M-X-116
ISSN 0704-769X

RECENT DEVELOPMENTS AND CURRENT PRACTICES IN FORESTATION IN CANADA

by
R. D. HALLETT
and
T. S. MURRAY

MARITIMES

CANADIAN FORESTRY SERVICE

MARITIMES FOREST RESEARCH CENTRE

The Maritimes Forest Research Centre (MFRC) is one of six regional establishments of the Canadian Forestry Service, within Environment Canada. The Centre conducts a program of work directed toward the solution of major forestry problems and the development of more effective forest management techniques for use in the Maritime Provinces.

The program consists of two major elements - research and development, and technical and information services. Most research and development work is undertaken in direct response to the needs of forest management agencies, with the aim of improving the protection, growth, and value of the region's forest resource for a variety of consumptive and non-consumptive uses; studies are often carried out jointly with provincial governments and industry. The Centre's technical and information services are designed to bring research results to the attention of potential users, to demonstrate new and improved forest managment techniques, to assist management agencies in solving day-to-day problems, and to keep the public fully informed on the work of the Maritimes Forest Research Centre.

Top: Kingsclear Nursery, Fredericton (New Brunswick Department of Natural Resources)

Centre: Site Preparation (Le Tourneau Crusher) Boiestown, New Brunswick

Bottom: Jack Pine Plantation Established 1974 Site Prepared by Marttiini Plough

RECENT DEVELOPMENTS AND CURRENT PRACTICES IN FORESTATION IN CANADA

by

R.D. Hallett and T.S. Murray

Maritimes Forest Research Centre

Fredericton, New Brunswick

Prepared for the Eleventh Commonwealth

Forestry Conference, Trinidad and Tobago, September, 1980

Information Report M-X-116

Canadian Forestry Service

Environment Canada

1980

Copies of this report may be
obtained from:
Maritime Forest Research Centre
Canadian Forestry Service
P.O. Box 4000
Fredericton, N.B. Canada E3B 5P7

ABSTRACT

Developments and current practices in forestation in Canada are outlined. In 1968 it was projected that 200 000 ha would be forested annually; it is now evident, with the expansion of forestation programs, that this will be surpassed. At the Canadian Forest Regeneration Conference (1977) it was recognized that forest renewal was inadequate and several needs and deficiencies in forestation were highlighted. New policies and programs are being implemented in most Provinces to effectively deal with forest renewal problems. One potential problem relates to the use of herbicides for protection of these forests.

RESUME

L'auteur résume les développements et les pratiques courante en reboisement au Canada. En 1968 on projetait la création annuelle de 200 000 ha de forêts; il est évident qu'avec l'expansion des programmes de reboisement cet objectif sera surpassé. On a reconnu à la Conférence canadienne sur la Régénération des forêts (1977) que le renouvellement des forêts était insuffisant et on y a signalé les besoins et déficiences par rapport au reboisement. La plupart des provinces essayent présentement d'introduire des politiques et des programmes susceptibles d'apporter des solutions pratiques aux problèmes du renouvellement forestier. Un problème anticipé concerne l'emploi d'herbicides pour protéger ces forêts.

TABLE OF CONTENTS

INTRODUCTION

Forestation efforts have increased substantially in most Canadian Provinces during recent years. In their report on "Man-made Forests in Canada", Cayford and Bickerstaff (1968) reported the establishment of 75 000 ha of plantations in 1965 and predicted that an annual level of establishment of 200 000 ha would be reached by 1985; this projection will soon be surpassed (see Table 1, below).

Table 1. Annual Rate of Establishment of Man-made Forests in Canada

Province	1965*	1979
	Thousands of hectares	
British Columbia	21.5	58.3
Alberta	6.1	14.5
Saskatchewan	3.6	6.6
Manitoba	2.4	1.0
Ontario	33.6	47.9
Quebec	3.2	23.0
New Brunswick	1.6	15.8
Nova Scotia	0.8	3.2
Prince Edward Island	0.4	0.3
Newfoundland	1.2	0.3
Total	74.3	170.9

*Adapted from Cayford and Bickerstaff (1968).

Although estimates of physical timber reserves in Canada indicate an overall surplus to the needs of existing industry, local deficits are developing in several provinces and two provinces are already in a deficit situation for softwood species (Reed et al., 1978). Recognition of this situation has led to increased attention to serious shortfalls in regeneration.

Of the 251 000 000 ha of productive forest land in Canada, 750 000 ha are cutover annually and nearly 200 000 ha of these are not regenerating adequately (Morgenstern, 1978). In addition, there is a tremendous backlog of 30 000 000 ha of inadequately stocked forest land (Reed et al, 1978). Two estimates of the regeneration deficit in 1977 are shown in Table 2.

Table 2. Estimated Regeneration Deficits for 1977

	Thousands of hectares From Paillé (1977)		From Morgenstern (1978)	
Cutover		767		756
Regeneration:				
Natural	403		324	
Planting	111		137	
Scarification and Seeding	63		102	
Selective Cutting	38	615	-	563
Regeneration Deficit		152		193

The problem of inadequate forest renewal has been a common factor recognized in numerous conferences, Royal Commissions and consultants reports. In the proceedings of a national forest regeneration conference for Canada (CFA, 1977), several needs and deficiencies were highlighted:

- forest renewal is inadequate at present;
- it is inefficient and uneconomic to separate timber harvesting from forest renewal;
- more intensive forest management practices can be utilized;
- appropriate statistics are lacking on the adequacy of forest renewal and related data;

- short-term and long-term policies are needed to encourage and sustain the necessary human and financial efforts; and
- there is a backlog of 30 000 000 hectares of insufficiently stocked forest land.

Again on a national basis, a major study was commissioned in 1976 to "improve the basis for policy formulation, planning and practice in intensive forest management" in Canada (Reed et al., 1978). The study reviewed forest management performance across Canada and examined options for augmenting timber supply - intensive forest management, closer utilization, and the extensive margin - of which intensive forest management was considered relatively more attractive.

In British Columbia, following a Royal Commission (Pearse, 1976) new legislation - the Forest Act, the Range Act and Ministry of Forests Act (B.C. 1980a) - was proclaimed. New program alternatives include: basic silviculture to maintain productivity, which includes increased planting; and intensive silviculture to improve yield and value, which includes backlog reforestation (B.C. 1980b).

In New Brunswick, more intensive forest management practices were prescribed by the "Forest Resources Study" (N.B. 1974). Federal assistance programs through the Department of Regional Economic Expansion supported new nursery and seed plant facilities and major increases in that province's forestation program, from less than two million seedlings in 1973 to thirty million by 1980. A new Crown Lands and Forests Act was passed in 1980 which will shift forest management responsibilities from the Department of Natural Resources to license holders (N.B. 1980). The Department will assume a monitoring role to ensure compliance with standards and will reimburse licensees for satisfactory work on special management functions such as site preparation and planting.

From the above examples it appears that the evolution of forest management in Canada has reached the point at which the recommendations of these various studies are being seriously considered by governments. Since 94% of the productive forest land in Canada is Crown-owned, active government involvement is essential for successful forest management.

SEED AND TREE IMPROVEMENT

Tree improvement programs exist in all provinces, yet seed for years to come will be collected from unimproved stands. A national workshop was held in 1978 to review tree seed production and tree improvement in Canada and identify the requirements for the next decade (Morgenstern and Carlson, 1978). Morgenstern (1978) estimated that 42% of the seed collections by 1987 will come from general collections within seed zones, 55% from seed production areas, and 3% from seed orchards. A primary objective of these programs is to put sound tree improvement concepts in place as soon as possible.

General seed collection programs in all provinces are based on some type of ecological or forest site classification system. All provinces have seed extraction facilities. There are two new plants of particular interest - one in Alberta at the new Smoky Lake Nursery and Tree Improvement Centre, and the other at the Maritime Forest Seed Centre in New Brunswick. The latter Centre was designed and built with federal funding to serve the needs of all forest agencies in the Maritimes Provinces.

Tree improvement is recognized as a primary forest management tool in support of forest establishment by planting. Research and applied programs exist in all provinces and, as suggested by Hall (1979), this bank of knowledge has many potential users and progress would be best accomplished through cooperative effort. Tree improvement cooperatives have been organized in several provinces, and this combination of research and application specialists with forest managers facilitates putting forest tree improvement principles into practice.

NURSERY PROGRAMS AND TRENDS

Much of the recent growth in forestation has been in container planting, and several provincial and industrial agencies have made large committments to container programs (see Table 3). Large-scale use of small containers for the production of forest tree seedling planting stock was developed in Canada during the 1960's. Development was particularly rapid in Ontario where, in 1966, 17 million tubed seedlings were outplanted (MacKinnon, 1968, 1970). Initial failures of tubeling plantations resulted in skepticism of the potential of container systems which is still reflected in many areas. The container program in British Columbia has grown to be the largest in Canada following the development there of the BC/CFS sytroblock (Kinghorn, 1970). Other provinces have utilized particular container systems: the Alberta Forest Service is using the Spencer-Lemaire roottrainer; the New Brunswick Department of Natural Resources, the Paperpot; and the Nova Scotia Department of Lands and Forests, the multipot.

Table 3. Nursery Stock Production in Canada

	Millions of Seedlings			
	1975*		1979**	
Province	Bareroot	Container	Bareroot	Container
British Columbia	50	15	67	34
Alberta	3	3	3	21
Saskatchewan	2.5	<1	16	2
Manitoba	2	<1	1	1
Ontario	50	8	62	10
Quebec	52	<1	31	1
New Brunswick	19	4	20	32
Nova Scotia	2.5	1	3	6
Prince Edward Island	<1	<1	<1	1
Newfoundland	<1	<1	<1	<1
Total	181	32	205	108

*Adapted from Hallett (1975) and **Smyth (1980).

Many companies beginning forestation programs on their private lands have selected the container option rather than bareroot nursery facilities for several reasons: they do not have to contend with the exacting site requirements associated with the location of a bareroot nursery; the initial investment is less and the time required for development of the nursery is shorter; stock production costs and production time are reduced; and the forest manager is more flexible in dealing with changing trends or priorities.

Some government programs include container stock to extend the normally short periods for planting bareroot stock and the logistical problems associated with outplanting a large number of trees in short periods. Thus they also obtain the socio-economic benefits of more continuous employment.

NURSERY TECHNOLOGY

Container Culture

Recent research and technical developments have favored container systems in Canada. However, much of the technology is applicable to other countries developing these systems. Recent "how to" and "state-of-the-art" manuals for the production of tree seedlings in containers in greenhouses illustrate this point (Carlson, 1979; Tinus and McDonald, 1979).

Four containers are widely used in Canada: Paperpot, 34%; BC/CFS styroblock, 34%; Spencer-Lemaire roottrainers, 24%; and Can Am multipots, 8%. All but the Paperpot are manufactured in Canada. Solid-wall container types with root-controlling ridges (hence, root-trainers) predominate.

Probably the most interesting aspect of Canadian container programs is the various types of greenhouse facilities and seasons of production that are used. Greenhouses may be used which require considerable capital investment, particularly where heating is used for winter production on a one-season growing and planting schedule. For example, black spruce (*Picea mariana* (Mill) B.S.P.), which requires a relatively long time to reach plantable size, is often winter-grown and summer-planted. In spring, other species requiring less production time, such as jack pine (*Pinus banksiana* Lamb.), are raised in a 12-wk period and also outplanted in the summer.

However, many seedlings are produced in unheated greenhouses of medium to low capital cost during the normal growing season. Some heat may be provided to promote rapid germination or to prevent temperatures dropping below a certain minimum while overwintering dormant stock in the greenhouse (following the growing season). Seedling production may be extended over two growing seasons to produce larger seedlings or to provide planting stock during summer months.

Energy conservation has become a critical factor. Whereas winter production from horticultural greenhouses has dropped off, winter crops of trees are still produced. This will continue as long as container stock costs compare favorably with those of bareroot stock. Winter crops are used for several reasons: same season growing and planting are associated with good survival and growth; stock is available for summer planting; and the crops may be less root bound (crops raised in Paperpots if held too long become root entangled between containers).

Research to conserve energy in greenhouses is essential. It is necessary to model both crop growth and the physical parameters of greenhouse structure. Determination of the optimal combination of options to cut costs then becomes possible. For instance, attempts may be made to reduce fuel costs in a number of ways: insulation where possible, and the use of energy curtains; utilization of more exacting engineering and biological technology to trim production times and reduce the winter growing period; and even curtailment of the use of greenhouses during winter months when feasible. Waste heat from thermal generating plants has been the determining factor in locating some new greenhouse complexes in Ontario.

Bareroot Culture

There have been several advances in bareroot technology in recent years. Unfortunately many nurseries fail to implement existing technology and new developments which would maximize the potential of the production systems they use. Armson and Sadreika (1979) prepared a widely-used nursery manual based largely on experience in Ontario, a province with well established nursery technology.

Herbicides

In recent years new herbicides and combinations of herbicides have been tested in many nurseries such as reported by Bunting and McLeod (1980) and van den Driessche and Balderston (1974). Weed control in conifer seedbeds is a particular problem because of the slow growth of seedlings during the first season and their susceptibility to injury by chemicals in their shallow rooting zone. Records of hand weeding in one nursery between 1973 and 1979 revealed a 73% reduction of man-hours through the use of new herbicides (Hallett, 1980). At that nursery in 1973 hand weeding cost $3,670/ha with labor at $2.75/hr but in 1979 only $1,980/ha with labor at $5.40/hr; herbicides are a small part of the total cost.

Stock Standards

There still are few site-specific recommendations for the quality, size and type of stock required for field conditions. Quality is still measured on the basis of morphologic characteristics, and often is equated with stock type, i.e. seedlings, transplants, and containers.

For the production of bareroot stock of relatively slow-growing species, such as black spruce or white spruce (Picea glauca (Moench) Voss), controversy exists over the suitability of raising stock in seedbeds (e.g. 3 + 0) as compared to transplanting (e.g. 2 + 2). Government nurseries tend to produce seedlings rather than the more expensive transplants. A return to transplanting is advocated by some who contend that production costs are more than offset by increased plantation growth (Mullin and Howard, 1973; Mullin, 1980).

Variation in the size and quality of stock which is a particular problem in seedbed systems (e.g. 3 + 0) has created problems both in the nursery and, most particularly, in plantation performance when suggested standards were not achieved (Scarratt and Reese, 1976; Krause, 1978) (see Table 4).

Table 4. Planting Stock Specifications, Spruce

Stock type and measurement	Heavy		Medium		Small[3]	
	Ont.[1]	N.B.[2]	Ont.	N.B.	Ont.	N.B.
Bareroot						
Total dry wt (g)	10.0	>7.5	5.0	3.0- 7.5	1.5	<2.5
Shoot/root ratio	3.5	3.5-4.5	4.5	2.5- 3.5	3.5	<4.3
Height (cm)	22.0	>25.0	22.0	15.0-25.0	15.0	<15.0
Root collar diam (mm)	5.5	>5.5	4.0	3.5- 5.5	2.5	<3.5
Container						
Total dry wt (g)	-	1.2	0.7	0.85	0.35	0.6
Height (cm)	-	25.0	15.0	20.0	7.5	15.0
Root collar diam (mm)	-	2.2	1.5	2.0	0.75	1.6

[1]Scarratt, J.B. and K.H. Reese. 1976.

[2]Bareroot and container specifications from H.H. Krause (1978) and R.D. Hallett, respectively.

[3]Bareroot stock of Dr. Krause's class 1 specifications or below, were not considered plantable.

Monitoring Growth

To meet these planting stock specifications the nurserymen must be able to predict seedling growth. Methodology is being developed

(Bunting, 1976; Day, 1979a) to monitor the growth of seedlings in the nursery so the requirements for irrigation, fertilization and pruning of roots or shoots can be forecast to keep seedling growth on target. Concurrently, it is essential to have methodology for the determination of soil fertility and soil moisture content. The former is well-established, while the latter is now being accomplished in part by use of tensiometers or electrical resistance blocks in conjunction with soil moisture characterization curves. A more advanced and reliable technique for determining soil moisture content, the neutron scattering method, is being developed (Day, 1980).

Measurement of plant moisture stress with the pressure bomb is widely promoted both as a nursery tool for determining irrigation requirements, and for assessing the condition of seedlings during lifting, storage, shipment and outplanting (Day and Walsh, 1980).

Frozen storage

Frozen storage is being used more extensively. For severe winter climates, frozen over-winter storage of stock often represents a gain in biological potential when compared with that of stock left in fields for spring lifting, and in addition it facilitates extension of the planting season (Bunting, 1974; Mullin and Bunting, 1979; Mullin and Reffle, 1980).

Mechanical Harvesting

Nurseries are labor intensive and stock production costs could be considerably reduced by mechanization of lifting. The Ontario Ministry of Natural Resources has been active in the development of a 6-row mechanical harvester (DeVries, 1978). For several years a Canadian company, Greyco Harvesters in Ontario, has been manufacturing seedling harvesters which remove seedlings by bed run and load them in batch boxes for later processing. Greyco machines are also used in nurseries in the United States and other countries. The primary differences between the Ontario and Greyco machines are: the type of beds in which they can be used and the arrangement of seedlings once lifted. The Ontario harvester is designed only for row seeded or transplant beds and keeps the seedlings reasonably oriented whereas the Greyco, although it can be used for broadcast as well as row seeded beds, tumbles the seedlings into disarray.

SITE PREPARATION

Mechanical

Canadian foresters have kept abreast of site preparation equipment developed in other parts of the world, particularly in Scandinavia where conditions are comparable to those in Canada. Some of their machines such as the Brachi cultivator and the TTS disc trencher are used extensively. The new hydraulic disc trencher was tested in Canada in 1980. Several types of equipment such as the LeTourneau crusher and Rome discs, developed in the United States, are also used.

Several types of equipment have been developed in Canada. The Ontario Ministry of Natural Resources has an equipment development unit which has been active in developing several forestry machines as well as site preparation equipment. The Caze and Heppner plough, a dry land plough, was developed in British Columbia in 1976 and subsequently used extensively throughout Canada. This plough has reduced the use of the Marttiini plough which has been widely used in Eastern Canada.

The Canadian Forestry Service designed a prototype V-blade in 1974, modified in 1976. This CFS V-blade is useful for applications where single-pass, single-row slash parting is required on cutover sites. In Boreal forest cutovers this blade has been used for site preparation by itself and in conjunction with trailing site preparation equipment, mechanical tree planters and row seeders.

The shark-finned barrels, first developed in central Canada in the 1960's, have been improved to suit individual users and are still used extensively. A drum-type scarifier, the Broyeur A.M., recently was developed by the Quebec Department of Lands and Forests.

Burning

Controlled burning is still being used extensively in spring and fall to remove logging debris prior to plantation establishment. It has not become a reliable site preparation tool because of the short burning season, i.e. the problem lies in achieving the required area of burn while minimizing the inherent danger of wild fire. In British Columbia, burning is now avoided on coastal sites with acceptable natural regeneration or on thin soils where damage would occur; fire was previously prescribed to reduce fire hazards on both these sites (Brown, 1970).*

Herbicides

The use of herbicides for site preparation and for control of competition during the period of establishment of a plantation is being curtailed by public controversy over the dangers from use of herbicides containing dioxin (TCDD). Pressure groups are effectively blocking the use of pesticides in forest management in some parts of the country.

*Brown, R.M., 1980. Pers. Comm., B.C. For. Ser. Silv. Br., Victoria, B.C.

Without herbicides, the feasibility of reforestation on many sites is questionable because survival and growth will be significantly reduced.

Aerial application of herbicides is viewed as the only workable means of application because mechanical or manual plantation tending are expensive ($70/ha vs $125 to $260/ha). Manual plantation tending presents several additional problems: could the size of area requiring treatment be handled? would it be sufficiently effective in controlling the unwanted vegetation? could it be done at all, as exemplified by the difficulties of eradication of raspberries (Rubus sp) in newly established plantings? and would the damage to the seedlings result in expensive loss of plantation volume?

It is certain that the choice of technique must be closely analyzed in relation to others available as to effectiveness, environmental impact and costs. Exacting specifications for all sites will be needed for silvicultural planning in the future.

A new herbicide, glyphosate (Roundup®), holds considerable promise for greater effectiveness in vegetation control in conifer plantations and is expected to be more acceptable to informed environmentalists.

Methods Employed

There are great regional differences in Canada resulting in unique site preparation problems as exemplified by the different approaches used in British Columbia and New Brunswick (Table 5). In New Brunswick Crown forests, all sites to be planted are site prepared but not to obtain natural regeneration. In British Columbia, 50% of the site preparation on Crown lands is in preparation for planting but 50% is for natural regeneration.

Table 5. Comparison of Site Preparation: British Columbia/ New Brunswick.

Method of treatment	British Columbia* For planting	New Brunswick* For planting
	(Hectares)	
Shark Finned Barrels	800	2 350
Disc Trencher	-	1 280
Letro-Crusher	-	700
Brachi Cultivator	-	1 120
Marttiini Plough	-	2 470
Marden Choppers	-	80
Cazes & Heppner Plough	2 600	1 900
Root Rake	-	360
Cutover clearing	20	-
Broadcast burn	16 500	1 530
Bunched & burned	5 890	-
Spot burning	730	-
Chemical	10	200
Other (including no treatment)	1 410	-
Total	27 960	11 990

*Derived from Provincial Statements.

DIRECT SEEDING

Many provinces in Canada have conducted direct seeding trials with varying results. With lower associated costs being the main advantage of direct seeding, this technique could conceivably become more attractive in the future. Inconsistent success is the main drawback to seeding, and such operational programs are limited (see Table 6).

Table 6. Direct Seeding, 1979*

Province		(Hectares)
Quebec		10 000
Ontario		24 200
Manitoba		70
Alberta		5 500
	Total	39 770

*Derived from Provincial Statements.

With the introduction of new spot-seeding methods, such as the plastic sowing shelters from Finland, interest in seeding has been renewed. Spot seeding although more expensive than broadcast seeding, has generally been more reliable. Although seed shelters have yet to be used operationally in Canada, many trials are presently being conducted with favorable preliminary results.

PLANTING

The problem of root deformation in planted trees caused by the type of stock (container or bareroot) as well as planting method has received considerable attention. A symposium on the root form of planted trees was held in Victoria, B.C. (Van Eerden and Kinghorn, 1978) but no clear conclusions as to the severity of the problem were reached.

Bareroot seedlings are still planted with shovel or grub hoes and container seedlings are planted with tube-type planters (Pottiputki) and dibbles. There have been few new developments in the actual planting process. However, major improvements have been made in the degree of biological care which seedlings are given during the storage and planting phase. Examples of this concern are the initiation of quality check systems at the time of plantation establishment and more sophisticated assessment systems after planting. As many provinces, particularly the Maritimes, are accumulating experience, refinements are resulting in far better forestation results.

Different approaches are used in these planting programs. In New Brunswick the government will be producing 5 million bareroot seedlings and 25 million container seedlings annually whereas the largest private planting program in Canada (also in New Brunswick) relies primarily on large bareroot transplants. In Nova Scotia, the government is developing a program to encourage the use of natural regeneration systems supplemented by planting.

As seen in Table 2 earlier, only portions of the actual cutover area are treated although some provinces treat greater proportions than others.

MECHANIZATION OF SILVICULTURE

In Canada, concurrently with mechanization of harvesting operations, there has been a growing momentum toward the mechanization of silvicultural activities. The renewal of high quality forests has become a prime concern as Canada moves into a new era of forest management, and mechanization must be a part of this.

Prior to 1979 the Forest Management Institute of Canada in its forest management technology program had developed conceptual programs and studies which led to new equipment for silviculture, reforestation and cone collection (FMI, 1979). The Institute was closed in 1979 and this program was transferred to the new Petawawa National Forestry Institute.

The Great Lakes Forest Research Centre has become a leader in the development of mechanization of silviculture in Canada. The Centre's project objectives are: 1) to develop mechanized regeneration methods and associated tree growing techniques for the efficient and effective reforestation of typical cutover sites in the boreal forest, and 2) to test available equipment and to develop new tools and techniques for other desirable silvicultural treatments (GLFRC, 1980).

Some equipment development is being accomplished through provincial and industrial agencies, particularly in the field of site preparation.

Mechanization of Planting

There are three planting machines in Canada: (1) the Timberland Planter, (2) the Cazes and Heppner Planter, and (3) the Walter's Planting Machine. However, they are not widely used. The main limitation is that they are restricted to specific planting sites. Forest managers tend to dispatch the machine into the roughest terrain for testing and conclude that it won't work. If sites are selected carefully, these machines can be very effective.

To conclude, in this paper we have presented an overview of forestation development and current practices in Canada. The recognition of the inadequacy of forest renewal to date has been an essential first step towards good forest management. New policies and programs arising from major studies of forest management in Canada and in the individual provinces are resulting in increased activities in the fields of tree improvement and seed production, nurseries, and planting.

LITERATURE CITED

Armson, K.A. and V. Sadreika. 1979. Forest tree nursery soil management and related practices. Ont. Min. Nat. Res. 179 p.

Bunting, W.R. 1976. Monitoring of stock by nurserymen. In Proc. of 1976 Northeastern Area Nurserymen's Conf. 16-19 August Kemptville, Ontario. Ont. Min. Nat. Res. pp. 52-67.

Bunting, W.R. 1974. Cold storage tests. Ont. Min. Nat. Res. Nursery Notes No. 35. 4 p.

Bunting, W.R. and G.R. McLeod. 1980. Orono Nursery herbicide screening trials. Ont. Min. Nat. Res. 20 p.

British Columbia. 1980a. Annual Report of the Ministry of Forests for Year Ended December 31, 1979. Province of British Columbia. 64 p.

British Columbia. 1980b. Forest and range resource analysis and five-year program summary. Province of British Columbia. 31 p.

Cayford, J.H. and A. Bickerstaff. 1968. Man-made forests in Canada. Dep. Fish. For., For. Br. Pub. 1240 68 p.

Canadian Forestry Association. 1977. Tomorrow's forests ... today's challenge? A conference on Adequate Forest Renewal in Canada. Quebec, 19-21 October, 1977. Publ. by Can. For Assoc. Ottawa. 244 p.

Carlson, L.W. 1979. Guidelines for rearing containerized conifer seedlings in the Prairie Provinces. Environ. Can. North. For. Res. Cent., Inf. Rep. NOR-X-214. 62 p.

Day, R.J. 1980. Effective nursery irrigation depends on regulation of soil moisture and aeration. In North American Forest Tree Nursery Soils Workshop, 31 July - 1 August, 1980. Syracuse, N.Y.

Day, R.J. 1979. The development of a method for monitoring the growth of nursery stock. School of Forestry, Lakehead University. Silv. Rep. 1979-1. 28 p.

Day, R.J. and S.J. Walsh. 1980. A manual for using the pressure chamber in nurseries and plantations. School of Forestry, Lakehead University. Silv. Rep. 1980-2. 49 p.

Forest Management Institute. 1979. Program Review 1976-78. Environ. Can., For. Manage. Inst.

DeVries, H.H. 1978. Lifting bareroot nursery stock. In Plantation Establishment Symp. Ed. R.F. Sutton. Environ. Can. Great Lakes For. Res. Cent. Symp. Proc. O-P-5. 123 p.

Great Lakes Forest Research Centre. 1980. Work Program. Environ. Can. Great Lakes For. Res. Cent.

Hallett, R.D. 1975. File report on nursery production in Canada. Environ. Can. Marit. For. Res. Cent.

Hallett, R.D. 1980. File report on herbicide work in nurseries. Environ. Can. Marit. For. Res. Cent.

Hall, P.J. 1979. Cooperative tree improvement programs in Canada. In Proc. 17th Meeting Can. Tree Impr. Assoc. Ed. C.W. Yeatman, Can. Tree Impr. Assoc. Ottawa. p. 25.

Krause, H.H. 1978. Appraisal of planting stock. Dep. For. Res., University of New Brunswick. 23 p.

Kinghorn, J.M. 1970. The status of container planting in Western Canada. For. Chron. 46(b) 466-69.

Morgenstern, E.K. 1978. The national scene. In Tree Seed Production and Tree Improvement In Canada. Ed. Morgenstern, E.K. and L.W. Carlson. Environ. Can. Petawawa For. Exp. Sta. Inf. Rep. PS-X-74. pp. 3-10.

Morgenstern, E.K. and L.W. Carlson. 1979. Tree Seed Production and Tree Improvement In Canada. Environ. Can., Petawawa For. Exp. Sta. Inf. Rep. PS-X-74.

Mullin, R.E., 1980. Comparison of seedling and transplant performance following fifteen years growth. For. Chron. 56. In Press.

Mullin, R.E. and W.R. Bunting. 1979. Container and tying variations in frozen overwinter storage of red pine. Ont. Min. Nat. Res. Nursery Notes No. 63.

Mullin, R.E. and C.P. Howard. 1973. Transplants do better than seedlings and ... For. Chron. 49(5) 213-218.

Mullin, R.E. and R.J. Reffle. 1980. Effects of dates of lifting and planting on success of frozen spring storage at Swastika Nursery. Ont. Min. Nat. Res., Nursery Notes No. 66.

MacKinnon, G.E. 1970. Container planting in Ontario. For. Chron. 46(6), 470-472.

MacKinnon, G.E. 1968. Reforestation in Ontario. For. Chron. 44(1) 14-17.

New Brunswick, 1974. Report of the Forest Resources Study. Province of New Brunswick, Fredericton. 362 p.

New Brunswick, 1980. An introduction to the new Crown Lands and Forests Act. Dep. Nat. Res., Fredericton, N.B. 18 p.

Pearse, P.H. 1976. Timber rights and forest policy in British Columbia. Rep. Roy. Comm. For. Res. 395 p.

Paillé, G. 1977. Resolving forest regeneration problems in Canada. In National Forest Regeneration Conference. Can. For. Assoc. Ottawa, pp 228-242.

Reed, F.L.C. and Associates. 1978. Forest Management In Canada. Vol. I. Environ. Can. For. Manage. Inst. Inf. Rep. FMR-X-102 155 p.

Scarratt, J.B. and K.H. Reese. 1976. Objectives and criteria for planting stock production in Ontario. Environ. Can. Great Lakes For Res. Cent. Inf. Rep. 0-X-253. 17 p.

Smyth, J.H. 1980. A directory of forest tree nurseries in Canada. Environ. Can. Great Lakes For. Res. Cent. Inf. Rep. 0-X-305. 52 p.

Tinus. R.W. and S.E. McDonald. 1979. How to grow tree seedlings in containers in greenhouses. USDA For. Serv. Gen. Tech. Rep. RM-60. 256 p.

Van den Driessche and M.B. Balderston. 1974. Trials with selective herbicides in forest service nurseries. B.C. For. Serv. Res. Note No. 61. 44 p.

Van Eerden, E. and J.M. Kinghorn. Ed. 1978. Proc. Root Form of Plant Trees Symp. B.C. Min. For. Can. For. Serv. Joint Report No. 8. 357 p.