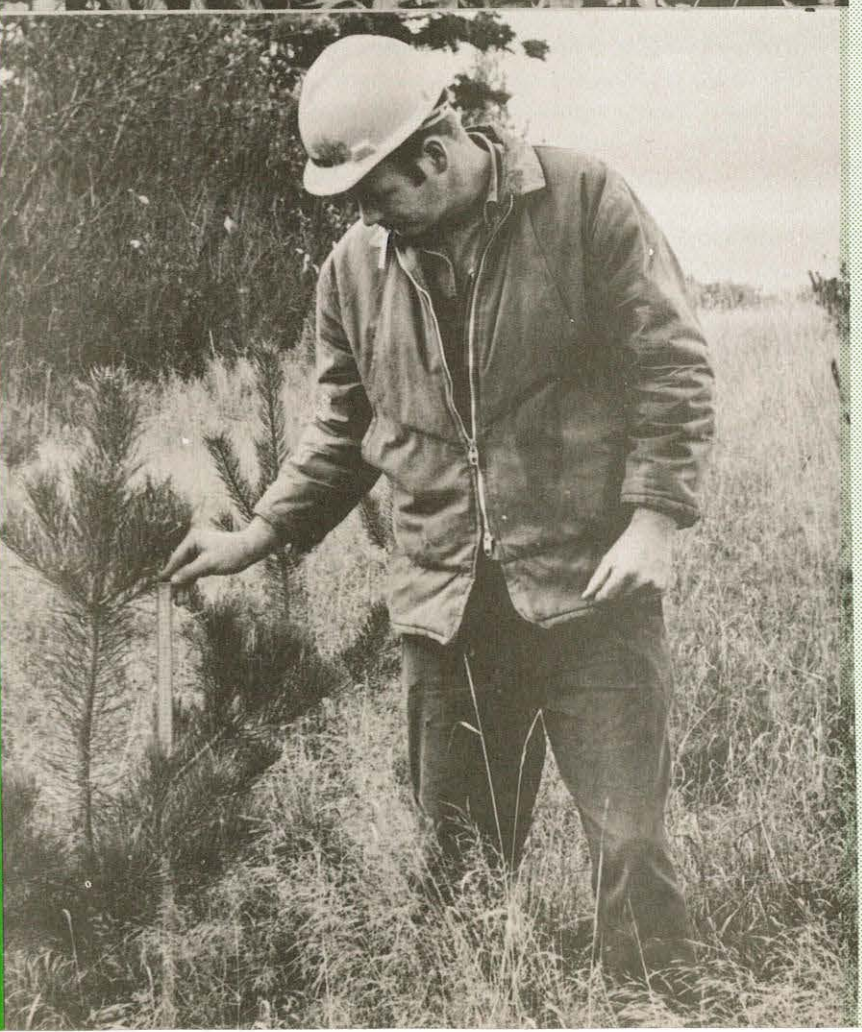

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REFORESTATION EXPERIENCE ON UPLAND SITES IN SOUTHWESTERN NOVA SCOTIA

by

Kalman J. Roller

MARITIMES

MARITIMES FOREST RESEARCH CENTRE

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Fredericton, New Brunswick

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ABSTRACT

A study was carried out between 1972 and 1976 to measure and evaluate the performance of about 865 ha of plantations established on upland sites of southwestern Nova Scotia from 1950 until 1970. The principal species planted were red pine (47%), white spruce (28%), and red spruce (23%). Transplant stock of 2 - 2 age class gave the best overall results for all species. Most of the successful plantations had been established in spring. Average survival over 20 years was 65% for white spruce, 50%for red spruce, and 66% for red pine. The relatively low survivals and rates of growth can be attributed mainly to inadequate soil drainage and aeration, drought, insect and disease infestation, porcupine damage, and insufficient attention at time of planting. White spruce has shown superiority in height growth over red spruce and red pine. Proper site selection, well-prepared planting sites, better seedling production, and improved planting technique are suggested as necessary to improve survival and growth of future plantations.

RESUME

Une étude a été conduite entre 1972 et 1976 à l'effet de mesurer et d'évaluer la performance d'environ 865 ha de plantations établies de 1950 à 1970 sur des stations de haute altitude dans le sud-ouest de la Nouvelle-Ecosse. Les principales essences plantées étaient le Pin rouge (47%), l'Epinette blanche (28%) et l'Epinette rouge (23%). Les semis de la classe d'âge 2 - 2 ont donné les meilleurs résultats pour toutes les essences. La plupart des plantations réussies avaient été établies au printemps. La survie moyenne au delà de 20 ans était de 65%pour l'Epinette blanche, 50% pour l'Epinette rouge et 66% pour le Pin rouge. Les survies et vitesses de croissance relativement faibles ont été attribuées principalement à l'aération et au drainage inadéquats du sol, à la sécheresse, aux infestations d'insectes et aux maladies y associées, aux dégâts du Porc épic et à l'insuffisance de soins culturaux au moment du plantage. L'Epinette blanche a manifesté une meilleure croissance en hauteur que l'Epinette rouge et le Pin rouge. Un choix convenable et une bonne préparation de la station, une meilleure production des semis et une meilleure technique de plantage sont suggérés comme objectifs nécessaires à l'amélioration de la survie et de la croissance des futures plantations.

INTRODUCTION

Until recently, forestry in southwestern Nova Scotia, as in most parts of Canada, consisted almost exclusively of resource exploitation. Between 1870 and 1950, there was extensive and largely uncontrolled cutting and several severe fires burned many thousands of hectares of productive forest. After such disturbances there is a natural tendency for many sites in southwestern Nova Scotia to remain in an unproductive or unstocked condition, mainly because of inadequate regeneration of commercially-important species. The end result has been a net loss of productive forest land. This situation has led to a need to develop effective methods for restocking productive sites with desirable species and for rehabilitating potentially productive, but presently unstocked, areas. Recently, the urgency of this need in the context of projected wood shortages in the Province and the Region has become very apparent.

Prior to 1927 only an insignificant amount of planting was carried out in Nova Scotia. Between 1927 and 1949 an estimated 4.5 million seedlings were planted, mainly on private land. From 1950 to 1970, about 10 million trees were produced by the Provincial Forest Nursery and lesser amounts by several private nurseries. The wide variety of plantations that has resulted from these earlier reforestation efforts can provide important guides for future plantings. Consequently, a study was carried out between 1972 and 1976 to measure and evaluate the performance of these older plantations and on this basis to develop recommendations for improving reforestation success.

Study Area

The study area (Fig. 1) consisted of seven of the ten counties in the southwestern half of Nova Scotia (similar work was carried out earlier by Strang (1969) in the three westernmost counties). The southern Uplands that occupy most of this area are an ancient tilted plain made up of quartzites, slates, and granites. The highest elevations in the north-central part of the sample area reach 180-200 m. The region's topography is gently undulating with gradual slopes from the height of land to the sea; local relief is, however, quite varied and irregular.

The soils are closely related to the underlying rocks. They are, for the most part, shallow and coarse-textured with many rocks and boulders scattered throughout. They are strongly acid and podzolized. Drainage varies from excessive on many of the higher ridges and slopes to totally impeded in local depressions. The soils underlying most of the sample plantations have been mapped as 'Gibraltar' and 'Halifax' series in the Nova Scotia Soil Survey Reports. These soils include wide ranges of texture and stoniness and are of low fertility. Average contents of available nutrients (kg/ha) for the Gibraltar series, for example, have been recorded as P_2O_5-110; K-270; Ca-2000; Mg-60; Al-60.

The climate of the area (Putnam 1940) is mild and humid. Mean annual temperature is 6.6°C (February -5°C, July +17°C). The frost-free period averages 143 days. Mean annual precipitation is 128 cm of which 36 cm falls as snow. Most rain falls between October and January.

The original forests of the area were dominated by red and white spruce, balsam fir, white pine, and hemlock, together with lesser amounts of red pine, black spruce, tamarack, and the tolerant hardwoods. However, most of the region has been repeatedly disturbed by fire, windthrow, land clearing, and logging, and a striking transformation in the forest cover and the ground vegetation has taken place. While softwoods continue to dominate the landscape, many disturbed areas have regenerated to pioneer hardwoods, such as white and grey birch, red maple, and trembling aspen, and extensive barrens with ericaceous vegetation have also been created. Sweet-fern, bracken, and huckleberry are dominant ground vegetation species on many sites.

Many of the plantations examined were on old fields, which, from the point of view of the establishment of new forest stands, are the poorest remnants of the once forested lands. Most old fields are characterized by poor drainage, dense sod, and uncontrolled brush vegetation. On these sites, most desirable softwood species are in a constant state of tension and struggle. However, white spruce can, and frequently does, become successfully established under these conditions by seeding from surrounding stands, especially where soil texture is not too heavy.

Study Methods

Plantations were surveyed during the summers of 1972 to 1975. Percent survival of the planted trees and infestations of fungi and other organisms were recorded in every second row of each plantation. Trees were measured for height

and, where appropriate, dbh, in randomly selected sample rows representing 10 to 20% of the total number of surviving trees in the plantation. Age was recorded as 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 was assessed (Table 1). A soil pit was dug in each plantation, and profile description, soil texture, and depth to compaction were recorded.

Results and Discussion

A total of 301 plantations occupying about 865 ha and containing approximately 1 million trees of bare-root origin was surveyed. Only coniferous species had been used for reforestation. The principal species planted were red pine (47%), white spruce (28%), and red spruce (23%). The remaining 8% included black spruce, white, Scotch, jack, pitch, lodgepole, and Virginia pines, Norway spruce, and hybrid larches. The three major species were mostly used on Crown land, and the minor species mostly in small lots on private land. Detailed data from all plantation assessments have been presented in five earlier reports (Roller and Hunter 1972, 1974, 1975, 1976, 1977).

Slit planting with a spade was the usual method of establishment. Records of the origin of stock are incomplete, but it is assumed that local seed was used in the earlier plantations; later, especially for red pine, seeds were purchased from Maine and Ontario sources.

Transplant stock of 2-2 age-class exhibited the best overall results for all species. Such stock generally has an adequate root system and are sturdy enough to compete with herbs, shrubs, and hardwood sprouts. The age-class of nursery seedlings varied from 2-0 up to 5-0, but, in general, results were inferior to those from transplants. Red pine, 3-0 stock, showed promise on

Table 1. Most frequent vegetation types

Dominant species[a]	Topography and soil	Commonly associated species
Bracken *Pteridium aquilium* (L) Khun	Summit and side slopes of morainal prominances. Usually on Ga soil series in Annapolis and Kings counties; well-drained productive forest soil, the best of Ga.	Lambkill, blueberry, sweet-fern, wintergreen, sweet gale, bunchberry, and hardwoods.
	In more acidic soil.	Blueberry or huckleberry becomes dominant.
	In nitrogen-rich fresh soil.	Sweet-fern becomes dominant.
Lambkill *Kalmia angustifolia* L.	Summit and side slope washed out; Hx and Ga as above; morainal prominances on rock, sometimes imperfect drainage, poorer than the above.	Blueberry, sweet-fern, bracken, wintergreen, sweet grasses, sparse strawberry, huckleberry, and rhodora clumps.
Broom crowberry *Corema conradii* Torr.	Tops of ridges and knolls; dry shallow soil on R soil type.	Bearberry, wintergreen, sparse blueberry, and stunted huckleberry; lichen is conspicuous on rocks and boulders.
	In depressions; peat over rocks.	Rhodora becomes dominant with huckleberry on lower slopes.

[a] Cover of 35% or more.
Ga - Gibraltar soil series, Hx - Halifax soil series, R - Rockland soil series.

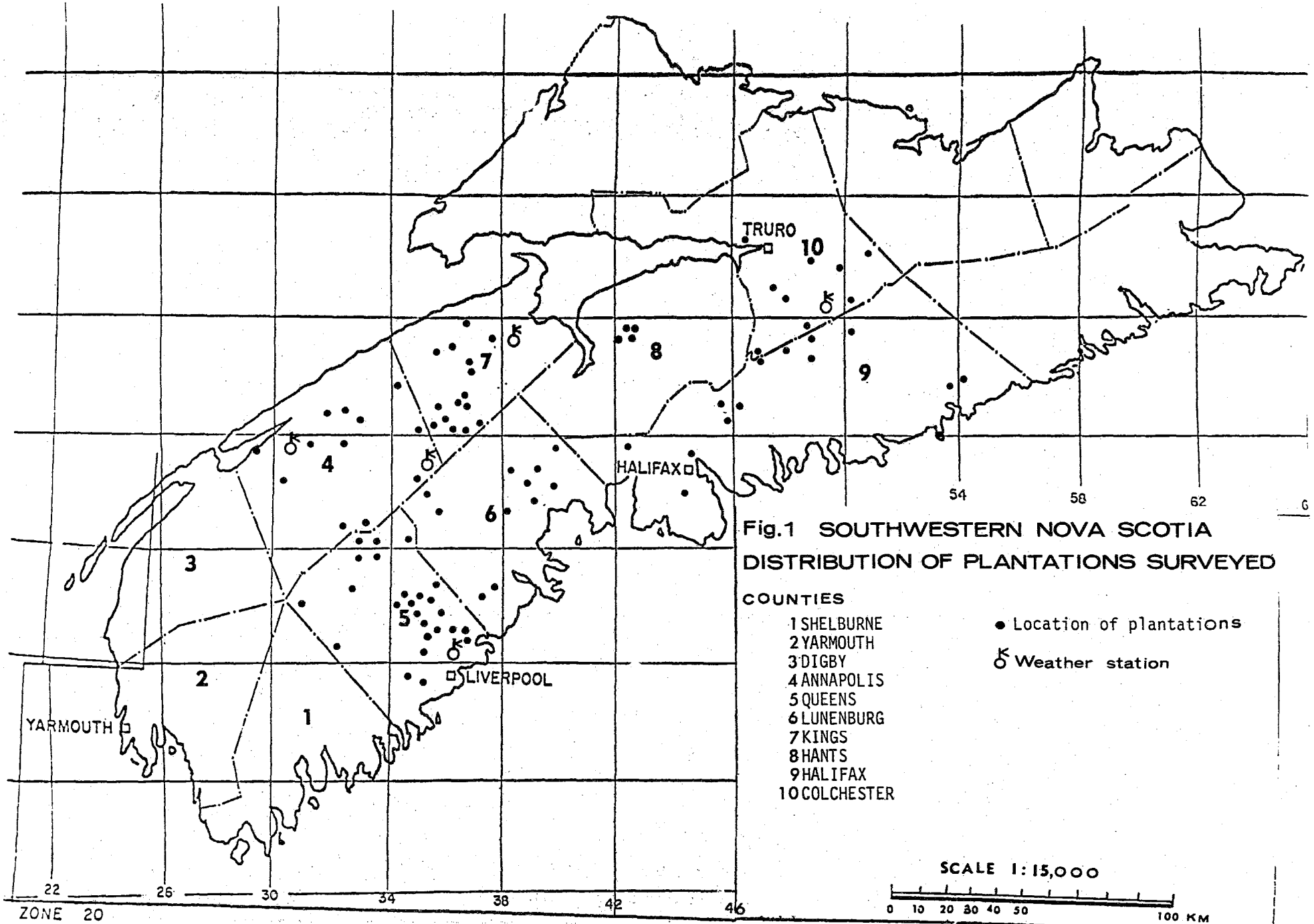

Fig.1 SOUTHWESTERN NOVA SCOTIA
DISTRIBUTION OF PLANTATIONS SURVEYED

COUNTIES

1 SHELBURNE
2 YARMOUTH
3 DIGBY
4 ANNAPOLIS
5 QUEENS
6 LUNENBURG
7 KINGS
8 HANTS
9 HALIFAX
10 COLCHESTER

• Location of plantations

Weather station

SCALE 1:15,000

0 10 20 30 40 50 100 KM

Squares 40,000 meters to side (24.8 mi. - approx.)

sites where there was little or no weed competition. Wildings were used in several plantations, but survival and early growth were generally poor. Container stock, in Ontario plastic tubes, was also used on a few productive cutover sites but was almost a complete failure because of frost heaving and drought.

Most of the successful plantings were established in spring. However, in Annapolis County, one late October planting which was followed by well-distributed fall precipitation had high survival. The same result was recorded in other counties in the western part of the region. This suggests that successful fall planting is more dependent than spring planting on climatic conditions, especially on an adequate frost-free period and sufficient precipitation after planting.

Average survival over about 20 years was 65% for white spruce, 50% for red spruce, 55% for black spruce, and 66% for red pine. Norway spruce and Scotch pine had the highest survival among the introduced species (73%), but the condition of the trees is poor and their future prospects are not promising. Survival of red pine decreased from 85 to 59% over the 20-year period from 1950 to 1970 (Fig. 2). It is probable that one of the factors responsible for this decreasing survival was the dry summers in 1957, 1960, and 1965 when only one-half of the 50-year-average May to August precipitation was recorded. The other species did not show this decrease because they were usually planted on moister sites than red pine.

Poor survival can, in many cases, be attributed to inadequate soil drainage and aeration. Soils with a high clay content offer considerable resistance to root elongation and branching of the feeder roots. Such soils also resist percolation to the extent that during and immediately after heavy rain the upper layers remain saturated and have inadequate aeration. Conversely, during drought, the surface soil can become extremely dry and seedlings with poorly-developed roots die because of their inability to reach supplies of moisture at lower levels. Survival in such soils can be improved by site preparation to break up the upper soil horizon thus providing drainage and aeration and restoring water balance.

About 70% of the root systems of retarded seedlings and of seedlings which had died without visible infection or damage had 'shovel root'. Brown and Carvell (1961) state that this condition can cause death or decline in vigor. Shovel root is a common result of careless slit-planting in heavy clay soils, where physical conditions for good root growth and development are unfavorable. Examination of root systems of such seedlings, in shallow single-plane planting holes, showed that roots were cramped, poorly oriented, or knotted.

On better sites, in lighter well-drained soils, early mortality was most frequently caused by competition from grasses, shrubs, and hardwood sprouts. Survival of indigenous species was superior to that of introduced species in such soils, except for red spruce, which is intolerant of competition from grasses and other ground vegetation. Survival of white and red spruce and red pine was best on former hardwood sites and burns. White spruce survived well under almost all conditions except recent clear cuts. Red spruce exhibited its lowest survival on sites previously occupied by mixedwood stands, probably because these sites usually support a vigorous ground vegetation of huckleberry and bracken following cutting.

Frequently, both indigenous and introduced species were planted on sites far from their ecological optima that did not meet their minimum requirements for survival and early growth. For instance, red spruce was often planted on poorly-drained heavy clay soils instead of the medium-textured well-drained slopes on which it naturally occurs. Red pine was set out, to a great extent, on shallow podsolic soils instead of the fresh, light, sandy loams on which it usually thrives. Trees planted without regard to ecological principles will always be especially susceptible to damage from drought, animals, insects, and diseases: very few such plantings will produce a merchantable crop. Norway spruce was severely attacked by the white pine weevil; hybrid larches and Scotch pine were damaged by porcupine; red pine was particularly susceptible to attack by the European pine shoot moth, shoot blight, and winter drying; some red spruce showed abnormal needle and branch growth as a result of attack by scale insects and aphids, and not infrequently, the species was subject to sudden killing by root rot about six to seven years after planting. Many of these problems can be attributed, at least partly, to inadequate matching of species and sites.

A definite association was found between root development and tree growth. The best height growth was associated with well-developed root systems and favorable moisture conditions in the rooting zone. Soils with compacted or "iron pan" BC or C horizons restrained root development, particularly for red pine, which is normally one of the more deep rooting of the native species. A series of red pine plantations was measured in the Stanley Management Unit in

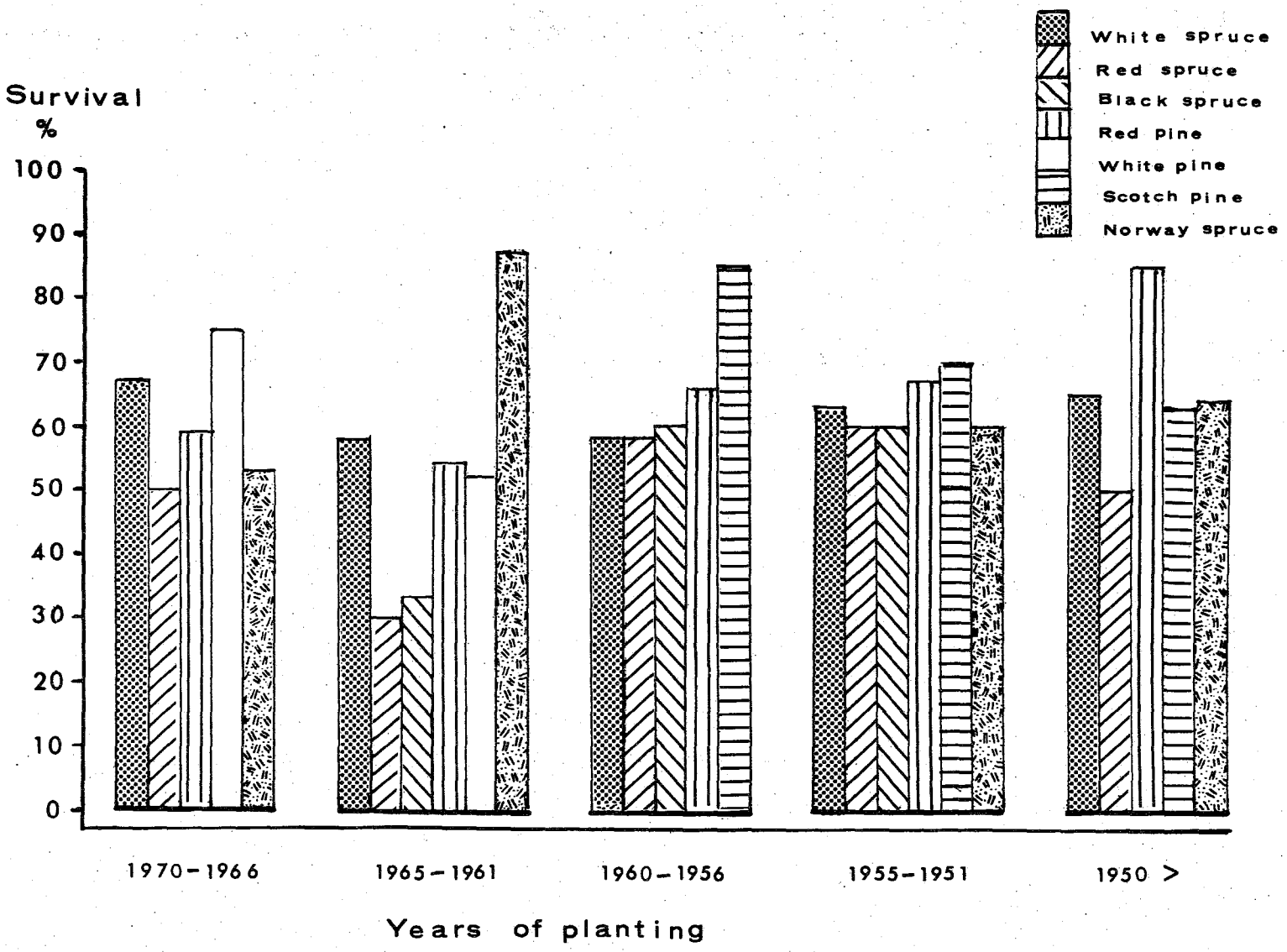

Fig. 2. Survival of seven species over five planting periods (based on assessments of 301 plantations occupying 865 ha).

Hants County and on Beach Hill in Lunenburg county. In these plantings, height and dbh decreased over a range of C horizon conditions from loose sandy loam to compacted soil, and over a range of B horizon conditions from well-drained to poorly-drained. The main root mass of red pine normally extends to a depth of 60 cm, and that of white spruce and red spruce to 40 cm, wherever soil conditions permit.

The coefficient of variation in heights for each of red pine, white spruce, and red spruce was about three times higher at age 2 to 5 years than it was at 20 years. This suggests that uneven early growth patterns, resulting from different planting care and the variable microenvironments affecting individual seedlings, gradually disappear with increasing age of the plantations. Comparisons of height growth between a series of plantations on Gibraltar soils in Kings County showed that slope, aspect, ground vegetation, microclimate, quality of nursery stock, treatment of planting stock from nursery to plantation sites, and planting methods were all associated with height growth differences within species and age-classes. These factors are probably at least as important in ensuring successful plantation establishment as is careful matching of species and soil conditions.

On several old fields, single-furrow ploughing by agricultural plow was used for site preparation. White pine survived and grew better when planted in the bottom of the furrows than when planted on the ridges, except on wet sites where the furrows served as drains. White spruce height growth was also better in the furrows, at least for the first 5 years after planting, but survival was better on the ridges. This is probably because the species develops a better root system in mixed organic and mineral soil materials then in pure mineral soils. Single ridge and furrow ploughing produce a variety of microsites, and it is therefore possible for the planter to select the most favorable microsite for planting according to species, soil depth, compaction and drainage conditions, vegetative competition, and exposure.

Many seedlings went through a period of planting check for about five to six years after planting. Symptoms are stagnation of growth, sparse foliage, short needles, and unhealthy yellowish appearance (Levy 1972). This handicap is the result of inadequate development of the root system, either because of poor physiological condition, improper planting, or unfavorable soil conditions, rather than of competition from ground vegetation. Retarded growth of the root system often results in the seedling dying of drought when the moisture content of the soil surrounding the roots approaches the wilting point. If the seedling survives, height growth stagnates (i.e. the seedling goes into check) until the roots start to develop.

Height growth patterns (Fig. 3) in the study area are similar for all native species up to the age of 15 to 20 years. After that, white spruce showed superiority over red spruce and red pine. This is probably a result of the tolerance of white spruce to a greater range of site conditions than the other two species. Clearly, careful site selection for red spruce and red pine is a "must". Too few older plantations of black spruce were available for conclusions to be drawn for that species, but it seems probable that on the basis of its wide site tolerance, its performance will be similar to that of white spruce.

The growth of Norway spruce and Scotch pine has been reasonably good, but the form of the trees is often poor and they have suffered considerable damage of different kinds. Only a scattering of plantations of these two species has been successful, and more experience with them is necessary before any recommendations can be made as to their possible operational use.

Spacings ranged from 1.2 x 1.2 m to 3.0 x 3.0 m in the plantations surveyed. Spacing did not affect planting success, but it will have a considerable effect on future silvicultural treatment and merchantability of the mature stands. The most frequent spacing was 2.4 x 2.4 m but this is likely to be too wide for maximum merchantable volume production (especially for pulpwood) and a spacing of 2.0 x 2.0 m is suggested as being nearer the optimum for a wide variety of sites and species in southwestern Nova Scotia.

CONCLUSIONS

The plantations surveyed during this study were extemely varied. However, the observations are considered of general application to any future plantation in southwestern Nova Scotia that consists of suitable species and seedling age-classes on sites that are at least moderately productive for merchantable timber. Continued investigation and research will, however, be necessary as increasingly large areas of plantation are established. In particular, attention will need to be directed to the hazards of extensive monocultures, to the long-term maintenance of site fertility, and to the potential role of hardwoods.

Several general principles of successful plantation establishment should be repeated; many of the same points are stressed by Levy (1972) and Robertson

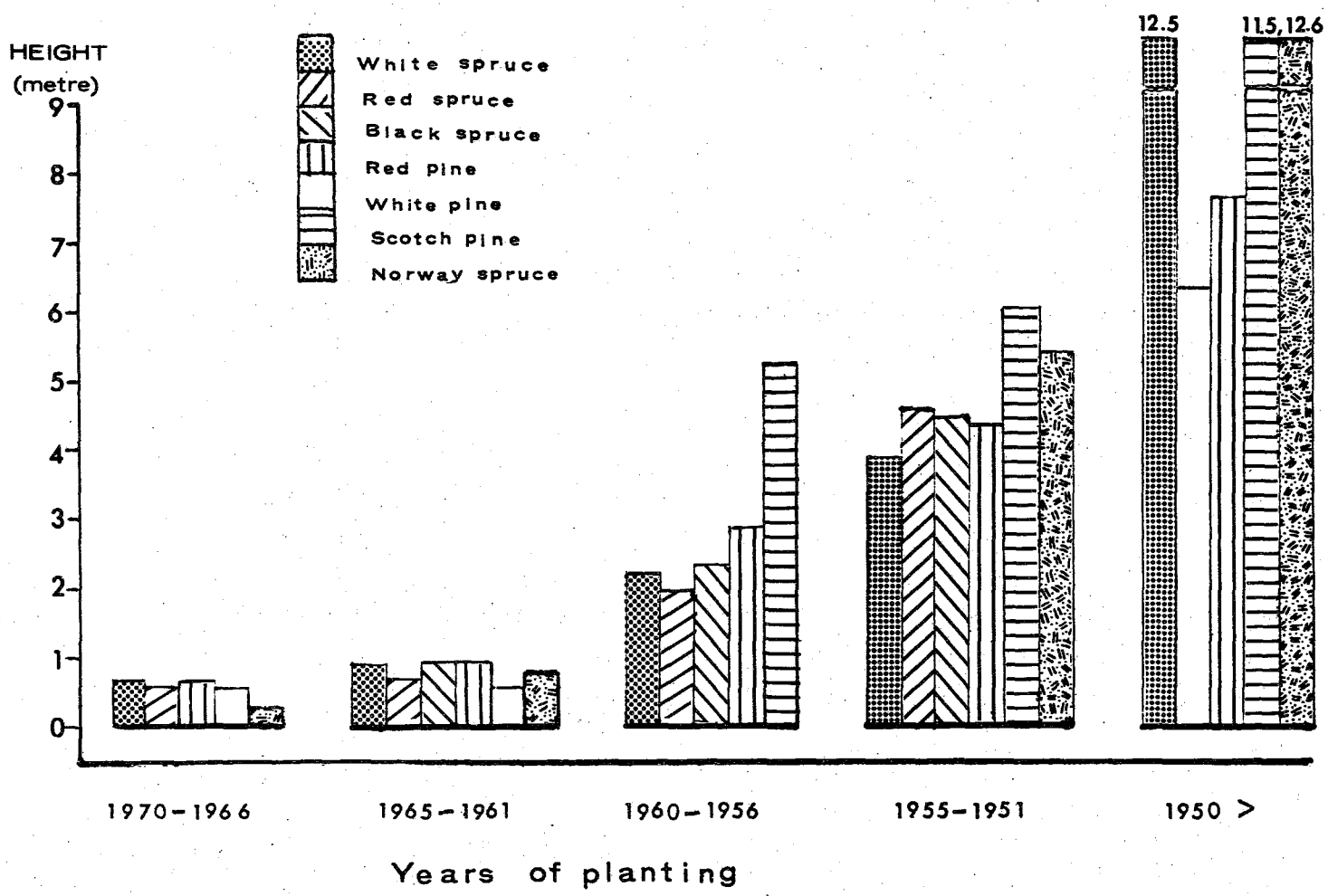

Fig. 3. Height growth of seven species over five planting periods (based on assessments of 301 plantations occupying 865 ha).

(1976) in their recent guides to reforestation in Nova Scotia.

Proper species selection is a priority. Commercially valuable species such as the spruces require the most productive sites available for reforestation. Pines can be planted on less productive sites but their requirements for nutrients and the tolerance of the different species to soil texture and drainage conditions must nevertheless be kept in mind.

Appropriate site preparation before planting and careful tending after planting are essential elements of successful plantation establishment. Ground vegetation, former stand type, soil characteristics, and the most suitable method of controlling competing vegetation should be investigated before planting. Old-field planting without site preparation is wasted effort.

Good survival and height growth can be expected only if good quality seedlings are used; careless planting will, however, negate the advantages of even the best quality seedlings. Increasingly better stock is required the more difficult the conditions. The larger the stock, the greater the necessity for care in planting to ensure that the roots assume their natural position.

Planting success can be increased by the application of sound and well-known cultural techniques. However, ultimate success depends upon the interrelationship of a complexity of factors affecting the plantations in any given area. This means that establishment of plantations on upland sites in southwestern Nova Scotia and, indeed, elsewhere, must be carried out with a thorough knowledge of local conditions.

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Common and Scientific Names of Trees and Plants used in the text

Common Name	Scientific Name
Birch, white	***Betula papyrifera*** Marsh.
Birch, grey	***Betula populifolia*** Marsh.
Fir, balsam	***Abies balsamea*** (L.) Mill
Hemlock	***Tsuga canadensis*** (L.) Carr.
Maple, red	***Acer rubrum*** L.
Pine, jack	***Pinus banksiana*** Lamb.
Pine, lodgepole	***Pinus contorta*** Dougl.
Pine, pitch	***Pinus rigida*** Mill
Pine, red	***Pinus resinosa*** Ait.
Pine, Scotch	***Pinus sylvestris*** L.
Pine, Virginia	***Pinus virginiana*** Mill.
Pine, white	***Pinus strobus*** L.
Spruce, black	***Picea mariana*** (Mill) BSP.
Spruce, Norway	***Picea abies*** (L.) Karst
Spruce, red	***Picea rubens*** Sarg.
Spruce, white	***Picea glauca*** (Moench) Voss.
Tamarack	***Larix laricina*** (Du Roi) K. Koch
Trembling aspen	***Populus tremuloides*** Michx.
Bearberry	***Arctostaphylos uva-ursi*** (L.) Spreng
Blueberry	***Vaccinium angustifolia*** Ait.
Broom crowberry	***Corema conradii*** Torr.
Bracken fern	***Pteridium aquilinum*** (L.) Kuhn
Bunchberry	***Cornus canadensis*** L.
Grasses	***Nardus, Agropyron. Panicum*** spp.
Huckleberry	***Gaylussacia baccata*** (Wang) K. Koch
Lambkill	***Kalmia angustifolia*** L.
Lichen	***Cladonia*** spp.
Rhodora	***Rhododendron canadense*** (L.) Torr.
Sweet-fern	***Comptonia peregrina*** (L.) Coult.
Sweet gale	***Myrica gale*** L.
Wild strawberry	***Fragaria virginiana*** Duchesne
Wintergreen	***Gaultheria procumbens*** L.