvements listed under discussion will probably require additional professional and technical staff. More staff is probably needed in any event to oversee and control a rapidly enlarging program of plantation establishment and assessment.

2. If a temporary sampling scheme, such as the one used by M.F.R.C., is to be repeated, some measurements of spacing between planted specimens along the rows and distances between rows should be obtained for each sample count. Such information would allow for more reliable calculations of average numbers planted per acre.

3. Site preparation, using mechanical devices such as barrel scarifiers, cut-over ploughs, and Bräcke spot scarifiers are considered essential, even if the planting program is being done in areas of wildfire or controlled burning. (Note that the most successful plantings to 1974 are those in the area of the 1971-Mud Lake fire where barrel scarifying and ploughing were also conducted and the least successful plantings were in areas given no site preparation.)

4. Jack pine, black spruce and white spruce, in that order, are recommended as the main species to be used in the planting program in the pilot project area. Red pine, tamarack, and white pine should be used for sites particularly suited to these species to avoid the establishment of large areas of monoculture. All species should be better matched to site conditions; in brief the pines on the dry soils, white spruce on fresh soils, and black spruce and tamarack on fresh to wet soils.

5. Container-grown seedlings appear highly suited to this region of New Brunswick, where frost heaving is a relatively minor problem. However, care in planting seedlings in containers is still required; microsites having mineral soil mixed with organic matter are to be preferred.

6. Sites for container-grown seedlings should be well prepared and natural regrowth controlled.

7. When using the Marttiini cut-over plough for site preparation, an overwintering period between ploughing and planting is recommended to allow soil slumping and settling in such severely-disturbed areas.

8. Planting programs should be terminated no later than the end of September, preferably earlier, to allow for a period of root development in the newly planted specimens.

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APPENDIX I

List of Tables

Table 2. Summary of Information from Establishment Reports, Including Cost Estimates

Plantation No.	Planting tool and/or method	Species planted	Type of seedling	Number planted (1,000's)	Acres	Number planted per acre	Cost per 1,000 planted	Cost per acre planted	Remarks
P-3-68	Shovel	rP wS bF	2-2 2-2 3-0	55 161 18	50 178 2(?)	1020	$71.00	$71.00	Information on number of seedlings and acres planted does not agree well.
P-9-68	NR[1]	wS rP	2-3 2-2	112 42	138 52	810	$51.36	$39.61	Another cost figure in the establishment report shows $63.55 as cost per 1,000.
P-10-68	Lowther-Beloit Wildland Planter	jP	NR	20	40	500	$42.24	$21.12	
P-2-69	Shovel: L-shape	rS	2-2	276	250	1100	NR	NR	
P-9-69	Lowther-Beloit Wildland Planter	rS	NR	NR	300	NR	NR	NR	
P-13-69	Shovel: L-shape	rS	2-2	54	50	1080	NR	NR	Difficult planting conditions in 1962 burn.
P-5-70(#1)	Spade: slit	rS,wS	3-0	8	7	1140	NR	NR	Planted by Consolidated Bathurst.
P-5-70(#2)	Spade: slit	rP wS,rS	3-0 3-0	2 10	11	1090	NR	NR	Planted by Consolidated Bathurst.
P-5-70(#3)	Spade: slit	bS,wS,rS	3-0	34	39	880	NR	NR	Planted by Consolidated Bathurst.
P-5-70(#4)	Spade: slit	bS,rS	3-0	12	15	830	NR	NR	Planted by Consolidated Bathurst.
P-11-70	Spade: L-shape	jP wS	3-0 3-0	87 8	140	500 to 1200	NR	NR	Spacing varies widely: fill planting.
P-12-70	Spade?: slit	wS	2-2	72	90	800	NR	NR	

Table 2. Continued

Plantation No.	Planting tool and/or method	Species planted	Type of seedling	Number planted (1,000's)	Acres	Number planted per acre	Cost per 1,000 planted	Cost per acre planted	Remarks
P-13-70	Machine-planted	wS	2-2	61	70	870	$12.83	$11.16	Costs include only machine rental and one labourer.
P-1-71	Spade?: Slit	wS jP	3-0 2-0	160 55	375	570 to 680	$54.40	$31.00	Cost per 1,000 calculated using 570 trees per acre.
P-2-71	NR	wS jP	3-0 2-0	65 15	175	460	$60.00	$27.60	Cost per 1,000 calculated using 460 trees per acre.
P-3-71	NR	wS jP	3-0 2-0	60 10	127	550	$35.14	$19.30	Spacing varies widely.
P-5-71	Spade?: wedge	wS	3-0	373	580	640	$46.25	$29.86	
P-6-71	Spade?: L-shape	wS	3-0	83	200	415?	$20.04	NR	Variable spacing.
P-7-71	Machine-planted	wS	3-0	8	10	900	$32.54	$24.58	See Costs under P-13-70
P-9-72	Spade: L-shape	jP bS	2-0 3-0	254 3	384	670	$57.25	$38.32	
P-10-72	Spade: L-shape	jP	2-0	565	695	810	$47.50	$38.61	
P-12-72	Spade: L-shape	jP bS	3-0 3-0	120 2	200[2]	600[2]	$81.00	$50.00	Acreage estimate seems much too high.
TP-13-72	Dibble	jP bS	Tube Tube	45 55	110[3]	910	$24.87	$14.00[3]	Tubes removed just before planting.
TP-1-73	Dibble	jP	Paperpot	107	115	930	$23.00	$21.43	
P-2-73	Spade?: L-shape	jP	2-0	340	285	1190	$50.00	$65.55	

Table 2. Concluded

Plantation No.	Planting tool and/or method	Species planted	Type of seedling	Number planted (1,000's)	Acres	Number planted per acre	Cost per 1,000 planted	Cost per acre planted	Remarks
P-3-73	NR	jP	3-0	101	100	1000	NR	NR	
P-5-73	Spade: L-shape	jP	2-0	523	613	850	$41.26	$35.21	
P-4-74	NR	jP	3-0	157[4]	310	About	$80.00	$66.00	
		wS	2-0	25		860			
		bS	2-0	25					
		rP	2-0	58					
P-6-74	Spade: wedge	wS	2-0	13	165	850	$58.55	$50.00	
		jP	2-0	128					
P-7-74	Dibble?	jP	Paperpot	601	1110	540	$30.00	$16.77	
P-8-74	NR	jP	2-0	606	685	910	$50.00	$41.23	
P-11-74	Shovel: L-shape	jP	2-0	71	130	550	$60.00	$33.40	Two separate areas.

[1] NR = not recorded.

[2] Estimate of acreage seems much too high: cost estimate per acre may be low.

[3] Cost per acre calculated using 175 acres planted: only about 110 actually planted.

[4] Various numbers reported are at variance: number per acre is probably inaccurate.

Table 3. Summary of Information on Plantation Establishment and Assessment

Plantation No.	Season of planting	Site preparation and year	Species planted	Type of seedling	Number planted per acre	Number of samples	Survival counts Autumn '75 or Spring '76			Number of survivors per acre	Height growth in 1975 (cm)	Total height to end of 1975 growing season (cm)
							Living (%)	Dead (%)	Missing (%)			
P-3-68	Spring	Nil	rP	2-2	1020	9	52	1	47	530	43	209
			wS	2-2	1020	18	57	0	43	580	22	107
			bF	3-0	1020	3	52	0	48	530	15	60
P-9-68	Autumn	Nil	wS	2-3	810	6	32	9	59	260	4	34
			rP	2-2	810	12	41	15	44	330	18	98
P-10-68	Autumn	Nil	jP	NR	500	12	56	3	41	280	40	236
P-2-69	Spring	Nil	rS	2-2	1100	10	72	5	23	790	4	37
P-9-69	NR[1]	Scraped 1969	rS	NR	NR	11	35	1	64	NR	NR	NR
P-13-69	Spring	Nil	rS	2-2	1080	Nil	NR	NR	NR	NR	NR	NR
P-5-70(#1)	Spring	Control burn 1965 Scarified 1967	rS,wS	3-0	1140	7	39	0	61	440	10	53
P-5-70(#2)	Spring	Scarified 1967	rP	3-0	1090	3	50	2	48	540	22	84
			wS,rS	3-0	1090	Nil	NR	NR	NR	NR	NR	NR
P-5-70(#3)	Spring	Control burn 1968	bS,wS,rS	3-0	880	11	52	0	48	460	13	57
P-5-70(#4)	Spring	Nil (Wildfire 1968)	bS,rS	3-0	830	3	47	0	53	390	14	63
P-11-70	Autumn	Nil	jP	3-0	680	5	29	8	63	200	22	68
			wS	3-0	(variable)	Nil	NR	NR	NR	NR	NR	NR
P-12-70	Autumn	Barrels, 1970	wS	2-2	800	11	78	0	22	620	17	84
P-13-70	Autumn	Nil (Old-field)	wS	2-2	870	10	77	2	21	670	21	100

Table 3. Continued

Plantation No.	Season of planting	Site preparation and year	Species planted	Type of seedling	Number planted per acre	Number of samples	Survival counts Autumn '75 or Spring '76			Number of survivors per acre	Height growth in 1975 (cm)	Total height to end of 1975 growing season (cm)
							Living (%)	Dead (%)	Missing (%)			
P-1-71	Spring	Nil (Wildfire 1968)	wS	3-0	570	18	67	1	32	380	10	42
			jP	2-0	(variable)	8	71	0	29	400	33	103
P-2-71	Spring	Barrels, 1970	wS	3-0	460	15	57	1	42	260	12	60
			jP	2-0	460	10	85	1	14	390	47	180
P-3-71	Spring	Nil (Recent cutover)	wS	3-0	550	Nil	NR	NR	NR	NR	NR	NR
			jP	2-0	550	Nil	NR	NR	NR	NR	50	152
P-5-71	Autumn	Barrels 1971	wS	3-0	640	23	73	3	24	470	9	41
P-6-71	Autumn	Nil (Cutover 1968)	wS	3-0	415?	Nil	very low	NR	NR	NR	NR	NR
P-7-71	Autumn	Nil (Old-field)	wS	3-0	900	3	59	0	41	530	9	37
P-9-72	Spring	Plough 1971	jP	2-0	670	24	81	2	17	540	41	115
			bS	3-0	670	Nil	NR	NR	NR	NR	NR	NR
P-10-72	Autumn	Plough 1971	jP	2-0	810	22	78	3	19	630	33	69
P-12-72	Spring	Nil (Wildfire 1971)	jP	3-0	610[2]	20	62	1	37	380[3]	34	93
			bS	3-0	610[2]	1	23	0	77	140[3]	6	32
TP-13-72	Summer	Barrels	jP	Tube	910	7	89	0	11	810	29	53
			bS	Tube	910	9	85	0	15	770	15	43
TP-1-73	Summer	Plough 1973	jP	Paperpot	930	22	85	1	14	790	20	36
P-2-73	Spring	Plough 1972	jP	2-0	1190	22	79	4	17	840	32	88
P-3-73	Spring	Barrels 1972	jP	3-0	1000	22	73	3	24	730	29	78

Table 3. Concluded

Plantation No.	Season of planting	Site preparation and year	Species planted	Type of seedling	Number planted per acre	Number of samples	Survival counts Autumn '75 or Spring '76 Living (%)	Dead (%)	Missing (%)	Number of survivors per acre	Height growth in 1975 (cm)	Total height to end of 1975 growing season (cm)
P-5-73	Autumn	Plough 1972-73	jP	2-0	850	16	74	2	24	630	17	34
P-4-74	Spring	Plough	jP	3-0	860[2]	4	43	2	55	370[3]	8	45
			wS	2-0	860	Nil	NR	NR	NR	NR	NR	NR
			bS	2-0	860	6	52	0	48	450[3]	7	28
			rP	2-0	860	7	58	1	41	500[3]	8	27
P-6-74	Spring	Plough and barrels 1973	wS	2-0	850	3	80	4	16	680	4	25
			jP	2-0	850	26	77	1	22	650	23	42
P-7-74	Summer	Plough 1974	jP	Paperpot	540	25	89	2	9	480	8	20
P-8-74	Autumn	Plough 1974	jP	2-0	910	30	67	26	7	610	6	14
			SP,rP,bS	2-0	910	Nil	NR	NR	NR	NR	NR	NR
P-11-74	Autumn	Plough 1974	jP	2-0	550	26	36	53	11	200	5	13

[1] NR = not recorded.

[2] Information on number and acres planted and average spacing used make these values into rough estimates.

[3] Information on number planted is at variance with spacing: numbers/acre are therefore only rough estimates.

Table 4. Weighted average survival for year of planting, site preparation, seedling stock, and planting method

(a) Year of planting	% survival	(b) Site preparation	% survival	(c) Seedling stock	% survival	(d) Planting method	% survival
1968	47	Machine planted	46	2+2 and 2+3[4]	57	Machine planted	46
1969	56	Controlled burn[3]	52	3-0	61	Slit-method	59
1970	56	Nil	54	2-0	73	L-shape and wedge	74
1971[1]	70	Wildfire	73	Tube[5]	87	Dibble[6]	88
1972	78	Barrels (and other scarifying)	74	Paperpot[5]	88		
1973	77	Cutover plough	74				
1974	72[2]						

[1] Site preparation first used on a large scale.
[2] 78% if two poor plantations are excluded.
[3] One small plantation.
[4] Used only in 1968, 1969, and some in 1970.
[5] Used for only 4 plantations in 1972, 1973, and 1974.
[6] Used only for tube and paperpot stock.

Table 5. Average total heights of jack pine seedlings

Plantation No.	Average total height: Tallest 20% (cm)	Average total height: All living (cm)	Number of growing seasons since planting	Type of seedling planted	Season of planting	Site preparation
P-10-68	333	236	7	NR[1]	Autumn	Machine-planted
P-11-70	116	68	5	3-0	Autumn	Nil
P-1-71	177	103	5	2-0	Spring	Wildfire
P-2-71	259	180	5	2-0	Spring	Barrel scarification
P-9-72	152	115	4	2-0	Spring	Ploughed
P-10-72	109	69	3	2-0	Autumn	Ploughed
P-12-72	131	93	4	3-0	Spring	Wildfire
TP-13-72	88	53	3	Tube	Summer	Barrel scarification
TP-1-73	53	36	2	Paperpot	Summer	Ploughed
P-2-73	124	88	3	2-0	Spring	Ploughed
P-3-73	108	78	3	3-0	Spring	Barrel scarification
P-5-73	51	34	2	2-0	Autumn	Ploughed
P-4-74	61	45	2	2-0	Spring	Ploughed
P-6-74	61	42	2	2-0	Spring	Ploughed
P-7-74	31	20	1	Paperpot	Summer	Ploughed
P-8-74	23	14	1	2-0	Autumn	Ploughed
P-11-74	19	13	1	2-0	Autumn	Ploughed

[1] NR = not recorded.

Table 6. Average total heights of red pine seedlings

Plantation No.	Average total height		Number of growing seasons since planting	Type of seedling planted	Season of planting	Site preparation
	Tallest 20% (cm)	All living (cm)				
P-3-68	278	209	8	2-2	Spring	Nil
P-9-68	123	98	7	2-2	Autumn	Nil
P-5-70	151	84	6	3-0	Spring	Scarified
P-4-74	37	27	2	2-0	Spring	Ploughed

Table 7. Average total heights of spruce seedlings

Plantation No.	Average total height		Number of growing seasons since planting	Species and type of seedling	Season of planting	Site preparation
	Tallest 20% (cm)	All living (cm)				
P-3-68	164	107	8	wS: 2-2	Spring	Nil
P-9-68	51	34	7	wS: 2-3	Autumn	Nil
P-2-69	58	37	7	rS: 2-2	Spring	Nil
P-5-70(#1)	85	53	6	rS,wS: 3-0	Spring	Scarified
P-5-70(#3)	102	57	6	bS,rS,wS: 3-0	Spring	Control burn
P-5-70(#4)	76	63	6	bS,rS: 3-0	Spring	Wildfire
P-12-70	124	84	5	wS: 2-0	Autumn	Barrel scarification
P-13-70	132	100	5	wS: 2-2	Autumn	Machine-planted
P-1-71	65	42	5	wS: 3-0	Spring	Wildfire
P-2-71	92	60	5	wS: 3-0	Spring	Barrel scarification
P-5-71	60	41	4	wS: 3-0	Autumn	Barrel scarification
P-7-71	54	37	4	wS: 3-0	Autumn	Machine-planted
TP-13-72	66	43	3	bS: tube	Summer	Barrel scarification
P-4-74	36	28	2	bS: 2-0	Spring	Ploughed
P-6-74	32	25	2	wS: 2-0	Spring	Ploughed

APPENDIX II

Description of Plantation Assessment Method Used by

Maritimes Forest Research Centre in 1975-1976

Field Instruction for Plantation Assessment
(Bathurst Pilot Project Area)

Study No.: M148

Objectives: To obtain information on the survival and early height growth of planted seedlings and information on competition to establish:

(i) whether a plantation has been successfully established.

(ii) if not successfully established, does plantation require fill-planting or complete replanting?

(iii) what is early height growth rate?

(iv) does planting stock require release from competition?

Data and Information Needed: The following data and information are needed:

(i) Survival rate (plus dead and missing proportions).

(ii) Reason(s) or probable reason(s) for dead and missing specimens.

(iii) Reason(s) or probable reason(s) for unhealthy, damaged or deformed stems.

(iv) Total height and height growth in the most recent growing season for living specimens. (Note: this information is to be taken only on plantations two or more growing seasons after planting: e.g. in autumn of 1975 plantings established in spring of 1974 or earlier.)

(v) Information on competition, its species, height and distance to planted specimens.

(vi) Miscellaneous notes on all aspects of the planting that may be pertinent such as: soil and site conditions, including wetness or dryness of site; site preparation method and its quality; planting method; root deformities; serious insect and disease problems as they may occur; or any other observable condition bearing on the rate of survival and the health and vigor of the planted specimens.

(vii) Rough sketch map of each plantation to delineate (a) areas of different species (b) areas of markedly different survival rates (c) areas showing marked differences in site conditions and/or competition.

Sampling Scheme: Obtain survival counts on samples of 30 seedling locations in randomly selected rows of the plantation. Travel throughout the plantation in a systematic manner and at specified distances along the travel lines, select two planted rows at random on which to obtain

survival counts on 15 seedling locations on each of the two rows. The first row to be sampled is to be selected randomly as from 1 to 10 rows beyond the measured (paced) distance along the line of travel (or at right angles to the direction of travel if planting rows and direction of travel are the same). The second sample row will be the next immediately adjacent row (see Table for sampling scheme in plantations of different sizes). For example if the size of a rectangular planted area is 55 ha (136 acres), then the lines of travel should be spaced 140 m (7 chains) apart and the samples along the line should be spaced 140 m (7 chains) apart. And in this case the approximate number of samples would be 28.

Additional information and data are to be obtained on the 5 (or fewer) living specimens at the first five planting locations for the first sample row selected. The details are outlined in the description of the tally form: next section.

Field Tally Form: The attached example of the tally form is in part self-explanatory. Since codes and abbreviations are to be used when possible, the measurement data or information to be recorded in each column is described briefly as follows:

Side 1: Survival Counts

Miscellaneous headings to show plantation No., Location, Observers, Date, whether site prepared, etc.

Column 1: Sample Number, in series as collected.
Column 2: Species planted, abbreviation.
Column 3: Survival counts to obtain the number of Living (L), Dead (D), and Missing (M) for a total of 30 planted locations.
Column 4: General remarks about the site and conditions of the sample of 30, particularly any condition adverse to the planted specimens.

Side 2: Individual Planted Tree Record

Column 1: Sample number (as on side 1).
Column 2: Seedling number.
Column 3: Status: Living (L), Dead (D), Missing (M).
Column 4: Species abbreviation.
Column 5: Total height of planted specimen, in centimetres.
Column 6: Height increment in most recent growing season, in centimetres.
Column 7, 8 and 9: Information on the species, distance from planted specimen and height of overtopping competitor(s), in metres.
Column 10: Remarks about individual seedling, its quality, the reason for its death or its damage, e.g. root deformed; Armillarea mellea; leader broken by snow; leader bent by snow; deeply planted; smothered by grass and snow, etc.

Sampling Scheme for Plantations of Varying Size

(Bathurst Pilot Project Area)

Size of Plantation	Travel Lines to be Spaced	Samples to be Spaced	Approximate No. of Samples
Up to 6 ha (15 acres)	60 m (3 chains)	60 m (3 chains)	minimum of 10
7 to 15 ha (16 to 37 acres)	80 m (4 chains)	80 m (4 chains)	11 to 23
16 to 25 ha (38 to 62 acres)	100 m (5 chains)	100 m (5 chains)	16 to 25
26 to 40 ha (63 to 99 acres)	120 m (6 chains)	120 m (6 chains)	18 to 28
41 to 55 ha (100 to 136 acres)	140 m (7 chains)	140 m (7 chains)	21 to 28
56 to 70 ha (137 to 173 acres)	140 m (7 chains)	160 m (8 chains)	25 to 31

Note: Break larger plantations into smaller, natural subdivisions, and layout sampling to obtain about 20 to 30 samples.

PLANTATION ASSESSMENT

(Side 1)

Plantation No.:_____ Observer(s):_____

Location:_____ Date:_____ Sheet: _____ of _____

Site Preparation: _____

Soil Conditions: _____

Vegetation Conditions: _____

(other than planting) _____

_____

Other General Comments: _____

_____

Sample Number	Species	Count	Remarks
		L. D. M.___ E 30	
		L. D. M.___ E 30	
		L. D. M.___ E 30	
		L. D. M.___ E 30	
		L. D. M.___ E 30	

PLANTATION ASSESSMENT

(Side 2)

1	2	3	4	5	6	7	8	9	10
Sample No.	Seedling	Status	Spec.	Tot. Ht. (cm)	Ht. Inc. (cm)	Competition			Remarks
						Spec.	Dist. (m)	Ht. (m)	
	1								
	2								
	3								
	4								
	5								
	1								
	2								
	3								
	4								
	5								
	1								
	2								
	3								
	4								
	5								
	1								
	2								
	3								
	4								
	5								
	1								
	2								
	3								
	4								
	5								