FIELD SURVEY OF PLANTATIONS IN COLCHESTER COUNTY, NOVA SCOTIA

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ABSTRACT

This report presents results of an assessment of 50 forest plantations in Colchester County, Nova Scotia, and includes a brief analysis of data on a thinning trial plantation, established by the Nova Scotia Department of Lands and Forests between 1954-1962. Data on survival, height and diameter increment, root penetration into different soil types, and volume production are presented in tables and diagrams.

The results suggest that the rate of diameter growth is a major factor in yield production and can be partially controlled by thinning. The initial spacing in plantations should be such that thinning will produce the most profitable yield.

Recommendations are made as guidelines for the establishment of future plantations in Colchester County.

RESUME

Ce travail présente les résultats d'une évaluation portant sur 50 plantations forestières du comté de Colchester en Nouvelle-Ecosse. Il comprend une brève analyse de données relatives à une expérience d'éclaircie dans une plantation, effectuée par le Nova Scotia Department of Lands and Forests entre 1954 et 1962. Les données, sous forme de tableaux et diagrammes portent sur la survie, l'accroissement en hauteur et en diamètre, la pénétration des racines dans divers types de sol et la production volumétrique.

Les résultats sous-entendent que le taux de croissance du diamètre est un facteur important de rendement productif qu'il est possible de contrôler partiellement au moyen des éclaircies. Il faudrait que l'espacement initial dans les plantations soit tel que des éclaircies pourront donner le rendement le plus profitable.

Les auteurs font des recommandations qui serviront de lignes directrices pour l'établissement des futures plantations dans le comté de Colchester.

FIELD SURVEY OF PLANTATIONS IN COLCHESTER COUNTY, NOVA SCOTIA

INTRODUCTION

This is the fifth report in a series on the assessment of forest plantations in the southwestern counties of Nova Scotia[1]. In August and September, 1975, the plantations in Colchester County were assessed for soil and site conditions, and for tree survival, height growth, and where possible, diameter (Appendix A). The results of that assessment are summarized and recommendations are made for improving reforestation success.

THE STUDY AREA

General Description

Colchester County is located in north-central Nova Scotia (Fig. 1). It has an area of 3.7 km^2 (366,039 ha). Farming is the leading industry and a substantial portion of the land has been cleared for this purpose.

Between 1948 and 1969, 50 tree plantations, covering 165 ha (407.5 acres), were established at the locations shown in Fig. 2. Seventy-eight percent of the plantations were established by Scott Maritime Pulp Ltd., 19% were on Provincial Crown Land, and 3% on the land of small private owners. Scott Maritime Pulp Ltd. established a

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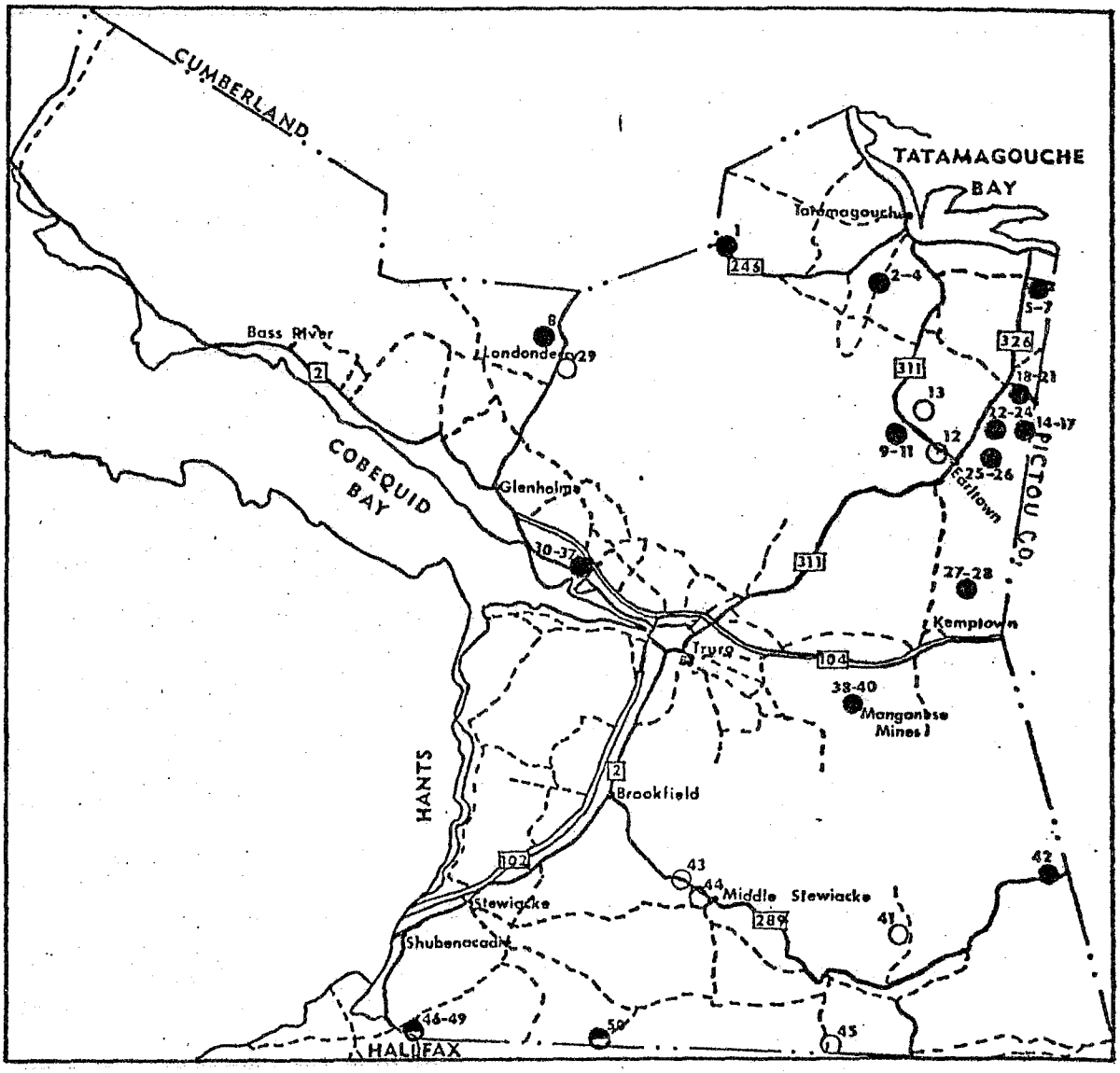
[1]Available from the Canadian Forestry Service, Maritimes Forest Research Centre, P.O. Box 4000, Fredericton, N.B. E3B 5P7

Fig. 1. Location of the study area, Colchester County



O — Less than 0.5 hectare

◓ — 0.5 to 2.3 hectare

● — More than 2.3 hectare

0 3 6 9 Miles

Fig.2. Locations of plantations surveyed in Colchester County.

large plantation of various species (Plantation Nos. 38-40) on 68.6 ha (169.5 acre) at Manganese Mines near Truro, and this is used by the Nova Scotia Teacher's College as a demonstration plot to study tree biology under natural conditions. The Nova Scotia Department of Lands and Forests conducts seed production and species trials on 8.2 ha (20.3 acre) (Plantation Nos. 30-37) of Crown Land at Debert.

Climate

Colchester County lies within the humid temperate zone. The mean annual temperature recorded at the weather station in Truro (elevation 30 m) is 5.6°C, with a minimum of -7.2°C in January and February and a maximum of 17.8°C in July. The annual average precipitation is 1179 mm, which includes 1119 mm snowfall. The frost-free period is 120 days, and the growing season is about 180 days. The above data are more or less characteristic of the climate of the reforested areas. The north shore (Northumberland Strait) has a somewhat later spring and a shorter frost-free period than the southern part of the county (Wicklund and Smith 1948).

Geology & Soils

Igneous, sedimentary, and metamorphic rocks are found in Colchester County. They are composed of different parent materials which give rise to numerous surface deposits and soil series. Most of the county has soils underlain by sedimentary rocks of Carboniferous origin. These rocks consist of grey and brown sandstones, grey and brown shales, grey and purplish red conglomerates, and to a lesser extent, limestone, and gypsum (Wicklund and Smith 1948).

In the plantations, several soil series are represented, according to maps prepared by Wicklund and Smith (1948). Description of soils is presented in Appendix B. The most common soils are Diligence (42% of all soil types), Westbrook (22%), Cobequid (12%), Truro (6%), Pugwash (6%), Thom (4%), and Kirkhill (4%). The remainder (4%) are insignificant. The above soils have developed on glacial tills and have the texture and color of the material from which they were derived. Thus, their texture ranges from clay to gravelly and stony. Variation in color is perhaps the most striking characteristic and is associated with soil quality, e.g. the red and brown soils are more friable and less stony than the grey soils.

In addition to the classification based on the Wicklund and Smith maps, one soil profile from a pit dug in each plantation was examined by routine field test. These profiles showed differences mainly in texture and depth of compaction, both of which affected tree survival and growth.

The largest plantation was on Diligence soils at Manganese Mines (Nos. 38 to 40). The soil had been ploughed long before planting. It was poorly drained and cracked during the dry summer of 1975. The plowed layer overlies a 15-cm Bt subsoil which has a high ratio of fine clay to total clay and becomes hard when dry. The Bt horizon is underlain by a silty-clay transition horizon (BC) with traces of iron pan. These subsoils do not promote root extension and root growth is restrained at about 35 cm.

Plantation Nos. 13 to 23 were established on old fields in Westbrook soils near Earltown. The surface and subsoils (A and B horizons) are deep, composed of clay loam and sandy clay loam. The C horizon is

clay and becomes slightly firm at about 55 cm in depth. These soils are well drained and rooting depth is about 45 cm.

The soils in plantation Nos. 24, 25, 28, and 29 near Biochran and Probert are classified as Cobequid series. The A and B horizons are loose silty loam, and are structureless with different sizes of stones and rocks in the subsoils. They are fairly well drained as is indicated by a rooting depth of 50 cm.

The soil in plantation No. 50, classified as Kirkhill series, is similar to the Cobequid series. It has a compacted C horizon at 50 cm.

Plantations at Debert, Nos. 30 to 37, are classified as Truro series. It was observed from the pit profile that the soils in the area are generally sandy and drainage varies from poor to good. Plantation No. 31 is the only one having a 20-cm Bt horizon of clay loam which changes to a transition horizon at about 50 cm and becomes firm below. The drainage of this soil is poor to fair. Plantation 37a has discontinuous pockets of iron-pan in the subsoil below 45 cm. It is a shallow soil as in indicated by the 25-cm rooting depth. The other site in this plantation, No. 37b, is on deep sandy loam and the rooting depth is 50 cm. The soil of plantation 32 consists of structureless, friable, loose sand overlying a subangular blocky, slightly firm, sandy clay loam subsoil. The subsoil becomes compacted at 40 cm, and drainage is poor. Plantations 33 to 35 are on a sandy site which is covered by heath vegetation and surrounded by a peat bog.

Plantations 2 to 7, and 46 to 49, near Beacon Hill, Denmark, and Gays River were established in Pugwash soils. Their subsoils are

highly variable ranging from sand, to clay loam, to compacted clay. There are also differences in the depth to the compacted C horizon. The variability of soil texture is indicated by the rooting depth which ranges from 25 cm to 40 cm.

The soils of plantations 26 and 27 are friable sandy clay loam with both loose and firm transition horizons of different sizes of rocks. Although these rocks, derived from quartz, exhibited orange-reddish iron traces, especially in plantation 27, iron-pan formation has not yet been observed.

Vegetation

Settlement of Colchester County began in 1755. The land was cleared for farming which has resulted in large areas of agricultural land, second-growth forest stands, and non-cultivated pasture lands. Farming has changed the soils, the vegetation, and probably the micro-climate. Plant associations as natural successions are rarely found.

According to Wicklund and Smith (1948), the county can be classified in two categories depending on its geomorphological and bioclimatic features. The lowland area in the western and southern part of the county is characterized by mixed conifer and hardwood forests. In the better drained areas, the dominant species are red spruce, white spruce, balsam fir, beech, sugar maple, yellow birch, paper birch, and trembling aspen. The poorly drained areas support chiefly black spruce, larch, wire birch, and alder. Red pine is not common but a few red pine plantations, Nos. 8, 20 to 37, 43 to 45, 49 and 50, have been established.

The other area, Cobequid Mountain, extends across the central part of the northern half of the county. The topography is rolling to hilly. Forest vegetation is mainly mixedwood. The color of the soil and the high content of organic matter accumulation indicate that they have developed predominantly under hardwood forest.

Most of the plantations in this area were established on old field sites, using spruce and pine. Goldenrod, flat-topped aster, raspberry, strawberry, witherod, sedges, and sweet grasses were the dominant ground vegetation plants found scattered throughout the planting sites. In the plantations near Debert, lambkill and blueberry replace the herbaceous plants. The change from cultivated-site vegetation to heath vegetation may indicate the continuous modification of ground cover in sandy soils under developing forest stands. Another exception was at Glenmore in plantation No. 50 and at Logan Brook, No. 42, where Labrador-tea, rhodora, blueberry, and lambkill were dominant under scattered bracken.

Planting

The seedlings for Crown Land and Scott Maritime Pulp Ltd. plantations were produced in the Forest Tree Nursery at Lawrencetown, Nova Scotia which is operated by the Department of Lands and Forests. Between 1948 and 1969, a total of 279,470 white spruce, 100,654 red pine, 19,100 red spruce, 10,500 black spruce, and 18,760 introduced species (such as pitch, Scots, Lodgepole, and Jack pines, Norway spruce, and Douglas fir) were planted. The introduced species were set out in small lots mainly by private land owners. Data on seed sources and planting methods were not available but most of the seedlings were set

out in the spring. The planting season of plantations Nos. 8 to 11, 19, 23, 37, 38, 43 to 45 and 47 to 49 is unknown. These plantations were established by small land owners who did not keep records. Plantation Nos. 13 to 20, 25 and 40 were prepared with disc furrow. There was no soil cultivation or soil treatment in the other plantations.

STUDY METHODS

Surveys were carried out in August and September, 1975. Most of the plantations assessed were established for operational purposes as part of larger reforestation projects but some were informal demonstration trials. In each plantation, except the trials, every tenth tree was measured for height, and, where appropriate, dbh. Survival and infestations of fungi and other organisms were assessed in every second row. The survival figures include all planted trees which were living at the time of the survey. Age refers to time since planting to avoid any confusion that might arise from the different age-classes of the seedlings. Percentage cover of the dominant and other important ground vegetation species were also assessed.

Surveys in the demonstration trials consisted of measuring trees for height and dbh in sample plots of various sizes, representing about 20% of each area.

RESULTS AND DISCUSSION

Spacing and Survival

The different spacings used in the plantations are presented in Table 1. A spacing of 1.8 x 1.8 m was used most frequently for all species except white spruce at Manganese Mines (No. 40) where a large

planting complex was established at 2.4 x 2.4 m. This spacing was necessary to conform to furrows cut to drain surplus moisture from the heavy clay soil. At Denmark (Plantation No. 5) a red pine plantation with 2 + 2 seedlings was established at 2.7 x 2.7 m.

Observations showed that close spacing, such as 1.2 x 1.2 m, results in too dense a stand and will not produce a profitable yield. This is especially true for pines. Experience in many parts of North America shows that about 2500 trees/ha, 2.0 x 2.0 m, is an optimum planting density for a wide variety of species, age-classes, and sites (Toumey and Korstian 1942). Seventy-one percent of red pine plantations were planted denser than this (Table 1). (The actual number of planted seedlings per spacing in Table 1 is not consistent with the number of seedlings calculated for a unit area because the size of planted lands was inaccurately estimated at the time of planting.)

Table 1 shows an apparent correlation between density and survival i.e. denser spacing, higher survival. However this is not a meaningful relationship in that red pine showed highest overall survival merely because it is hardier than the other species and it was only by chance that red pine was planted at denser spacing or in higher proportion (86%) than the spruces (column one). The red pine plantations Nos. 29 and 38 in irregular and 0.6 x 1.8 m spacing, respectively, were excluded from the table because survival was less than 5%.

The low survival in plantation No. 29 was the result of heavy weed competition rather than poor rooting, although the rocky, shallow soil is not, in any case, favorable for growing trees.

Table 1. Proportions of the plantations established at different spacings, and survival (%) by age and spacing

	1.2 x 1.2 m	1.8 x 1.8 m	1.8 x 2.4 m	2.4 x 2.4 m	Irregular	Other*
Distribution of spacing (%) for the planted area	3	41	4	46	3	3
No. of seedlings needed/hectare	6944	3086	2315	1736	2500**	1904
No. of seedlings planted per hectare	6616	2557	2332	2368	2750	1658
No. of seedlings surviving/hectare	5420	1830	1330	1417	1500	998
Overall survival (%)	82	71	57	59	55	60
	Species distribution in spacing (%)					
Spruces (red, black, white)	1	36	5	54	4	0
Red pine	24	47	1	13	7	8
Others	3	73	6	5	-	13***

* Spacing: 0.6 x 1.8 m, 1.5 x 2.1 m, 1.8 x 2.1 m, 2.4 x 3.0 m, and 2.7 x 2.7 m.
** Number of seedlings for irregular spacing was calculated as for 2 x 2 m spacing.
*** Only Norway spruce was planted at 1.8 x 2.1 m spacing.

Soils with high clay content offer considerable resistance to root elongation and branching. Often relatively long periods elapse between rains in Colchester County, and the survival of seedlings is best where the surface soil is loose textured. Early spring planting is suggested in these soils because the seedling roots can penetrate deep into the subsoil before the upper soil dries out. This was the case in the sandy loam soil at Debert where high survival was obtained in the red pine plantations. Also when the cultivated surface soil has a high clay content, it may resist percolation to the extent that during and immediately after rainy seasons the top soil remains saturated and has little aeration. Low initial survival can be expected in this kind of soil as was observed at Manganese Mines. Special site preparation is recommended to drain the soil surface and restore the aeration and water balance.

Data on stock-age were not available from the planting records except in a few cases. Available data (Appendix A) suggest that seedlings or wildings were often too old for good survival and early growth, but data are insufficient to draw any definite conclusions.

Average survival for the native species was: red pine 74%, white spruce 64%, black spruce 55%, and red spruce 32%. At Denmark (Plantation No. 7) red spruce exhibited the lowest survival. This site was in Pugwash soils where weed competition was intolerable for red spruce. Sweet grasses, clumps of alders, and wild roses grew over the 3 + 0 red spruce seedlings and choked them immediately after planting. The best performance of white spruce and red pine (90% survial) was in Pugwash, Westbrook, and Thom soils where there was relatively good drainage

and adequate depth of soil. Among the introduced species, Norway spruce and Jack pine exhibited good survival (80-90%) while that of Douglas fir was less than 15%.

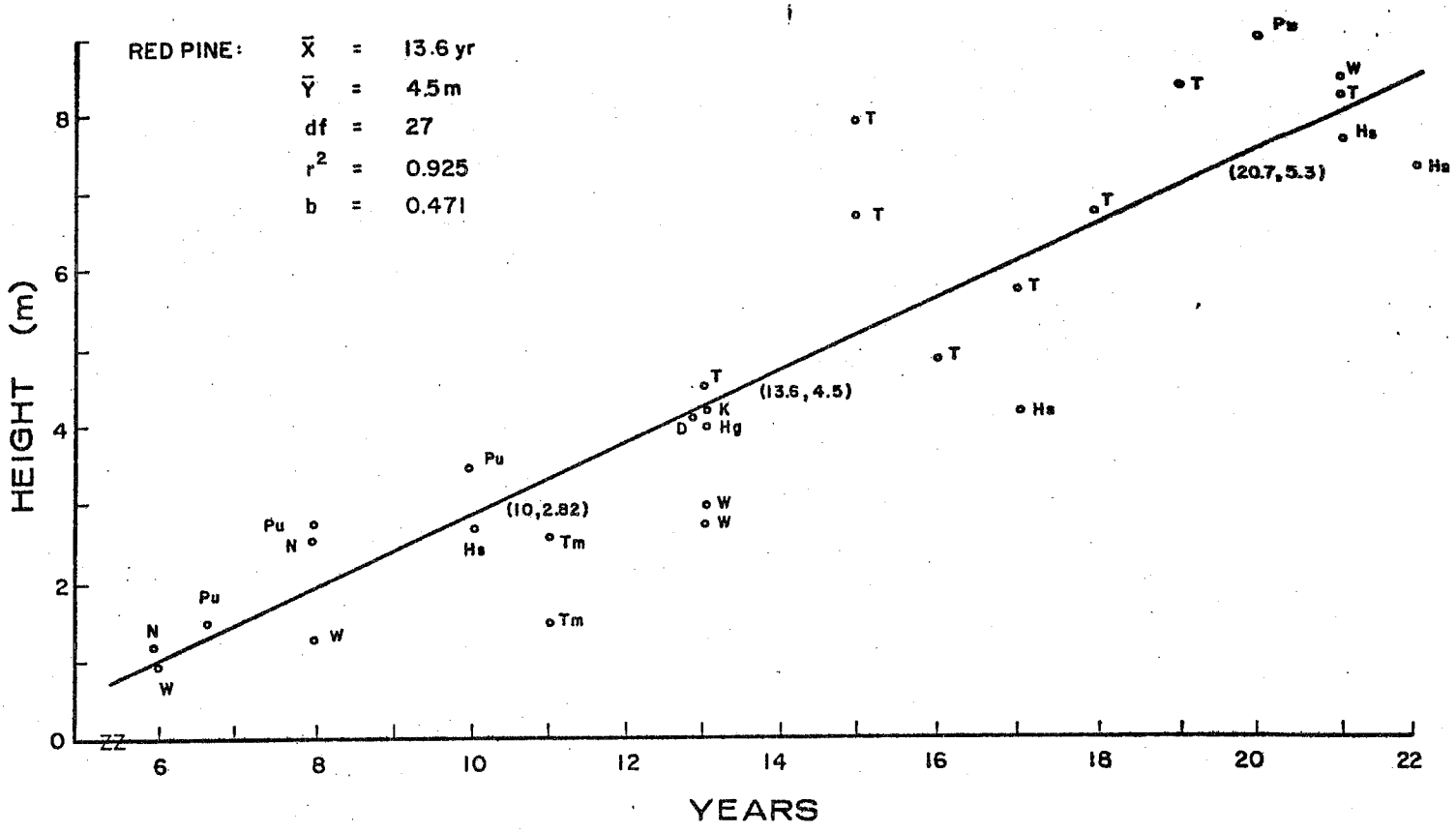
Observations on injuries from fungi, insects, and porcupines are presented in Appendix A. About 44% of the red pine plantations were infested by European pine shoot moth and 11% heavily damaged by porcupines. Porcupines damaged mainly the older red pines planted before 1964 and all the Scots pines. Light infestations of budworm were recorded in 73% of the white spruce and 83% of the red spruce plantations. White spruce was attacked by budworm in the large planting areas, such as at Manganese Mines (54.2 ha), rather than in the small scattered plantations.

Height Growth

Only the data on red pine were analyzed by regression for height growth because the other species were represented by insufficient numbers of plantings and age-classes. Figure 3 shows the association between height and age up to 22 growing seasons. Six of the eight plantings in Truro soils, four of the six in Pugwash soils, two of the six in Westbrook soils, and one in Nappan soils showed better than average height growth.

Two younger plantings (Nos. 2 and 49) in Pugwash soils which displayed low survival were established in clay-loam soils with shallow Bth and firm lower horizons. On these sites the seedlings apparently failed soon after planting because of poor drainage and aeration in the soils and heavy sweet grass competition. Those that survived were able

Figure 3. Regression of heights on age for red pine plantations.



o - red pine
Pu - initial of soil series, see Appendix B for full term.

to outgrow the weeds, probably because of favorable weather conditions in the later years. The remainder of the plantings with above-average height growth, particularly those at Debert (Truro soils), displayed high survival. They were established in relatively good sandy loam soils which were less favorable for competitive sweet grasses and more suitable for red pine.

Growth of the different species in identical soil series and age classes was compared. Variation between and within species was great in regard to site quality. In several plantations (Nos. 41a, b, 48) trees of exotic species grew well. Seventeen-year-old, Norway spruce and Scots pine were taller than red pine of the same age-class. White spruce generally grew slower than red pine, except in plantation No. 28 on a good, well-drained silty-loam soil. However, the initial survival of white spruce in plantation No. 28 was poor.

The soils in the assessed plantations are, in general, deep enough to allow root development characteristic of each species, and consequently there was no clear association between root development and tree growth. Roots penetrated to a depth of 40 cm or more in 64% of the soils investigated. The shallowest rooting depth (25 cm) was measured in Plantation Nos. 42 and 48 on shallow clay-loam soils with a compacted horizon at 28 cm and in Plantation No. 37a on a shallow sandy loam soil with iron pan at 35 cm. Root penetration deeper than 40 cm was found in 75% of all Truro soils followed by 55% of Pugwash and 45% of all Westbrook soils. The Diligence and Thom series were the least suitable soils for root elongation; the roots did not extend beyond 40 cm depth in any instance. Poorly drained, shallow surface soil and clay subsoil, frequently firm and compacted, were responsible for the adverse effects on root development. Growth in these soils was retarded as a consequence of unsuitable soil conditions.

Thinning trials at Debert

Plantations of red pine at Debert covering 8.2 ha (2.02 acres) are being used for thinning and seed production trials; 5.0 ha for thinning, and 3.2 ha for seed production (Mullin, 1977)*. The plantations were established between 1954 and 1962 on old fields. The soils are friable, loose structureless sandy loams with a compacted horizon at about 50 cm. Plantation No. 37a is divided into two plots; the smaller plot has an iron-pan layer at about 45 cm while the larger plot has a deep sandy soil deposited over granite-quartzite parent material. The measurements in the two plots were averaged.

The spruces, in plantations 36a,b,c,d were planted on the hilly side of the demonstration area in better soil than that of the red pine. It consists of deep, reddish-orange sandy loam and a loamy upper horizon. No compacted layer was found to a depth of 50 cm.

Details of the thinning and seed production treatments and data on the performance of the plantations are given in Table 2.

Diameter (dbh), and actual and estimated volume per hectare are illustrated in Fig. 4. The estimated volume per hectare refers to 2500 trees, as the most suitable density would be and is based on the assessed data. Volume was calculated by Honer's (1967) Standard Total Cubic foot volume equation. The charts in Fig. 4 indicate the relative effect of age, site quality, and thinning on the single tree growth in identical spacing. The actual volumes were apparently controlled by spacing applied at planting, and indicate the effect of thinning operation also at different times.

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*Mullin, T. 1977, Forester, Nova Scotia Dept. Lands and Forest by correspondence.

Table 2. Performance of plantings at Debert in 1975.

Age Year	Species and Code No.	Spacing (m)	No. of trees survived/ha (%)	Height (m) and Standard error of estimate $S_{\bar{x}}$	Annual height growth (cm)	Dbh (cm)	Volume/tree* (m^3)	Total volume/ha* (m^3)
22	red pine 32a	1.8 x 1.8	80 2388	8.3 ± 0.10	38	14.5	0.0718	171
20	red pine 31	2.4 x 2.4**	90 1562	8.1 ± 0.09	41	16.9	0.0899	140
19	red pine 30a	2.4 x 2.4†	85 1476	6.7 ± 0.06	35	11.7	0.0365	54
18	red pine 30b	2.4 x 2.4†	70 1215	5.7 ± 0.07	32	11.4	0.0269	33
17	red pine 30c	2.4 x 2.4†	75 1302	5.8 ± 0.07	34	12.3	0.0326	42
17	red pine 33	2.4 x 2.4**	90 1562	4.8 ± 0.13	28	7.4	0.0092	14
16	red pine 32b	1.2 x 1.2	80 5369	6.6 ± 0.11	41	10.4	0.0256	137
14	red pine 37a	1.8 x 1.8	85 2537	4.4 ± 0.22	31	7.6	0.0110	28
18	white spruce 36a	1.2 x 1.2	40 2684	5.3 ± 0.36	29	7.6	0.0133	36
18	red spruce 36b	1.2 x 1.2	50 3355	5.4 ± 0.38	30	7.0	0.0113	38
18	black spruce 36c	1.2 x 1.2	65 4362	5.7 ± 0.37	32	8.0	0.0145	63
18	Norway spruce 36d	1.2 x 1.2	40 2684	5.9 ± 0.00	33	8.1	0.0160	43

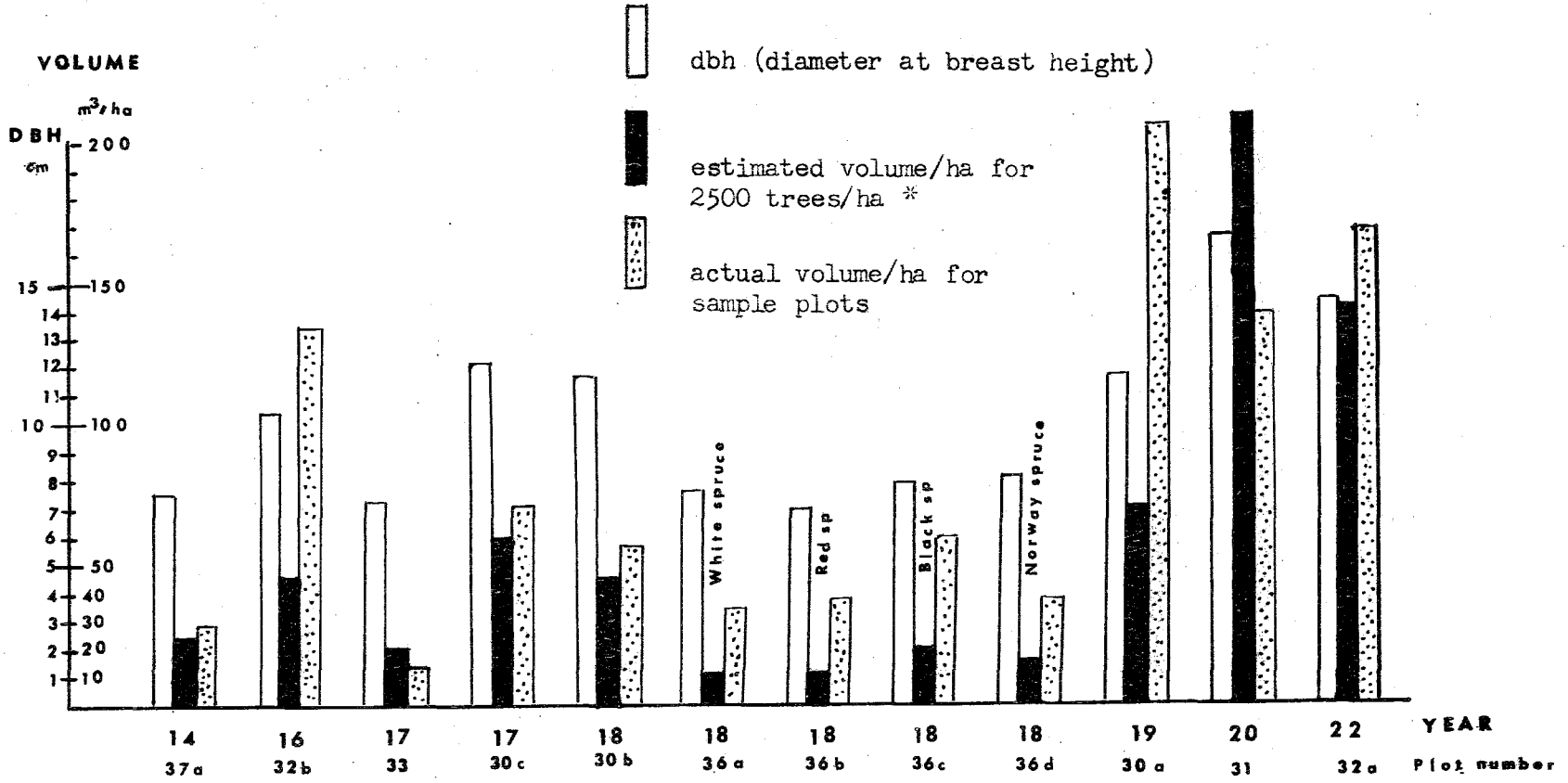
* Stump and top included in the volume. Honer (1967) equation was used to calculate the volumes using his regression coefficients in height (ft) and dbh (inch) then converted to cubic meter.

** Thinned in 1973 from 1.2 x 1.2 m to 2.4 x 2.4 m (approx. 50%).

† Thinned in 1965 from 1.2 x 1.2 m to 2.4 x 2.4 m.

Fig. 4. Average dbh, actual volume/ha and estimated volume/ha in red pine stands, at Debert, Colchester County

(white, red, black and Norway spruce are shown for comparison)



* Honer's tables: for red pine (I-2), white spruce (I-7), black spruce (I-5) red spruce and Norway spruce (I-6)

Many authors have emphasized that red pine height growth can be improved by thinning. and the following statements can be relevent to red pine in Nova Scotia, Engle and Smith (1951) pointed out that in natural stands the effect of thinning was much more pronounced than in plantations. In fact, they said thinning in young, well-stocked or overstocked stands can improve height growth. Ralston (1954) recommended leaving a maximum of 1500 stems/ha, well distributed throughout the plantation after a commercial thinning at 25 years of age to obtain greater annual growth. The growth and yield potential of an intensively managed red pine plantation was studied by Zasada and Buckman (1957) in Minnesota. The plantation was established in 1.2 x 1.2 m spacing. Survival after 15 years from planting was 89%. The close spacing in this plantation was not particularly detrimental during the first 15 years of growth, and the planting produced 219 m^3/ha (approx. 0.037 m^3/tree). A total of 57 m^3 was then cut and 3710 trees/ha were left which was still denser than the usual initial stocking. After 5 years the yield was assessed again and was found to be 382 m^3/ha (approx. 0.103 m^3/tree), with a total height of 9.75 m and 11 cm dbh. The authors stated that the good results can be attributed in large measure to proper site preparation and the effective release work during the early life of the stand. However, Bickerstaff[2] emphasized that research within the Canadian Forestry Service indicated that in the range near optimum stocking, the annual increment was almost constant, but once stocking drops below 80% by heavy thinning, increment will be

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[2]Bickerstaff comments on a report by L. Holt presented at the group session on forest management of the Annual Meeting of the Canadian Pulp and Paper Association. Woodland Section Index No. 1265 (F-2), 1952.

lost. He pointed out that at least 75% of full stocking is necessary to produce satisfactory yields after thinning.

Applying the above discussion to the present study, it seems that Plantation No. 31 was affected by thinning in 1973, which is indicated by its increased height growth and diameter, while Plantation No. 33 did not show any improvement compared to the other plantings established in the same year. Plantations Nos. 30a,b,c thinned first in 1965 for seed production, did not show significant growth increment, reinforcing Bickerstaff's statement concerning decreasing density. Figure 5 shows these stands in 1976 after the second thinning to 80%, difference in density between Plantation No. 31, thinned in 1973, and Plantation Nos. 30a and b thinned in 1965 and 1975. Several of the plantations will need 'weeding' i.e. the removal of stems infested by diseases and insects and damaged by other abiotic agents. This kind of thinning will be uneconomical at present. The spruces need particular attention to restore the stand. Many Norway spruce were damaged by weevils that gradually will spread to the red, black, and white spruce. Many of the spruces were smothered by weeds in the early years after planting.

From the above observations it can be concluded that the rate of diameter growth is a major factor in yield production and more or less can be controlled by thinning. Furthermore, future dividends can be expected from early thinning but there is no return at present.

a. Planted in 1956 (Pl.No.31), spacing 2.4x2.4 m in 1976. Avg ht = 8.1 m, dbh = 17 cm.

b. Planted in 1957 (Pl.No.30a), spacing 4.9x4.9 m in 1975. Avg ht = 6.7 m, dbh = 11.7 cm.

c. Planted in 1958 (Pl.No.306), spacing 4.9x4.9 m in 1975. Avg ht = 5.7 m, dbh = 11.4 cm.

Fig. 5. Red pine plantations on old field sites in sandy loam soils at Debert, 1976. (Camera distances were identical in each picture.)

RECOMMENDATIONS

The field performance of various tree species growing on different soils was assessed in plantations from 6 to 22 years old. The plantations were extremely variable because of many factors, such as differences in seed sources, changing nursery practices throughout the 17 years that the seedlings were provided, and outplanting sites differing in soil types, aspect, exposure, climatic effects, spacing, ground treatment and silvicultural operations. However, the observations presented in this report on survival, growth, and variation between species could be applied to any plantation in the area that consist of the better species, sites, and seedling age-classes.

Proper species selection is important. In Colchester County, species were frequently planted in soils too poor for satisfactory development. The objective in the establishment of the plantations was to plant commercially valuable species on sites with the least slash or stumps, and in suitable soil. Site conditions must be considered, i.e. ground vegetation, former stand type, soil characteristics, and the removal of competing vegetation. In the early stages, competition from lesser vegetation such as lambkill, bracken, sweet fern, sweet grasses, flat-topped aster and their associates, suckers of alder, hazel, red oak, and aspen are detrimental and preclude the possibility of the plantations surviving. Field planting without site preparation is wasted effort. It is necessary to give the planted trees at least two or three years grace to establish their roots sufficiently to enable

them to compete successfully with lesser vegetation (Paul 1957). Furrowing was mainly used for site preparation in the plantings. In some cases, the furrowing adversely affects the drainage of sandy soils, especially in a dry summer and can cause frost-heaving in the heavier soils in winter. Light machines such as marden roller and rome disc rather than heavy equipment are suggested for use in cutover areas. Plowing is satisfactory in old fields.

Increased survival and height growth can be expected if good quality seedlings are used. Transplanting and certain other nursery treatments such as the application of proper fertilizer mixture to develop the root systems will produce sturdier seedlings and well-balanced planting stock with good stem/root ratios. Increasingly better stock is required the more difficult the conditions.

In general, the plantings have been carried out by the slit method. This method may provide good early survival. However, experience shows that the full effects of planting methods may not show up for 10 to 30 years (Paul 1957). Under severe stress, such as extreme climatic conditions or severe competition for moisture and nutrients when the tree crowns close in, the poor root distribution that result from a type of planting such as the slit method, especially in heavy compact soils, may result in high losses. Therefore, in the clay soils of Colchester County, deep planting systems are suggested. The larger the stock the greater the necessity for speading the roots so that they assume their natural position.

It appears that in many plantations the seedlings were forgotten after being planted. Release work is needed in all plantations except those established on extremely open sites. 'Weeding' is necessary at a very early stage when the damaged and diseased stock, and the undesirable high bushes such as alders, oaks, and aspens must be taken out. Ground vegetation and tree suckers are competition and endanger the growth of the planted trees. However, by maintaining mixed stands of unrelated but congenial species that have regenerated naturally and exhibited commercially promising wood it is possible to avoid large, pure, even-aged stands and prevent serious damage from pathological and entomological pests. As the plantations mature, they should be thinned moderately and given the same silvicultural treatment as natural stands to obtain the maximum output from the investment.

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APPENDIX A: Summary of Plantation Records

Summary of Plantation Records

Plantation number	1	2	3	4	5	6
Species	rP	rP	wS	rS	rP	wS
Planting date (19..)	67	68	68	68	67	67
Stock age (years)	2/2	4/0	3/2	3/2	2/2	3/0
Spacing (m)	2.4x2.4	2.4x2.4	2.4x2.4	2.4x2.4	2.7x2.7	2.4x2.4
Survival (%)	70	45	80	60	75	40
Mean height (m)	2.7	1.4	1.3	0.9	2.6	1.5
Mean dbh (cm)	0	0	0	0	0	0
Soil type*	N	Pu	Pu	Pu	Pu	Pu
Soil texture	c.l.	c.l.	c.l.	c.l.	c.l.	c.l.
Area (ha)	2.3	2.4	1.2	1.2	1.0	0.7
Rooting depth (cm)	48	30	30	30	41	41
Status	Good	Fair	Good	Fair	Fair	Fair
Significant infestation	nil	nil	nil	nil	E.P.S.M.	BW
Number trees planted	3900	4000	2000	2000	1450	1000

Plantation number	7	8	9	10	11	12
Species	rS	rP	rP	rP	rP	rP
Planting date (19..)	67	53	54	58	62	65
Stock age (years)	3/0	-	-	-	-	-
Spacing (m)	2.4x2.4	1.8x1.8	1.8x1.8	2.1x2.1	1.8x2.4	1.2x1.2
Survival (%)	5	85	80	65	70	65
Mean height (m)	0.8	7.3	7.6	4.1	4.0	2.6
Mean dbh (cm)	0	12.8	13.6	7.2	0	0
Soil type*	Pu	Hs	Hs	Hs	Hg	Hs
Soil texture	c.l.	s.l.	s.l.	s.l.	s.l.	s.l.
Area (ha)	1.2	2.0	0.2	0.4	0.1	0.2
Rooting depth (cm)	41	46	46	46	-	51
Status	Poor	Good	Good	Good	Good	Fair
Significant infestation	BW	nil	nil	nil	nil	-
Number trees planted	3600	5200	600	1000	360	1600

Plantation number	13	14	15	16	17	18
Species	rP	wS	rP	wS	wS	rS
Planting date (19..)	69	69	69	69	67	67
Stock age (years)	-	-	-	-	-	-
Spacing (m)	1.8x1.8	2.4x2.4	2.4x3.0	1.8x1.8	1.8x1.8	1.8x1.8
Survival (%)	75	70	75	90	55	35
Mean height (m)	1.1	0.9	1.0	0.7	0.9	0.7
Mean dbh (cm)	0	0	0	0	0	0
Soil type*	W	W	W	W	W	W
Soil texture	c.l.	c.l.	c.l.	c.l.	c.l.	c.l.
Area (ha)	9.3	2.4	2.8	8.9	4.0	4.8
Rooting depth (cm)	45	45	45	45	36	36
Status	Fair	Fair	Poor	Good	Poor	Poor
Significant infestation	EPSM	BW	EPSM	nil	BW	BW
Number trees planted	20400	4000	2900	17000	11000	13000

Plantation number	19	20	21	22	23	24
Species	wS	rP	rP	rP	rP	wS
Planting date (19..)	67	67	62	54	62	67
Stock age (years)	-	-	-	-	-	-
Spacing (m)	1.8x2.4	1.8x1.8	1.8x1.8	1.8x1.8	1.8x1.8	1.8x1.8
Survival (%)	60	80	85	70	50	65
Mean height (m)	0.8	1.2	2.9	8.4	2.7	1.0
Mean dbh (cm)	0	0	0	13.9	0	0
Soil type*	W	W	W	W	W	Cd
Soil texture	c.l.	c.l.	s.l.	c.l.	c.l.	s.l.
Area (ha)	1.2	0.8	2.0	0.2	0.2	12.5
Rooting depth (cm)	32	32	46	28	28	38
Status	Fair	Fair	Good	Good	Poor	Fair
Significant infestation	BW	EPSM	Nil	WW	WW	Nil
Number trees planted	3000	2400	5200	500	700	36000

Plantation number	25	26	27	28	29	30a
Species	NS	rP	wS	wS	rP	rP
Planting date (19..)	67	64	64	69	69	57
Stock age (years)	-	3/2	3/2	-	-	2/2
Spacing (m)	1.8x1.8	2.4x2.4	2.4x2.4	Irr.	Irr.	1.2x1.2
Survival (%)	90	10	70	50	5	85
Mean height (m)	1.0	2.5	1.4	1.5	0.9	6.7
Mean dbh (cm)	0	0	0	0	0	11.7
Soil type*	Cd	Tm	Tm	Cd	Cd	T
Soil texture	s.l.	c	l	l	l	s.l.
Area (ha)	3.2	1.2	5.7	4.0	0.8	0.8
Rooting depth (cm)	38	35	38	46	45	48
Status	Fair	Poor	Fair	Good	Poor	Good
Significant infestation	WW	Porc.	BW&WW	TM	-	Porc.
Number trees planted	10000	2900	9250	12000	1200	5400

Plantation number	30b	30c	31	32a	32b	33
Species	rP	rP	rP	rP	rP	rP
Planting date (19..)	58	59&60	56	54	60	59
Stock age (years)	2/1	-	4/0	-	-	-
Spacing (m)	1.8x1.8	1.8x1.8	1.2x1.2	1.8x1.8	1.2x1.2	1.2x1.2
Survival (%)	70	75	90	80	80	90
Mean height (m)	5.7	5.8	8.1	8.3	6.6	4.8
Mean dbh (cm)	11.4	12.3	16.9	14.5	10.4	7.4
Soil type*	T	T	T	T**	T**	T**
Soil texture	s.l.	s.l.	l	l	l	s.l.
Area (ha)	0.8	1.6	2.4	0.8	0.8	0.2
Rooting depth (cm)	48	48	38	50	50	50
Status	Good	Good	Good	Good	Good	Good
Significant infestation	Porc.	Nil	Nil	Porc.	Nil	Nil
Number trees planted	2400	4800	16330	2400	5400	870

Plantation number	34	35	36a	36b	36c	36d
Species	pP	wS	wS	rS	bS	NS
Planting date (19..)	66	60	58	58	58	58
Stock age (years)	-	-	-	-	-	-
Spacing (m)	2.4x2.4	1.2x1.2	1.2x1.2	1.2x1.2	1.2x1.2	1.2x1.2
Survival (%)	50	70	40	50	65	40
Mean height (m)	0.6	1.3	5.3	5.4	5.7	5.9
Mean dbh (cm)	0	0	7.6	7.0	8.0	8.1
Soil type*	T**	T	T	T	T	T
Soil texture	s.l.	s.l.	s.l.	s.l.	s.l.	s.l.
Area (ha)	0.6	0.4	0.1	0.1	0.1	0.1
Rooting depth (cm)	50	50	46	46	46	46
Status	Poor	Poor	Poor	Fair	Good	Poor
Significant infestation	Nil	BW	Nil	WW	WW	WW
Number trees planted	1000	2720	500	500	500	500

Plantation number	37a	37b	38	39	40	41a,b
Species	rP	DF	rP	wS	wS	SP
Planting date (19..)	62	64	62	67	66	48
Stock age (years)	-	-	-	SN	SN	-
Spacing (m)	1.8x1.8	1.8x2.4	0.6x1.8	1.8x1.8	2.4x2.4	1.8x1.8
Survival (%)	85	15	5	75	60	75
Mean height (m)	4.4	1.0	4.0	1.0	1.5	8.9
Mean dbh (cm)	7.6	0	0	0	0	13.4
Soil type*	T	T				H
Soil texture	s.l.	s.l.	c.l.	c.l.	c.l.	c.l.
Area (ha)	0.8	0.4	0.2	14.2	54.2	0.2
Rooting depth (cm)	28	28	27	31	31	40
Status	Good	V. Poor	V. Poor	Good	Good	Poor
Significant infestation	Nil	BW	Porc.	BW	BW	Porc.
Number trees planted	2400	1000	1360	35000	146000	870

Plantation number	41b	42	43	44	45	46
Species	LP	bS	JP	JP	JP	rP
Planting date (19..)	48	59	52	50	51	55
Stock age (years)	-	SN	-	-	-	-
Spacing (m)	1.8x1.8	1.8x2.4	1.8x2x4	1.8x1.8	1.8x1.8	1.5x2.1
Survival (%)	70	55	80	70	75	90
Mean height (m)	6.6	3.7	10.6	12.8	10.5	8.9
Mean dbh (cm)	9.0	5.0	11.7	13.8	13.1	12.8
Soil type*	H	K	Hg	Se	K	Pu
Soil texture	c.l.	1	sl	1	c.l.	c.l.
Area (ha)	0.2	4.5	0.1	0.4	0.2	0.4
Rooting depth (cm)	40	48	45	40	40	40
Status	Fair	Fair	Good	Good	Fair	V. Good
Significant infestation	Nil	WW	Nil	Nil	Nil	Nil
Number trees planted	580	10000	230	1200	480	1700

Plantation number	47	48	49	50
Species	SP	SP	rP	rP
Planting date (19..)	59	48?	65?	62
Stock age (years)	-	-	-	-
Spacing (m)	1.8x2.1	1.8x1.8	1.8x2.4	2.4x2.4
Survival (%)	70	50	50	75
Mean height (m)	6.4	12.0	3.4	4.1
Mean dbh (cm)	11.3	17.5	6.0	7.1
Soil type*	Pu	Pu	Pu	K
Soil texture	cl	cl	cl	cl
Area (ha)	1.1	0.2	0.3	1.8
Rooting depth (cm)	40	25	40	45
Status	Poor	Fair	Fair	Fair
Significant infestation	Porc.	Porc.	EPSM	EPSM
Number trees planted	2400	500	800	2400

Legend:

* - Names of soil types are listed in Appendix B.
- (dash) - data not available
0 - Mean dbh under 4 cm

Spacing:
- Irr. - irregular

Stock age:
- SN - Wildings

Infestation:
- BW - Budworm (not too severe)
- EPSM - European Pine Shoot Moth
- TM - Tussock Moth
- WW - White Pine Weevil

Soils:
- cl - clay loam
- sl - sandy loam
- l - loam
- ** - poorly drained associates

Damaging agents: Porc. - Porcupine damage 20-50% of the trees in the plantation

APPENDIX B: Description of Soil Types

Description of Soil Types

A Soils developed on glacial till.

(1) Nappan (N) - Clay loam soils developed on clay loam to clay till, derived from shales and sandstones. Imperfect drainage.

(2) Pugwash (Pu) - Sandy loam soils developed on sandy loam to sandy clay loam till, derived from sandstones. Good to fair drainage.

(3) Westbrook (W) - Gravelly loam soils developed on gravelly sandy loam to gravelly clay loam till, derived from comglomerate. Good to excessive drainage.

(4) Cobequid (Cd) - Gravelly loam soils developed on gravelly sandy loam till, derived from igneous rock material. Good drainage.

(5) Thom (Tm) - Gravelly sandy loam soils developed till, derived derived from sandstone breccia.

(6) Truro (T) - Sandy loam soils developed on sandy loam till, derived from red sandstone. Good to fair drainage.

(7) Diligence (D) - Clay to clay loam soils developed on clay loam to clay till, derived from shale. Imperfect drainage.

(8) Harmony (H) - Gravelly sandy loam soils developed on gravelly clay loam till. Good drainage.

(9) Kirkhill (K) - Shaley loam soils developed on brown sandy loam till, derived from shale and slates. Good drainage.

B Soils developed on kames, eskers, outwash and fluviatile deposits.

(1) Hebert (Hs) - Sandy loam soils developed on sand and gravel. Excessively drained.

(2) Hebert (Hg) - Gravelly sandy loam soils developed on gravel and cobblestone. Excessively drained.

C Immature soils developed on alluvial deposits.

(1) Stewiacke - Relatively uniform deposits of brown silty clay loam and clay. Drainage variable.

APPENDIX C: Common and scientific names of forest insects cited in text

Common and Scientific names of forest insects

Scientific Name	Common Name
Adelges abietis (Linn.)	Eastern spruce gall aphid
Adelges sp.	Gall aphid
Aphididae	Aphids
Choristoneura fumiferana (Clem.)	Spruce budworm
Herculia thymetusalis Wlk.	Spruce needleworm
Orgyia leucostigma (J.E. Smith)	Whitemarked tussock moth
Pissodes strobi (Peck)	White pine weevil
Pissodes sp.	Weevil
Rhyacionia buoliana (Schiff.)	European Pine Shoot Moth

APPENDIX D : Common and scientific names of most common trees and plants in the areas surveyed.

Common and Scientific Names of Most Common Tree and Plants

Scientific Name	Common Name
Acer saccharum Marsh.	Sugar maple
Alnus rugosa (Du Roi) Spreng.	Speckled alder
Betula alleghaniensis Britton	Yellow birch
Betula papyrifera Marsh.	Paper or white birch
Betula populifolia Marsh.	Wire or grey birch
Fagus grandifolia Ehrh.	American beech
Larix laricina (Du Roi) K. Koch	Tamarack
Picea abies (L.) Karst	Norway spruce
Picea glauca (Moench) Voss	White spruce
Picea mariana (Mill.) B.S.P.	Black spruce
Picea rubens Sarg.	Red spruce
Pinus banksiana Lamb.	Jack pine
Pinus contorta Dougl.	Lodgepole pine
Pinus resinosa Ait.	Red pine
Pinus rigida Mill.	Pitch pine
Pinus sylvestris L.	Scots pine
Populus tremuloides Michx.	Trembling aspen
Prunus virginiana L.	Choke cherry
Pseudotsuga menziesii (Mirb.) Franco	Douglas fir
Quercus rubra var. borealis (Michx.f.)	Red oak
Salix nigra Marsh.	Black willow

Scientific Name	Common Name
Amelanchier laevis Wieg.	Shadbush
Aster macrophyllus L.	Large leaved aster
Aster umbellatus Mill.	Flat topped aster
Carex spp.	Sedges
Cirsium arvense (L.) Sop.	Canada thistle
Cladonia spp.	Reindeer lichen
Dennstaedtia punctilobula (Michx.) Moore	Hay-scented fern
Fragaria virginiana Duchesne	Wild strawberry
Hieracium aurantiacum L.	Devils paint-brush
Kalmia angustifolia L.	Lambkill
Ledum groenlandicum Oeder	Labrador tea
Lycopodium obscurum L.	Ground pine
Lycopodium spp.	Club-moss
Myrica gale L.	Sweet gale
Nardus, Agropyron, Panicum spp.	Grasses
Pteridium aquilinum (L.) Kuhn	Bracken fern
Pyrola secunda L.	Winter green
Rhododendron canadense (L.) Torr.	Rhodora
Rosa virginiana Mill.	Wild rose
Rubus allegheniensis Porter	Blackberry
Rubus strigosus Michx.	Wild red raspberry
Solidago canadensis L.	Goldenrod
Spiraea tomentosa L.	Steeplebush
Vaccinium angustifolium Ait.	Blueberry
Vaccinium mirtilloides Michx.	Blueberry
Vicia angustifolia Reichard	Common vetch
Viola spp.	Wild violets