forestry report

Fall 1981 (No. 24) **Northern Forest Research Centre** **Edmonton, Alberta**

Meeting the challenge in reforestation

In this issue:

Silviculture

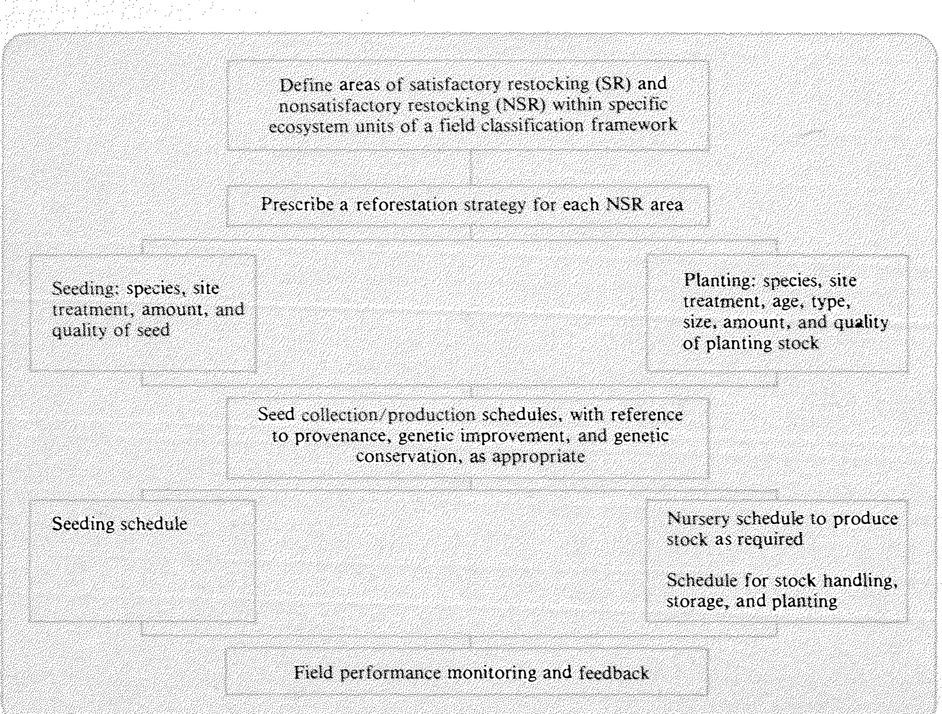
Concerns about the adequacy of forest regeneration in Canada have been expressed in forestry circles for many years, but public awareness seems to have been heightened as a result of publicity associated with the 1977 National Forest Regeneration Conference held in Quebec City and sponsored by the Canadian Forestry Association. In this region the response to long-standing professional and recent public concern about reforestation has been dramatic; there have been rapid increases in nursery capacity and an increased emphasis on reforestation by both industry and government. In Alberta, Saskatchewan, Manitoba, and the Northwest Territories, tree planting programs have increased the number of seedlings being planted each year, from about 7 million in 1972 to 14 million in 1976 and 30 million in 1980. Nevertheless, out of a total regional annual cutover of about 55 000 ha, over 15 000 ha are being added to the backlog of unregenerated forest land.

Ideally, problems in reforestation should be tackled from within a comprehensive field classification framework based on ecological principles and by field performance monitoring of planted and seeded areas. Many elements of such an approach are now in place, with the notable exception of a field classification framework from which to initiate planning for reforestation. As a result, we are still in doubt in many instances about how to match site treatments and planting or seeding practices to our sites, and the development of effective silvicultural prescriptions for reforestation is being delayed.

To a large extent our reforestation problems are related to a lack of communication regarding knowledge and techniques that already exist. Our lack of communication is well exemplified by comments heard repeatedly across the region in nurseries and field planting areas. Nurserymen are saying, "I wonder how that stock we shipped out last year survived and grew." Fieldmen are asking, "What was the production, storage, and shipping history of that stock that did so poorly?" Others are asking about planting times and methods. It is an ideal climate for passing the buck when failures occur. There is, however, a growing desire by all concerned to get answers and to get the job done right — a kind of "no-fault" approach to reforestation.

This *Forestry Report* attempts to bridge the communication gap by bringing together some current knowledge about reforestation. The challenge for the future is to implement a field classification framework for forest management and to bring available and new information together in the form of silvicultural prescriptions, thus facilitating progress in reforestation.

Lorne Brace



Idealized reforestation pro edure.

A field classification framework for forest management

As demands for the use of forest land and products grow in both amount and variety, so does the need for more-refined forest management. If such management is to be sound it must be based on an understanding of forest land ecosystems. The productivity of a forest ecosystem is a function of regional climate, soil, parent material, terrain relief, interrelationships among living organisms, and age of the ecosystem.

Forest vegetation has long been recognized as a reflection or integration of the major physical and biological forces acting in a given location over time. Knowledge of the forest ecosystem as characterized by trees, associated vegetation, and soils has been used in the past as the basis for management decision making on both a formal and informal basis, with success varying according to ecosystem complexity and the personal knowledge and expertise of the people involved.

In recent years there has been an increase in efforts to formalize forest ecosystem classification in an attempt to promote the use of ecological principles in forest land use planning and management on a broader scale. The degree to which any of these systems has actually been successfully applied in forest management decision making has been limited. The system of Krajina (1965), for example, has been accepted with variations by both industry and the government of B.C. and is being developed with refinements for site-specific use on coastal areas in particular. It is now being adapted for use in Alberta (Kojima and Krumlik 1979, Kojima 1980).

Application of Krajina's system involves special surveys to classify the forest into broad zones (biogeoclimatic zones) that are defined in terms of vegetation, soils, and nutrient cycling patterns within a common regional climate. The zones are usually named after one or more shade-tolerant trees (climax vegetation) that can regenerate themselves within the zone. This concept is illustrated in the transect from Lloydminster to Jasper.

Zones are further divided into subzones and ecosystem types. Zones and subzones are used mainly for broad regional planning — perhaps at a mapping scale of 1:1 000 000 — such as developing policies on land use allocation and devising broad protection, inventory, breeding, seed collecting zone, and reforestation strategies. Ecosystem types, which recognize factors such as soil moisture and nutrient status, are useful for detailed decision making and planning, such as site-specific stand improvement and silvicultural prescriptions for reforestation. This stage of refinement has not yet been reached throughout Alberta but is in progress in some areas of the province.

The primary use of any classification framework for site-specific application in forest management must be as a supplement to, not substitute for, local knowledge and experience. Indeed, in this region intensive forest management must proceed prior to the development of a full-fledged system or systems (however desirable or useful they may be) because of current demands for management — for example, the rapidly expanding reforestation programs. Meanwhile, forest managers should become familiar with classification systems as they develop and should utilize them, where appropriate, to improve the quality of their management decisions.

Lorne Brace
George Krumlik

Suggested reading

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Kabzems, A., A.L. Kosowan, and W.C. Harris. 1976. Mixedwood Section in an ecological perspective. Sask. Dep. Tourism Renewable Resour. Tech. Bull. 8.

Kojima, S. 1980. Biogeoclimatic zones of southwestern Alberta. Report prepared by Western Ecological Services Ltd., Edmonton, Alberta, for Alberta Energy Nat. Resour. Alberta For. Serv.

Kojima, S., and G.J. Krumlik. 1979. Biogeoclimatic classification of forests in Alberta. For. Chron. 55(4): 130-132.

Krajina, V.J. 1962. Biogeoclimatic zones in British Columbia. Prog. Rep. Natl. Res. Counc. Grant T-92.

______ 1965. Biogeoclimatic zones and classification of British Columbia. Ecol. West. North. Am. 1:1-17.

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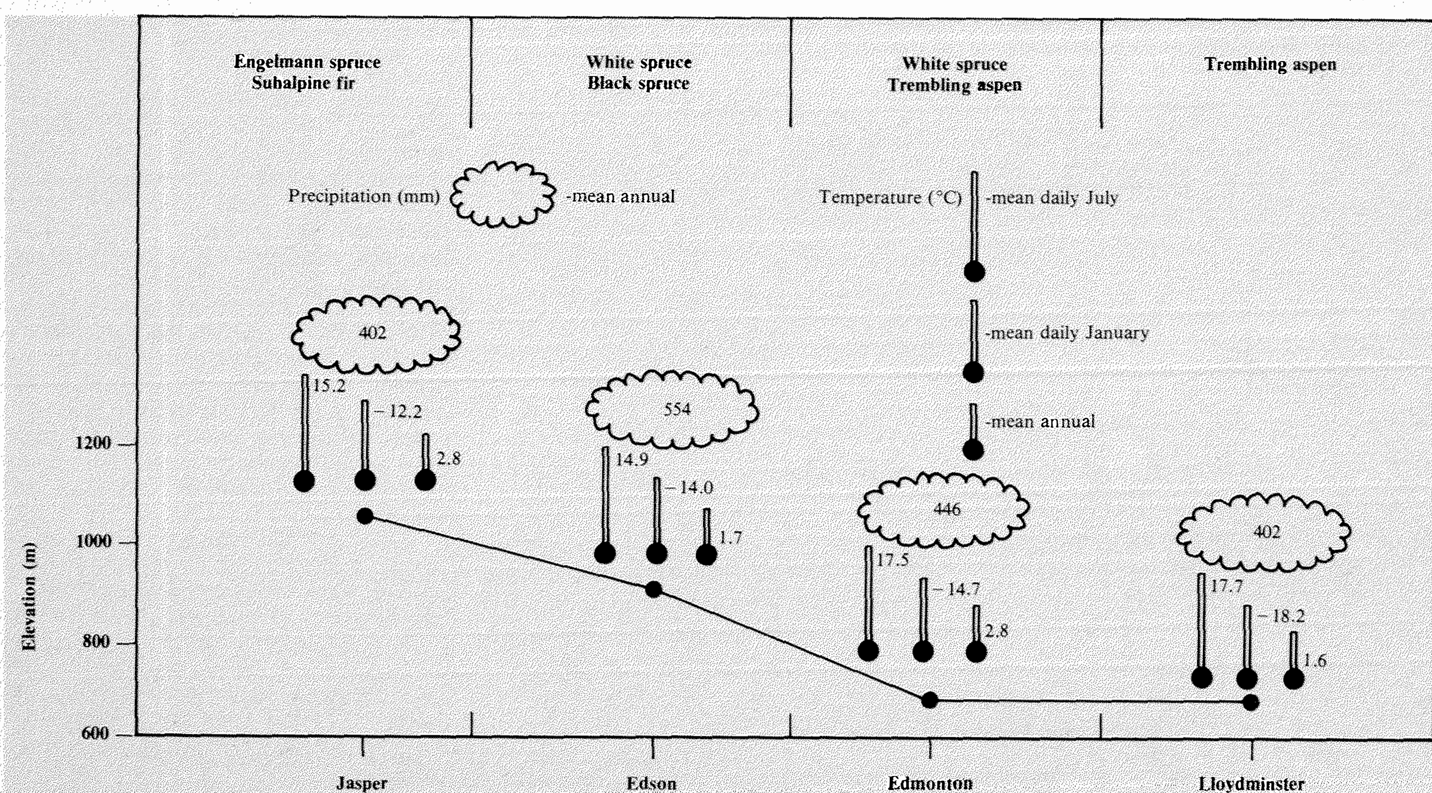
Lacate, D.S. 1969. Guidelines for biophysical classification. Can. Dep. Fish. For., Can. For. Serv. Ottawa, Ont. Publ. 1264.



Biogeoclimatic zones between Lloydminster and Jasper, Alberta.

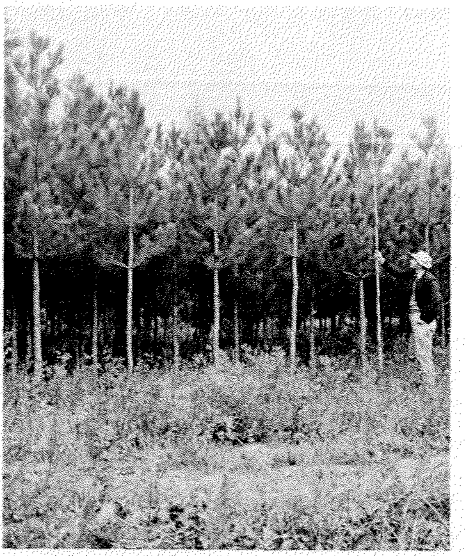
Factors affecting field performance of seedlings

The field performance — survival and growth — of seedlings is determined by a variety of factors including seed quality as affected by genetics, cone and seed handling, and extraction and storage procedures; seedling quality as affected by nursery practices such as production, storage methods, and schedules; planting quality as affected by shipping, on-site storage, site selection (including microsites), site preparation, and planting procedures; and postplanting factors such as weather and biological agents. Chances of success can be improved to the extent that quality can be maintained throughout the entire process. The following articles provide information on field performance and on specific phases of seedling production and planting procedures.

1978 regional plantation resurvey

Ten-year-old jack pine planted in southern Manitoba.

Despite the funneling of major resources into reforestation projects through planting programs in the three prairie provinces, many questions remain pertaining to plantation performance following establishment. In 1971 a survey of bare-root and container seedling plantations was conducted to provide information on the establishment success of plantations that were 1, 3, and 5 years old. Success rates were excellent (average survival 82%) in southeastern Manitoba, but they were generally unsatisfactory in the remainder of the three provinces. Detailed results of that survey are contained in Information Report NOR-X-31, *An appraisal of recent plantations in forests of the prairie provinces.*



Fifteen-year-old red pine planted in southeastern Manitoba.

A resurvey of plantations judged successful in 1971 was carried out in 1978 to determine performance following the establishment phase. The resurvey involved 34 plantations (2550 ha) in Manitoba, 4 plantations (445 ha) in Saskatchewan, and 8 plantations (200 ha) in Alberta. Along with the approximately 100 10-tree plots randomly located in each of the plantations, two 4-m^2 quadrats were established in each plantation to evaluate ingress or determine stocking where plantation evaluation was impossible for various reasons. Data were collected on survival, recent mortality, height, competition, and damage by a variety of agents.

Drought-prone southeastern Manitoba (Agassiz, Whiteshell, and Sandilands areas) maintained its previously established lead in terms of survival but showed an overall loss of 8% since 1971 (from 82% to 74%). Losses since 1971 in the remainder of the Manitoba plantations varied between 0 and 12%, but the plantations maintained an overall survival of 61%.

In Saskatchewan, where fill-in operations had been undertaken, an average of 71% of the original and fill-in seedlings were surviving in the three plantations examined.

The resurvey in Alberta was most difficult because of access and relocation problems, poor survival, overlap treatments, and natural ingress. Systematically established quadrats provided an estimate of stocking for areas where survival tallies would have been unreliable. Where comparison was possible, postestablishment losses averaged 5%.

Heavy competition resulted in losses in many areas. In those situations, surviving stock was found to be performing poorly, and additional losses, particularly of pine, must be expected. Natural ingress in many areas compensated for losses of planted stock. In Alberta pine plantations, ingress sometimes even resulted in overstocking.

Among the plantation problems identified, competition, poor planting, and adverse weather ranked highest. Browsing, insect and disease damage and loss, and human activities accounted for negative influences to varying degrees. Looking at these factors collectively, significant improvement appears not only possible but essential. Much can be achieved by applying current knowledge of good planting practices, otherwise we run the risk of replacing a backlog of unregenerated forest land with plantations that are marginally stocked and perform poorly.

Klem Froning

Note

The exclusion of certain manufactured products does not imply rejection nor does the mention of other products imply endorsement by the Canadian Forestry Service.

Information Reports (NOR-X series) and Forest Management Notes mentioned in this report are available from the Northern Forest Research Centre, 5320 - 122 Street, Edmonton, Alberta, T6H 3S5.

Trouble with bare-root planting

Among plantation problems, faulty planting can be blamed not only for much of the early mortality but also for continuing losses into the sapling stage and perhaps even beyond that. How can poor planting be assessed as to the cause of a problem 10 or more years after planting?

Take a close look around. You may well find some of the following poor planting clues that were found during the regional plantation resurvey in 1978:

1. very low survival of trees in one row (or more) compared to the survival in an adjacent row, with a repeating pattern,
2. a high proportion of doubles (two seedlings per hole),
3. leaning saplings or blowdown, and
4. the root collar of many planted trees more than 5 cm below ground level.

The survey crew went to the root of the leaner problem and discovered that in every case poor anchorage and root deformation resulting from improper planting were the causes of leaning saplings and blowdown. Hockey-stick and "J" planting had prevented roots from growing normally. The main stem was left poorly supported on at least one and sometimes two sides.

"J"-shaped root system of a leaner illustrates the results of poor planting techniques 10 years earlier.

A leaner in a 10-year-old jack pine stand.

Generally, color and vigor of these trees are normal, but when they reach the sapling stage, snow, ice, rain, and wind combine to gradually push them over, and they eventually die.

According to our survey, leaners can comprise as high as 9% of the saplings in a plantation. The leaner problem appeared to be greater on lighter soils, but it could be that symptoms only show up earlier on these lighter soils. There also appears to be a relationship between the number of doubles and the number of leaners found in a plantation, and poor planting is most likely the common denominator. The point is that there is trouble with planting, and something can and must be done about it.

Klem Froning

Saskatchewan plantation assessment

Saskatchewan foresters and technicians have for some time realized the importance of good plantation assessment data. Between 1963 and 1978, 61 bare-root plantation assessments were carried out in central and eastern Saskatchewan. The results showed an average 1st-year survival of 80% (15-98%) for white spruce and 69% (0-99%) for jack pine; 5th-year survival dropped to 60% and 49%, respectively. Five years after planting, white spruce averaged 0.5 m and jack pine averaged 0.7 m in height.

The plantation assessment technique used in Saskatchewan is a staked-point method in which a plot of 100 trees is established for each 40 000 trees planted. Each plot has four subplots of 25 trees. All trees are assessed for vigor, tree damage, and quality of planting. Through repeated investigation of staked trees it is possible to determine what effect stock and planting quality have on plantation survival and growth. This information has been instrumental in initiating research projects and planter training programs in Saskatchewan. Continued assessment of our plantation planting will enable our personnel to learn from past mistakes and thereby improve future reforestation programs.

C.M.A. Halland
G. Carter
Saskatchewan Forestry Branch

A 48-year-old jack pine plantation.

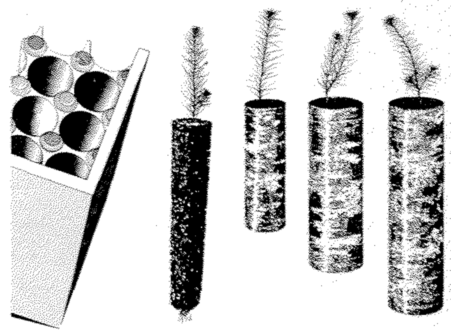
Containerized conifer seedling field performance in Alberta and the Northwest Territories

The concept of reforestation using container-reared seedlings was introduced to Alberta in 1965. In 1971 a field performance trial of 40-cm^3 BC/CFS (British Columbia/Canadian Forestry Service) styroblock and ARC (Alberta Research Council) sausage containers was begun at six locations in Alberta and one location in the Northwest Territories. Performance comparisons were made with 3-0 conventional bare-root nursery stock at the five Alberta locations. The species used were lodgepole pine, jack pine, white spruce, and Engelmann spruce. Planting was carried out between 1971 and 1974.

Results after 3 and 5 years showed that, compared to conventional bare-root nursery stock, container-reared seedlings showed superior survival, had good growth, and extended the planting season without loss of performance. Details of these trials are contained in Information Report NOR-X-218, *Containerized conifer seedling field performance in Alberta and the Northwest Territories.*

The main conclusions regarding site preparation, stock quality, field performance, and planting methods are as follows:

1. Container-reared seedlings were successfully planted during June, July, and August; conventional plantations established after June were failures.
2. Initial preplanting weight is a very important characteristic in that larger seedlings had better survival and growth rates. Longer rearing periods to maximize seedling size to the full capability of the container may be desirable. Larger containers, producing larger seedlings, should also be considered for good-quality sites with severe competition.
3. A shoot-root ratio between 1:1 and 2:1 for container seedlings was not necessarily optimum; larger seedlings with higher shoot-root ratios performed better after outplanting.
4. Both the styroblocks and the ARC sausages produced large, healthy stock with good field performance. Larger seedlings were produced in the styroblocks in 3 of the 4 years. Rearing the sausage seedlings required more time and attention.
5. Dibbles (noncore) proved to be the easiest and quickest method of planting container seedlings.
6. Frost heaving of container seedlings to a large extent can be eliminated by setting the plug approximately 1 cm below the ground surface and pressing a small amount of soil over the top.
7. Shallow topsoils underlain with shale or containing a large number of stones should be planted with bars or spades, as dibbles fail to make adequate holes for container plugs. Dibble planting on dry to very dry, fine soils is extremely difficult, and the planting operation should be delayed until there is adequate moisture to ensure a reasonable planting rate and to avoid the possibilities of shallow planting.



BC/CFS styroblock. ARC sausage.

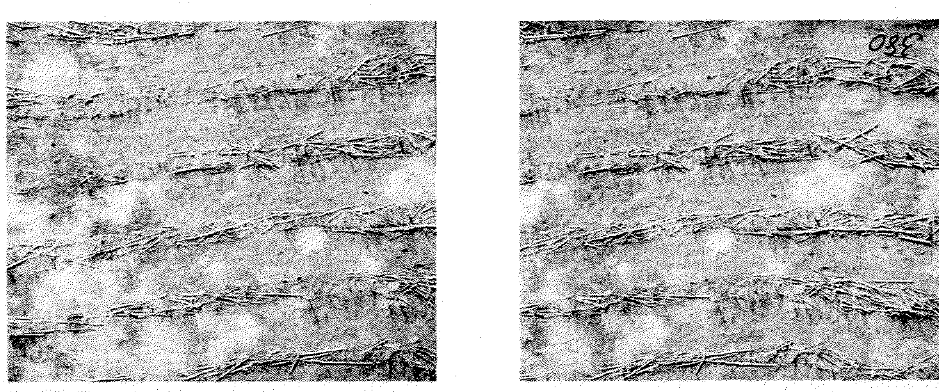
8. To minimize soil disturbance and to avoid continuous bulldozed strips with their resultant problems of animal traffic and water channeling, increased use should be made of a scarifier such as the Bracke cultivator where forest conditions permit.

Norm Walker
Harry Johnson

Monitoring regenerated areas from the air

With current forest regeneration costs in Canada of over $56 million annually, forest managers — who are accountable for such allocations — require an economical method of reviewing such investments for several years following treatment.

Large-scale color photography offers an attractive monitoring alternative to conventional ground surveys. Softwood seedlings 0.3 m or more in height can be readily identified using imagery at scales of 1:500 to 1:1 000. Imagery is obtained when deciduous trees are leafless in early May after the snow has gone. The method is fast, inaccessible areas are no problem, and costs are only a fraction of those for conventional ground surveys.



The stereogram illustrates a 15-year-old white spruce plantation 10 years after treatment. Site preparation is seen more clearly than are the three rows of machine-planted seedlings per bulldozed strip. The seedlings are approximately 0.8 m in height, while aspen suckers are approximately 3.4 m. At a scale of 1:900 the seedlings, enhanced by shadows, appear as dark dots; under a stereoscope the dots appear as green seedlings. The area is evidently well stocked.

Readers wishing additional information on this subject should consult Information Report NOR-X-216, *An aerial reconnaissance of softwood regeneration on mixedwood sites in Saskatchewan,* and NOR-X-221, *A camera and interpretation system for assessment of forest regeneration.*

Jim Ball

Testing peat moss quality

Peat moss is usually a better medium than soil for growing conifer seedlings; however, commercial brands of peat vary widely in characteristics that are significant to seedling growth.

Two studies were undertaken using five commercial peat brands to determine the effects of texture [coarse-fine (< 2 mm) ratio] and pH on the growth (shoot-root ratio and total seedling weight) of 14-week-old white spruce and lodgepole pine seedlings. In Study 1 all brands were adjusted to coarse-fine ratios of 1.00, 0.75, 0.50, 0.25, and 0.10 and a uniform pH of 4.5. Study 2 had a uniform coarse-fine ratio of 1.00 and pH adjusted to 3, 4, 5, 6, 7, and 8. Trays were randomly arranged on greenhouse benches, and seedlings were reared using Carlson's (1979) rearing schedule.

The influence of the coarse-fine ratio was only slight, but the ratio appeared best for both species at 0.50. The influence of pH was very pronounced, with the best spruce and pine seedling growth occuring at pH 4 and 5. The two photographs illustrate the effects of peat pH. In the acid medium (pH 3), roots were slow growing, short, and thickened, but top growth was surprisingly good. In the alkaline medium (pH 7 and 8), root tips died and laterals tried to take over. Few seedlings became established and many died. Fungus appeared on the soil surface of these two treatments.

Tree seedlings can be grown in any of the commercial peat brands studied, but before using any peat as a growing medium it should be tested and modified to meet the acceptable standards. All brands tested were best in at least one category in the results obtained.

Elmer Wambold

Reference

Carlson, L.W. 1979. Guidelines for rearing containerized conifer seedlings in the prairie provinces. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-214.

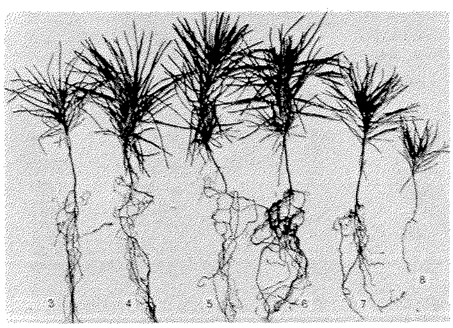
Characteristics of five commercial peat brands and acceptable standards

Brand	Texture (coarse-fine ratio)	Water-holding capacity (%)	pH	Ash content (%)	Concentration of mineral salts (electrical conductivity) (mS/cm)
Alberta Rose	0.35	728	5.1	6.9	0.49
Canada Brand	0.92	851	3.6	1.9	0.21
Emerald	1.27	698	4.9	14.2	2.75
Green Thumb	0.43	696	4.0	8.9	0.37
Sunshine	1.70	833	3.5	6.7	0.60
Acceptable standard (Carlson 1979)	>0.50	600-900	4.5 to 5.5	<10	<0.50

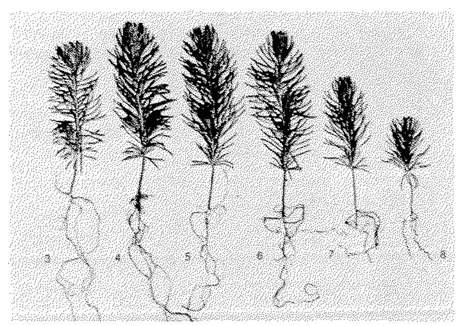
Study 1, effects of peat texture on white spruce and lodgepole pine

Texture (coarse-fine ratio)	White spruce		Lodgepole pine	
	Shoot-root ratio[1]	Total weight (mg)	Shoot-root ratio[1]	Total weight (mg)
1.00	7.4	107	4.8	206
0.75	7.3	108	5.0	206
0.50	7.1	113	4.7	220
0.25	7.2	108	4.8	205
0.10	7.6	111	4.8	207

[1] Based on weight (mg).



Effects of peat pH on the growth of lodgepole pine.



Effects of peat pH on the growth of white spruce.

Study 2, effects of peat pH on white spruce and lodgepole pine

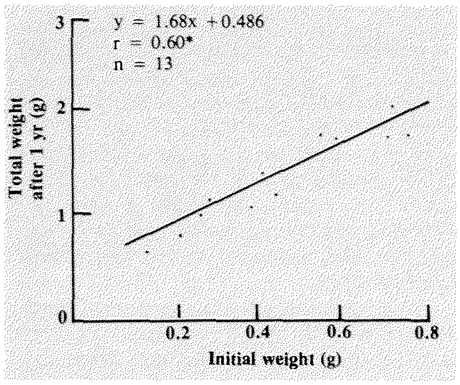
pH	White spruce		Lodgepole pine	
	Shoot-root ratio[1]	Total weight (mg)	Shoot-root ratio[1]	Total weight (mg)
3	8.3	86	3.9	119
4	8.1	110	3.4	162
5	8.9	105	3.5	164
6	9.2	73	3.5	119
7	6.2	34	3.5	52
8	5.2	17	3.8	23

[1] Based on weight (mg).

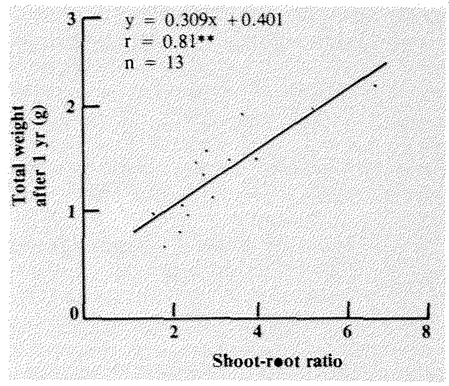
Increasing shoot-root ratio and seedling size improves 1st-year performance

Container seedlings have been reared in the past with the view that a well-balanced seedling with a shoot-to-root ratio between 1:1 and 2:1, regardless of size, would perform better once outplanted in the field. A large-scale container planting trial carried out from 1971 to 1974 using two plug-type seedlings grown in the BC/CFS styroblock and the ARC sausage provided data on the effects of various shoot-root ratios. A greenhouse rearing period of 10-15 weeks, a cold frame period of 3-9 weeks, and 3 years of replication produced a range of seedling sizes with varying shoot-root ratios. Total seedling weight and shoot-root ratios were obtained for each lot from a sample of oven-dried seedlings prior to planting. Representative seedlings were excavated after one growing season in the field, and total seedling weight was measured.

Linear regressions for styroblock white spruce seedlings showed that the total weight 1 year after outplanting was a function of the preplanting weight and of the initial shoot-root ratio. The larger seedlings with a larger shoot-root ratio performed significantly better than the smaller seedlings with a balanced or lower shoot-root ratio. Similar relationships were determined for the ARC sausage container and for lodgepole and jack pine.



The effect of initial total weight on growth (total weight) of white spruce seedlings grown in the BC/CFS styroblock.



The effect of initial shoot-root ratio on growth (total weight) of white spruce seedlings grown in the BC/CFS styroblock.

Jim Ball
Norm Walker

Soil amendments and fertilizers improve bare-root seedling growth in tree nurseries

The addition of amendments and fertilizers to improve the physical and chemical characteristics of the soil in tree nurseries is a common practice. To assess the effects of soil amendments (peat and sulfur) and fertilizers (including amount, nitrogen form, and timing of application) on the growth of white spruce, jack pine, and lodgepole pine bare-root stock, four studies were conducted at the Alberta Tree Nursery located at Oliver, Alberta, and the Prince Albert Forest Nursery located at Prince Albert, Saskatchewan. Soil and site characteristics at the two nurseries are described in the accompanying table. In all studies the seed was sown in rows, and the seedlings were thinned to 12-15 per 30 cm. Plots were hand weeded and watered as required by nursery personnel.

Article continues on pages 8-10.

Site and soil characteristics of tree nurseries at Oliver, Alberta, and Prince Albert, Saskatchewan

Site and soil characteristics	Oliver	Prince Albert
Location	la . 53°40', long. 113°28'	lat. 53°13', long. 105°13'
Elevation - m	699	431
Mean annual pr ipitation - mm	441	392
Mean summer precipitation (May-Sept.) - mm	292	250
Mean summer temperature (May-Sept.) - °C	13	14
Average frost-free period (0°C) - days	100	110
Soil subgroup	orthic black chernozem	dark gray chernozem
Parent material	alluvial, lacustrine	glaciofluvial, alluvial
Texture (top 20 cm)	sandy clay	sandy loam
Silt, %	17	17
Sand, %	47	68
Clay, %	36	15
pH	6.2	7.4
Electrical conductivity - mS/cm	1.1	0.1
Organic matter - %	0.7	3.8
Nitrate - ppm	21	4
Phosphorus, extractable - ppm	8	10
Potassium, exchangeable - ppm	172	78
Cation exchange capacity - me/100 g	30	21

Study 1 — Addition of peat and sulfur

Soil at the Prince Albert tree nursery is a neutral to slightly alkaline (pH 7.4) sandy loam underlain by moderately alkaline sand. Organic matter on the surface soil (0-15 cm) averages 3.8% but is less than 1% in the subsoil. Wind erosion in exposed areas has removed topsoil, bringing the coarse subsoil to the surface. Ideal soil pH for growing most conifers is pH 5-6, and organic matter increases available water capacity of the soil.

In the spring of 1975, sphagnum peat was spread on the soil surface at depths of 0, 5, 10, and 15 cm and then plowed into the top 20 cm of soil. Powdered elemental sulfur (S), an acidifying agent, was spread and plowed in at rates of 0, 560, 1120, and 2240 kg/ha. Sixteen combinations of peat and sulfur were tested. Jack pine and white spruce were seeded following a general application of nitrogen (N) as ammonium nitrate (33.5-0-0) at 112 kg/ha, phosphorus (P) as ordinary superphosphate (0-20-0) at 80 kg/ha, and potassium (K) as potash (0-0-62) at 60 kg/ha. Plots were not fertilized the 2nd and 3rd years. The seedlings were grown for 3 years.

Generally, seedling growth increased significantly with S at 560 kg/ha but leveled off at higher applications. For pine, the optimum treatment combination was S at 560 kg/ha mixed with 10 cm of peat (height growth 42.5 cm; total dry weight 9.2 g). Regardless of the level of S applied, height, shoot, and root weights were uniformly lower in the absence of peat than when peat was applied. There was a significant interaction between peat and S. Mean height growth in response to 10 cm of peat without S was 3.5 cm and in response to 560 kg/ha of S without peat was 1.8 cm. When peat and S were combined, height growth improved by 8.0 cm. A similar peat-sulfur interaction was indicated in the shoot and root dry weights.

For white spruce, the optimum combination was 10 cm of peat and S at 2240 kg/ha (height growth 22.7 cm; total dry weight 3.2 g). Significant increases in height and dry weights occurred with successive increments of S up to the maximum application of 2240 kg/ha. The effect of peat was less marked; mean height increased from 19.5 cm without peat to 21.8 cm with 10 cm peat and decreased at the higher application rate. Shoot weight remained constant between 0 and 10 cm of peat but decreased sharply with 15 cm. Peat-sulfur interaction was not significant for spruce, although height and dry weights were increased by either amendment.

The positive response of both species to peat indicated that it is a necessary amendment for these moderately coarse soils. Organic matter increases available water and cation exchange capacities and improves tilth. No amount of S could compensate for the low organic matter in these soils. The greater effect of peat on pine growth reflects its ability to benefit from subsurface moisture because of its deeper rooting habit. Spruce has a shallow rooting system, and therefore its growth is not enhanced significantly by increased application of peat.

The effect of S was more marked for white spruce, most likely because of pH changes in the soil. Soil pH was 6.6, 6.0, 5.5, and 4.7 when measured 2 years after S was applied at rates of 0,560,1120, and 2240 kg/ha, respectively. Optimum growth of jack pine occurred at pH 6.0, whereas the best growth of white spruce was associated with pH 4.7. The data indicated that jack pine was tolerant of a wider range in soil pH (slightly acid to very strongly acid), whereas white spruce had a more-specific requirement (very strongly acid). Without S, height and dry weights of both species were less than without peat. This indicated that unsuitably high soil pH was a major limiting factor on these soils when growing conifers.

Study 2 - Application of N, P, and K fertilizers

Seeding was carried out in late May 1973 at Prince Albert and in early June 1974 at Oliver. Nitrogen (N) as ammonium nitrate (33.5-0-0) and phosphorus (P) as superphosphate (0-20-0) were applied in 16 combinations at Oliver. At Prince Albert, N as ammonium sulfate (21-0-0), P as superphosphate (0-20-0), and potassium (K) as potash (0-0-62) were applied in 24 combinations. Fertilizers were applied only in the first 2 years. In each of these years, two equal applications were made during the growing season (mid-June and late July). The fertilizers were watered into the soil. The seedlings were grown for 3 years and then were harvested.

At Oliver the best treatment for lodgepole pine was N at 224 kg/ha and P at 45 kg/ha (height growth 17.1 cm; total dry weight 5.4 g); for white spruce it was N at 112 kg/ha and P at 45 kg/ha (16.5 cm; 3.6 g). At Prince Albert white spruce grew best with N at 112 kg/ha (10.3 cm; 1.0 g), and applications of P and/or K did not improve growth significantly. Jack pine grew best with N at 224 kg/ha, P at 90 kg/ha, and K at 112 kg/ha (25.7 cm; 8.6 g).

The higher P requirement at Prince Albert is attributed to the more-alkaline soil. Should the soil be acidified, less P fertilizer would be required. The coarse- to medium-textured soils, besides being low in exchangeable K, are also low in K reserves. Such levels are apparently adequate for the slower-growing white spruce but are insufficient for jack pine with its greater rate of accumulation of dry matter. This explains why the addition of K enhanced the effect of N and P on growth of jack pine. Although additional P and K did not increase growth of white spruce, a positive response to both nutrients should be anticipated in this relatively poor soil. Growth in terms of height and dry weight declined when the highest levels of fertilizers were combined, indicating that the salinity tolerance of the seedlings was exceeded.

White spruce (3-0) beds at the Alberta Forest Service's Pine Ridge Forest Nursery at Smoky Lake.

Study 3 - Nitrogen source

Sources of nutrients, particularly those of nitrogen (N), are known to vary in their effect according to soil conditions and plant species. Ammonium nitrate (33.5-0-0) is very soluble and is subject to leaching; ammonium sulfate (21-0-0) increases soil acidity; urea (46-0-0) is slow to react, first raising pH then lowering it as nitrification occurs; and calcium nitrate (15.5-0-0) is alkaline in its reaction. To investigate these differences, a study was carried out at the Prince Albert tree nursery between 1976 and 1978 using jack pine and white spruce.

In each of the first 2 years, each N source was applied at rates equivalent to N at 56 and 112 kg/ha. Each N source was applied to the soil surface and watered in (solid) or dissolved in water and applied with a watering can (liquid). As a control, a routinely used mixed fertilizer (11-48-0) was applied at 224 kg/ha. Seedlings were measured in 1978 after 3 growing seasons.

Nitrogen in the forms of calcium nitrate at 56 kg/ha and ammonium sulfate at 56 and 112 kg/ha gave the best height growth (45.1, 40.4, and 40.1 cm, respectively) and total dry weight accumulation (8.5, 8.4, and 7.9 g, respectively) for jack pine. For white spruce the mixed fertilizer (11-48-0) at 224 kg/ha yielded the best growth (27.9 cm; 5.7 g), and ammonium nitrate at 112 kg/ha (26.3 cm; 5.9 g) was second-best overall.

The effectiveness of ammonium sulfate for jack pine is attributed to the rapid reduction of soil pH to a suitable level, which for conifers is pH 5-6. Nitrogen uptake increases as pH is lowered; therefore, a fast-acting acidifier such as ammonium sulfate could favor jack pine.

White spruce benefited most from ammonium forms of N. This is partly because NH_4^+ reduces soil pH to the level considered optimum for the species. Adsorption and retention of the positively charged ammonium ion by the soil also favors utilization of this form by the more-slowly growing spruce. Nitrate ions are generally more mobile in soil and would be subject to more leaching in this moderately coarse-textured soil. In artificial media (e.g., perlite and vermiculite) it has been found that NH_4^+ and NO_3^- are equally effective for spruce.

Liquid vs. solid application: Jack pine grew 15% taller and 24% heavier and white spruce was 10% taller and 4% heavier when solid fertilizers were applied. Fertilizers applied in solid form move through the soil more slowly than liquids and so are available over extended periods. Despite the inferiority of liquid fertilizers in this study, they are used in nurseries because they can be applied conveniently with irrigation water, although less-concentrated and more-frequent applications are required.

Study 3, 3-year growth response of jack pine and white spruce to different nitrogen sources at the Prince Albert Tree Nursery, 1976-78

Source[1] and rate of nitrogen fertilizer (kg/ha of N)	Jack pine (3-0) Height growth (cm)	Jack pine (3-0) Total dry weight (g)	White spruce (3-0) Height growth (cm)	White spruce (3-0) Total dry weight (g)
U - 56	33.5	6.0	22.9	4.7
U - 112	36.3	6.2	23.3	4.2
AN - 56	36.1	7.6	24.1	4.6
AN - 112	37.7	6.7	26.3	5.9
AS - 56	40.4	8.4	22.8	4.3
AS - 112	40.1	7.9	26.0	5.6
CN - 56	45.1	8.5	25.6	4.6
CN - 112	35.0	6.8	25.1	5.3
Control	34.3	6.2	27.9	5.7

[1] U = urea, AN = ammonium nitrate, AS = ammonium sulfate, and CN = calcium nitrate; Control = mixed fertilizer (11-48-0) at 224 kg/ha.

Lifting 3-0 white spruce bare-root planting stock using a Fobro Tree L fter.

Lifting 3-0 white spruce bare-root planting stock using a Grayco Tree Lifter.

Study 4 - Timing of fertilizer application

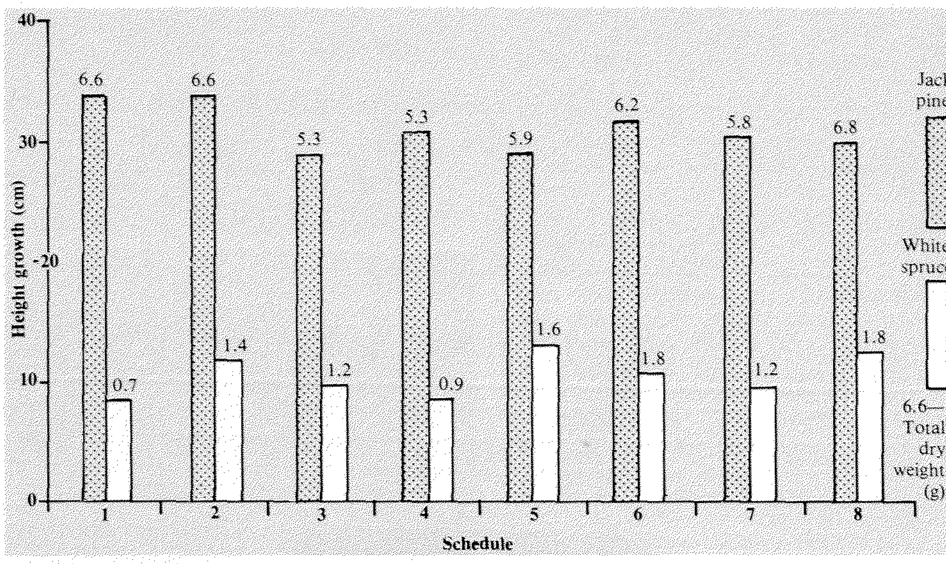
Timing of fertilization is controversial among nurserymen. Some advocate no fertilization during the first growing season, and others have obtained good response with late-season (September and October) applications.

In 1975 the Prince Albert tree nursery test plots were treated with sulfur (S) at 1120 kg/ha, phosphorus (P) as ordinary superphosphate (0-20-0) at 56 kg/ha, and potassium (K) as potash (0-0-62) at 90 kg/ha prior to the seeding of white spruce and jack pine. Seedlings were grown for 3 years according to eight different fertilization schedules using N, P, and K. Total annual dosages were N as ammonium sulfate (21-0-0) at 105 kg/ha, P as triple superphosphate (0-45-0) at 70 kg/ha, and K as potash (0-0-62) at 57 kg/ha. Fertilization was not carried out during the third growing season.

Early application of N fertilizer was important in maximizing the growth of both species. Jack pine required fertilization throughout the first 2 years (schedules 1 and 2), whereas white spruce achieved best results with 1st-year application only (Schedule 5). Pine is faster growing, and because of its deeper root system it benefited from more-frequent applications. First-year application was sufficient to enrich the rooting zone of spruce and to satisfy its lower growth rate. White spruce is less tolerant than jack pine of salinity, and growth might have been depressed by high levels of application during the 2nd year. It has also been found that white spruce responded to late applications (August and September) of fertilizers, but these schedules were not included in this study because of the shorter frost-free period at this tree nursery.

Study 4, fertilization schedules for N, P, and K at the Prince Albert tree nursery, 1975-77 (as fraction of annual dosage applied on each date)

Schedule	1st year June 5	1st year July 3	1st year July 28	2nd year June 5	2nd year July 3	2nd year July 28
1	⅓	⅓	⅓	⅓	⅓	⅓
2	½	½	Nil	½	½	Nil
3	Nil	½	½	Nil	½	½
4	Nil	Nil	Nil	⅓	⅓	⅓
5	⅓	⅓	⅓	Nil	Nil	Nil
6	½	Nil	½	⅓	⅓	⅓
7	⅓	⅓	⅓	½	Nil	½
8	Nil	½	½	½	½	Nil



Study 4, 3-year growth response of jack pine and white spruce to different N, P, and K fertilizer schedules at the Prince Albert tree nursery, 1975-77.

Recommendations

Oliver

1. Grow hardwoods instead of conifers, for which the soil texture is unsuitable.
2. If conifers are to be grown, ensure control of weeds and grow seedlings for 3 years.
3. Prior to seeding, mix in P as superphosphate at 90 kg/ha. Application of soil amendments is not practical.
4. In each of the first two growing seasons, top dress with N as ammonium nitrate at 112 kg/ha. In the third growing season apply at 56 kg/ha.

Prince Albert

1. Prior to seeding, if the seedbed contains less than 4% organic matter and pH is greater than 6.5, mix in 10 cm of peat and S as elemental sulfur at 1120 kg/ha. Also prior to seeding, mix in P as superphosphate at 90 kg/ha and K as potash at 1120 kg/ha.
2. Grow pine for 2 years and spruce for 3 years. In each of the first two growing seasons, top dress with N as ammonium nitrate at 224 kg/ha for pine and at 112 kg/ha for spruce. In the 3rd year for spruce, apply N at 56 kg/ha.
3. Root prune and immediately irrigate spruce at the beginning of the third growing season.

General

1. Plant seed in rows and thin to 12-15 seedlings per 30 cm.
2. Apply fertilizers in solid form.
3. Split application of the N top dressing during each of the first 2 years into three portions applied 3 weeks apart (early June to early August). In the third year, split the application into two portions but apply 3 weeks apart.
4. Following each top dressing, immediately irrigate in order to dissolve the fertilizer crystals.

Ivor Edwards

Saskatchewan cold storage test

Very little information is available on the length of time that bare-root nursery stock can be kept in cold storage. During 1975 to 1978 a test was conducted by the Prince Albert Forest Nursery to determine what effect extended cold storage had on survival and growth of 2-2 jack pine and white spruce.

The planting stock used for the test were lifted in early May and put into cold storage. A total of 100 trees was planted at monthly intervals from mid-May to mid-October. The jack pine were planted at Candle Lake the same day as they were taken from storage, while the white spruce were kept overnight in their storage containers and then were planted the following day at Torch Lake. The roots of all trees were dipped in a water-clay solution before planting. Survival, height, and vigor were evaluated and recorded in October 1975 and each fall to 1978.

The table shows the performance rating (percent survival × mean height growth in cm) in the fall of 1978. It is evident from these results that cold storage does in fact greatly affect survival and subsequent height growth of nursery stock. Jack pine was affected less than white spruce. Planting stock lifted in early May should not be held in cold storage later than the end of July.

Four-year performance rating[1] of jack pine and white spruce held in cold storage, dipped into a water-clay solution, and planted at monthly intervals in 1975

Species	Month planted						Average
	May	June	July	August	September	October	
Jack pine	**2852**	**2686**	**2109**	1164	280	2	1516
White spruce	**617**	**560**	**492**	55	15	5	291

[1] Performance rating = survival (%) × mean height growth (cm). Performance ratings higher than average for all plantations (1516 for pine and 291 for spruce) were considered successful and appear in bold type.

C.M.A. Halland
Saskatchewan Forestry Branch

Preplanting conditioning and overwintering of container seedlings

The production of containerized seedlings in the prairie provinces has increased dramatically from 5 million in 1974 to an expected 22 million in 1981. A relatively large number of seedlings can be produced in one season in a greenhouse, even on a single-crop schedule, and multiple-crop schedules with greenhouse periods as short as 4 weeks further enhance production capabilities. Production rates are only one side of the coin, however; the other side is survival through the overwintering stage and survival and growth in the field for stock planted either in the year of production or following an overwintering period.

Experience with overwintering of container stock in this region indicates that losses can be significant for both pine and spruce. Pine is the most susceptible to winter damage, and even first-crop seedlings can suffer major damage, especially if snow cover is inadequate. Overwintering damage can result in poor field survival and growth and in stem deformities.

In greenhouse production, the first (spring) crop sown will tend to be more mature at the time of outplanting than subsequent crops, because later crops germinate and grow during a time of declining day length at northern latitudes. Ordinarily, first-crop seedlings will be further advanced in epicotyl development at the time of removal to outside conditions. Even so, nature does not always provide correct day length and conditioning temperatures to enable these seedlings to advance from the epicotyl to the shoot stage. The later-sown crops in particular have less time to adapt to and develop under outside conditions. Prescribed conditioning would help to overcome these difficulties.

Planting container-grown black spruce on a scarified cutover.

Usually 4-6 weeks outdoors will be sufficient time for first-crop seedlings to set buds and for soft tissues to mature prior to the onset of winter. Later crops, however, may require special treatments such as shorter photoperiod and lower temperature to prepare them for the outdoor environment. Such treatments are being studied at the Northern Forest Research Centre to determine their effects and practicability. One alternative is to reduce or eliminate multiple-crop schedules. In addition, if seedlings are to be overwintered before planting, special protective procedures may be necessary, particularly where snow cover is inadequate. Some of the techniques being used include adding more insulation either with or without special structures, placement under the protection of trees, and even removal from containers and packing and storing in cold rooms, as is done with bare-root stock. Studies of specially insulated structures for winter storage are currently being undertaken.

Future research should be directed at improving preconditioning of container stock and improving the overwintering environment of those that must be held for planting the following year. Guidelines for recognizing damage in overwintered stock and relating damage to field survival and growth would be desirable. Such guidelines could be used in culling procedures and in support of management decisions to alter production and overwintering practices, including determining the number of crops to be grown in a season, overwintering as few pine as possible, and providing special winter protection for those that must be held over until the following year.

Harry Zalasky

Saskatchewan root dipping tests

Very dry planting conditions occur sporadically during most planting seasons in Saskatchewan, resulting in desiccation of planting stock roots when being handled in the field. Field tests carried out in 1975 and 1978 in central Saskatchewan indicated that increased survival, growth, and vigor of bare-root stock planted in dry weather can be obtained by dipping roots into a Gelgard slurry. Gelgard, which is manufactured by Dow Chemical of Canada Ltd., is a water thickener used in fire suppression. By mixing Gelgard with water (approximately 10 g per 5 L of water), it is possible to increase the thickness of the water layer adhering to the tree roots at the time of planting.

A test was conducted in 1975 at Tobin Lake using 2-2 white spruce under very dry weather conditions. Two containers were prepared, one containing water, the other containing Gelgard mixed with water. Two groups of roots were dipped simultaneously into the containers and were immediately spread out on branches on the ground, completely exposed to sun and wind. Ten trees from each treatment were then planted simultaneously at 10-minute intervals to 60 minutes and thereafter at 30-minute intervals from 90 to 300 minutes.

In 1978 further testing was conducted at Gem and Grassy lakes using 3-0 jack pine and white spruce stock, respectively. Three treatments were tested: Gelgard, water, and untreated. Twenty trees for each treatment were dipped, exposed, and planted simultaneously at 20-minute intervals from 0 to 180 minutes.

Trees from both tests were measured for survival and growth in September 1978, and tree vigor was assessed as good, fair, or poor.

Survival, growth, and vigor of Gelgard-treated seedlings were significantly improved for 3-0 jack pine and for 2-2 and 3-0 white spruce stock throughout the range of planting intervals. Survival and growth showed a general decline for all treated and nontreated stock as the interval between treatment and time of planting increased.

Treatment of seedling roots with the Gelgard mixture is recommended when dry planting conditions exist. Ideally the stock should be treated in the field immediately after removal from the storage boxes and planted as soon as possible. If planting is unduly delayed, retreatment of the roots would be desirable.

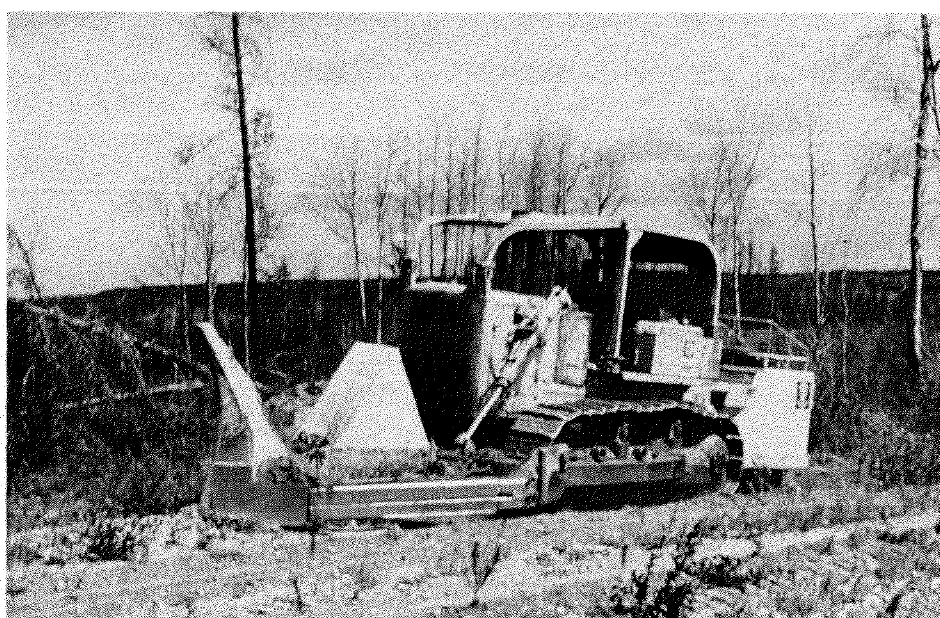
C.M.A. Halland
Saskatchewan Forestry Branch

Advances in mechanical reforestation

In recent years the decreasing availability and rising cost of labor for tree planting coupled with the ever-increasing expense of operating and maintaining site preparation equipment has led to the development of machines capable of performing both operations at once. Two such machines are the Cazes and Heppner (C & H) tree planter and the Bracke cultivator. In developing these machines the emphasis was placed on matching simplicity of design and ruggedness of construction with minimum site disturbance and high productivity. In 1977 the Canadian Forestry Service undertook preliminary evaluation of both machines and concluded that each was reasonably successful in achieving this combination.

The C & H system is made up of three units: a bulldozer, a plow, and a planter. The plow creates a continuous furrow of exposed mineral soil 7-10 cm deep and 60-90 cm wide. It is equipped with a tooth and side arms for cutting roots and clearing slash. The planting unit is made up of a circular colter that creates a continuous furrow, a planting chute, and a pair of packing wheels. The system is capable of planting over 1 000 trees per hour on flat, relatively slash-free, jack pine sites and about 700 trees per hour on rougher sites. A planting trial with jack pine container stock resulted in 96% survival 114 days after planting. The production and survival figures indicate that the system is efficient and successful in providing the general physical requirements for survival of a planted seedling.

The Bracke cultivator is a wheeled machine generally attached to a bulldozer or skidder and consists of a set of revolving teeth mounted 2 m apart on a frame that adjusts the scalping depth. The teeth leave twin gouges or scalps in the ground that generally measure 15-25 cm deep and one square metre in area. The cultivator comes equipped with a seeding head that can be made to automatically deposit preset amounts of seed onto the scalps. A regeneration survey on a site treated with the Bracke cultivator and left to seed naturally from cone-bearing slash showed that 72% of plots containing scalps were stocked with jack pine, while only 46% of unscarified plots supported seedlings. (This represented an increase in the chance of obtaining successful germination of 26% — a strong case for using the seeding head where natural seeding is limited.) The Bracke does not distribute evenly or alter the pattern of cone-bearing slash over an area, and a single scalp may contain up to 24 germinated seedlings. For these reasons the study concluded that the best application of the cultivator would be as a site preparation tool in tree planting operations on upland sites. Thus utilized, production rates in Saskatchewan in 1976 amounted to 1.6 ha/hour at a cost of $30-35 per hectare. This compared favorably with other types of site preparation equipment.



C & H tree planter.

Recently there has been an effort to catalogue the equipment available for mechanical reforestation in Canada, and two noteworthy publications are currently available. The first is *A compendium of silvicultural equipment,* released in 1978 by the Forest Management Institute (Environment Canada, Ottawa, Ontario) as Information Report FMR-X-115. Details of equipment are limited to manufacturer, price, physical and mechanical specifications, and some limited operational specifications. The second publication is *Silvicultural equipment catalogue for northern Ontario,* released in 1980 by the Forest Resources Branch, Ontario Ministry of Natural Resources. It goes beyond physical and mechanical descriptions of equipment to provide more details on site limitations, production rates, operating costs, and a users' assessment based on interviews with field staff.

The field of mechanization in silviculture is expanding rapidly, and there is need for a coordinated effort to get equipment information to potential users. At present there is a lack of performance evaluation of many of the machines on the market. Because this performance information must be site specific, there is a need for a comprehensive catalogue of silvicultural equipment in this region similar to that produced by Ontario and with a plan for regular revision and updating.


Bracke cultivator.

Russel Bohning
Lorne Brace
Alex Gardner

Site treatment improves survival and growth of planted spruce in Saskatchewan

Site preparation is an important component of any planting program. Between 1972 and 1974 two small planting trials were carried out near Hudson Bay, Saskatchewan, to assess survival and growth of white and black spruce container seedlings planted on two site treatments. Upland sites were scalped using a bulldozer and straight blade, and lowland sites were scalped and furrowed using a Marttiini plow. Container-grown white spruce were planted on both types of scarification as well as in the adjacent rough, while black spruce were planted only on the scalped treatment on the upland site. Measurement occurred 5 years after planting.

Survival and height growth of white spruce were better on both types of scarification than in the rough. Black spruce on the scalped strips performed slightly better than white spruce, which is attributed to the initial larger size and more-rapid juvenile growth rate of black spruce. Seedling mortality on the scalped strips was caused by flooding and in the adjacent rough by severe hazel competition. On the furrow shoulders, overwintered white spruce plugs performed better than 2-2 bare-root stock, and both performed better than plugs planted between the furrows in the alder rough. Further details of this study are contained in Forest Management Note 4, *Plantation performance in perspective.*

Jim Ball
Vic Kolabinski


A 36-year-old white spruce plantation.

Five-year survival, height, and height growth of white and black spruce planted on scalped and furrowed strips, Hudson Bay, Saskatchewan

Planting site	Site treatment	Planting stock	5-year performance: Survival (%)	Height (cm)	Height growth (cm)
Upland with a hazel shrub cover	Nil	White spruce plug[1]	78	19	14
	Scalped	White spruce plug[1]	86	28	23
	Scalped	Black spruce plug[1]	90	36	26
Lowland with an alder shrub cover	Nil	White spruce plug[2]	85	30	22
	Scalped and furrowed	White spruce plug[2]	94	46	38
	Scalped and furrowed	White spruce 2-2 bare-root stock	77	39	28

[1] Grown in BC/CFS styroblock 2, with 16-week rearing period.
[2] As above but overwintered before outplanting.

The seedbed can make a difference

A good seedbed is essential for germination and growth of conifer seed, hence mechanical scarification has become a common silvicultural technique for providing favorable seedbeds. The object is to expose mineral soil so that soil moisture becomes available for germination; exposure of the mineral soil through scarification also reduces initial weed and shrub competition.

Various types of equipment — such as bulldozer blades, plows, barrels, and anchor chains — are commonly used for site treatment. In a Saskatchewan study, scarified strips prepared with a Marttiini plow were tested for suitability for direct seeding of white spruce and jack pine. The first trial was begun in 1973 on a treated cutover in the Hudson Bay region near Greenbush, and the second was begun in 1974 on burned-over land regrown with 20-year-old poplar in the Meadow Lake region near Leoville. Distribution of seedbed types on the furrow bench and the percentage of furrow mounds or overturned debris on the seeded plots at the two locations are given below.


Marttiini plow.

Percentage distribution of seedbed types on the furrow

Location	Furrow bench: Undisturbed duff	Exposed humus	Exposed mineral soil	Decayed wood	Furrow mounds
Greenbush	2	34	21	2	41
Leoville	<1	4	62	<1	33

First- and fifth-year stocking of seeded plots at Greenbush and Leoville, Saskatchewan

Location	Species	Viable seeds (1000 per ha)	Percent stocking[1] 1st year	Percent stocking[1] 5th year	Seedlings (1000 per ha) 1st year	Seedlings (1000 per ha) 5th year
Greenbush	White spruce	25-63	98	86	21	9
		75-113	100	95	29	12
Leoville	White spruce	67-167	99	98	14	13
		200-300	100	100	26	19
Leoville	Jack pine	58-145	97	91	14	7
		174-261	100	98	19	10

[1] Stocking basis = 1/2469 ha (1/1000 acre).


Prepared seedbeds on a moist to very moist clay loam till at Greenbush. Note poor exposure of mineral soil on the furrow bench.


Prepared seedbeds on a fresh to moderately moist sandy loam till at Leoville. Note exposed mineral soil on furrow bench and adjacent furrow mounds.

Elongated 1/2469-ha (1-milacre) plots were established on the bench portion of the furrows and were seeded by hand with varying amounts of seed ranging from 52 to 224 per plot. This represented a rate of 0.2 to 1.0 kg of white spruce seed per hectare and 0.4 to 1.9 kg of jack pine seed per hectare. Viability ratings of this untreated seed were as follows: Greenbush white spruce 20.3%; Leoville white spruce 54.0% and jack pine 47.0%.

Initial stocking was satisfactory for all application rates on both sites; although less mineral soil was exposed and fewer viable seeds were sown at the Greenbush location, initial stocking was as successful as at the Leoville location. After 5 years, seedling numbers were markedly reduced. Mortality was most notable on the Greenbush site due to reinvasion of vegetation. Growth of white spruce at Greenbush averaged 9.6 cm over 5 years compared to 14.2 cm at Leoville. It is apparent that the larger amount of humus seedbed exposed at Greenbush, while not affecting germination, had a significant effect on vegetative regrowth and subsequently on survival and height growth of the white spruce. Jack pine at Leoville was severely affected by snowshoe hare browsing damage during the fifth growing season, and height at 5 years averaged 10.4 cm.

Vic Kolabinski
Jim Ball

Core dibble reduces impact of soil compaction on seedling growth

Landings and haul roads in some logging operations can comprise 20% or more of the cutover area, and on these areas soil compaction could pose a planting problem. Compacted soil layers whose bulk density exceeds 1.8 g/cm^3 for sand and 1.6 g/cm^3 for clay can prevent good root penetration. Planting with the solid dibble, because it compresses the soil around the sides and bottom of the hole, can result in poor seedling growth in such compacted soils. The core dibble offers an alternative because it pushes the soil out of the hole. Built much like a solid dibble, the core dibble has a machined head that is hollow and tapered, similar to the shape of the container plug to be planted.

In 1975 a study was undertaken at Candle Lake, Saskatchewan, to test the effectiveness of a core dibble on the survival and growth of lodgepole pine planted in a logged area with clay loam soil of three different soil densities. After three growing seasons, the results indicated that

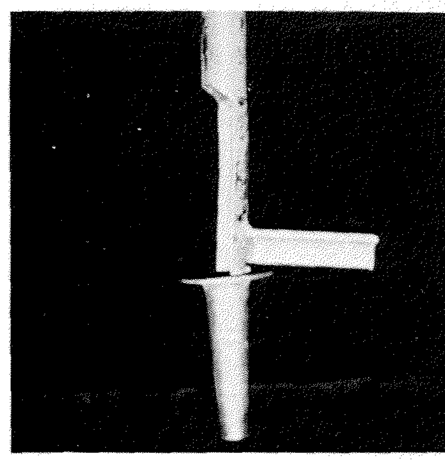
1. on 80% of the cutover, where there was minimal soil compaction due to logging, the core dibble did not significantly improve seedling survival or growth, and
2. growth of seedlings planted with the core dibble on landings and haul roads was significantly better where the clay loam bulk density was 1.9 g/cm^3 and higher.

Use of the core dibble offers no significant advantage to seedling growth or survival on the 80% of a logged area that has normal bulk densities. On the landings and haul roads, where soil bulk density can range up to 1.9 g/cm^3, use of the core dibble to avoid further compaction immediately around the planted seedling is both desirable and beneficial. Eight years of experience in using the core dibble has shown it to be a fast, efficient planting tool that prepares a satisfactory planting hole.

Russel Bohning

Survival and height growth of lodgepole pine 3 years after planting using a core or solid dibble

	Cutover (Soil bulk density 1.5 g/cm^3)		Log landing (Soil bulk density 1.6 g/cm^3)		Haul road (Soil bulk density 1.9 g/cm^3)	
Planting method	Survival (%)	Avg. height growth (cm)	Survival (%)	Avg. height growth (cm)	Survival (%)	Avg. height growth (cm)
Core dibble	80	34	93	54	90	43
Solid dibble	82	31	96	49	83	28



Core dibble.

Container plug seedlings enhance survival and extend the planting season

Even the most successful reforestation programs in this region are limited by the short time during which planting can occur. It would be beneficial, therefore, if the spring planting season could be extended into late July and even August, and it is often argued that container stock will permit this extension. In Alberta, a large-scale container planting trial utilizing a plug form of seedling was started in 1971. Planting was replicated over a 3-year period in five forest districts of Alberta and an area near Fort Smith, Northwest Territories.

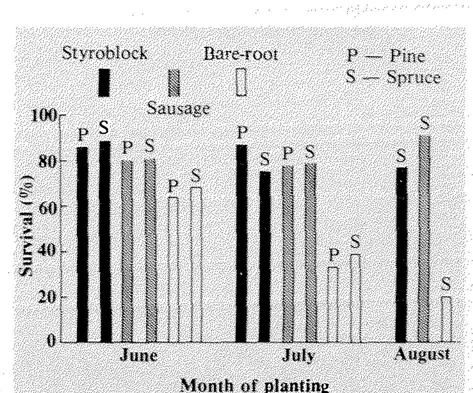
Spruce and pine were reared in the 40-cm^3 BC/CFS styroblock and the ARC sausage. The greenhouse rearing period varied from 10 to 15 weeks, after which the seedlings were placed into outdoor cold frames for an additional 3-9 weeks before outplanting. Fertilizer was applied each week in the greenhouse, with two more applications being made in the cold frame. Planting took place during June, July, and August. The entire polyethylene sausage casing was removed from the ARC plug prior to planting. Each area in Alberta was also planted with approximately 200 conventional bare-root (3-0) stock to provide a comparison. Survival measurements were made on plots of 1000 container seedlings in each forest district.

Survival after three growing seasons was 81% or better on 70% of the container plantations; only 20% of the bare-root plantations had survival of 81% or better. The month of planting did not significantly affect survival of the container seedlings, but it was a critical factor in the bare-root plantations. The average survival by month of planting for the container plantations was better than 70%, but for the bare-root stock it was less than 70% in all cases, decreasing with each month of planting. Of the seedlings planted in June, 73% of the container and 36% of the bare-root plantations had survival rates of 80% or more. When planted during July or August, 67% of the container plantations had a survival rate of 80% or more; none of the bare-root plantations was within this range.

The decreasing survival of bare-root stock in an extended planting season can in part be explained by the better moisture conditions prevailing in June and by storage problems as the season progresses. Plot survival of June plantings, however, was still 100% greater for container than for bare-root seedlings. This is attributed to the active and healthy root mass of the plug seedling, which is planted in its entirety. Unpublished Canadian Forestry Service studies on container seedlings grown and planted within the same year showed that lodgepole pine planted in mid-June and excavated August 21 and 22 had a shoot and root weight increase of 69% and 192%, respectively; for white spruce the weights were 52% and 263%, respectively.

The mean height of bare-root seedlings was generally greater than that of the plug seedlings, but no attempt was made to distinguish spring from late summer plantations. Meaningful comparisons of mean plantation height or growth cannot be made, since the median weight of the bare-root pine seedlings was 5.6 g and of the spruce was 3.6 g, while the plug seedlings at no time exceeded 1 g in weight when planted.

Norm Walker



Three-year survival of bare-root and container-grown (BC/CFS styroblock and ARC sausage) lodgepole pine and white spruce planted throughout the summer.

Paperpot containers ineffective in extending the spring planting season in Saskatchewan and Ontario

In Saskatchewan, two stock tests using jack pine and white spruce were begun in 1975 to determine the usefulness of FH 408 paperpots (70-cm^3 cavity size) in extending the planting season into July and August. Regular nursery production stock was used for the tests. Stock lifted in May was cold-stored prior to planting in May, June, and July, while stock for August, September, and October was lifted just prior to planting. The age classes used for jack pine were 2-2, 3-0, 2-1, 2-0, and FH 408 paperpots and for white spruce were 2-2, 4-0, 3-0, 2-1, and FH 408 paperpots. The paperpots were planted with the paper sleeve in place.

Four replications (25 trees each) of each age class were planted each month from mid-May to mid-October. Survival, vigor, and height of each tree were recorded each fall until 1978.

Jack pine paperpot seedlings survived best in May, June, and July and had performance slightly below or comparable to the various classes of bare-root pine stock tested. August survival of paperpot seedlings was good (86%) compared to that of bare-root stock (29-57%), but performance was inadequate to justify August planting because of relatively poor height growth (16.7 cm vs. 20+ cm in May, June, and July). Late fall (October) paperpot and bare-root plantings gave poor performance, except for 2-1 stock.

White spruce paperpot seedlings showed May and June survival and performance comparable to the bare-root stock tested and July performance superior to all bare-root stock except 2-2 seedlings. Although survival of paperpot seedlings remained high from May through October (94-100%), August performance was inadequate because of poor growth (4.3 cm vs. 5.0+ cm in May, June, and July). Only 2-2 stock qualified for late fall (October) planting on the basis of performance rating.

According to the performance rating applied in these tests, the FH 408 paperpot is not suitable for extending the planting season into August and is not recommended for fall planting of either jack pine or white spruce in Saskatchewan.

Three-year survival, height growth, and performance rating of bare-root and FH 408 paperpot seedlings in Saskatchewan

	Performance rating[1]						Survival and height growth			
	Bare-root stock						Bare-root stock		FH 408 paperpot	
Month	2-2	3-0	2-1	2-0[2] or 4-0	Average	FH 408 paperpot	Average survival (%)	Average height growth (cm)	Survival (%)	Height growth (cm)
					Jack pine					
May	**2852**	**2909**	**3039**	**2940**	**2935**	**2614**	98	29.9	99	26.4
June	**2686**	**2860**	**2394**	**2159**	**2525**	**2580**	93	27.1	100	25.8
July	**2109**	**2156**	**2027**	34	1582	**2160**	68	23.2	100	21.6
August	429	884	918	806	759	1436	48	15.7	86	16.7
September	1645	1181	**1870**	1747	1611	1431	85	18.9	90	15.9
October	778	1474	**2074**	1378	1426	1004	74	19.2	62	16.2
Average	1750	**1911**	**2054**	1511	1806	**1871**	78	23.2	90	20.9
					White spruce					
May	**614**	**646**	**619**	**508**	**597**	**608**	91	6.6	98	6.2
June	**560**	**546**	**549**	**555**	**552**	**545**	93	5.9	94	5.8
July	**490**	423	414	466	448	**484**	95	4.7	95	5.1
August	**509**	328	292	289	354	404	83	4.3	94	4.3
September	**543**	**498**	**524**	**502**	**517**	441	95	5.4	98	4.5
October	**557**	392	479	344	443	400	93	4.8	100	4.0
Average	**546**	472	479	444	**485**	480	92	5.3	96	5.0

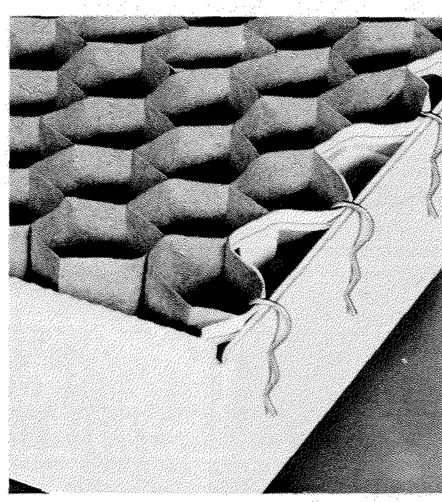
[1] Performance rating = survival (%) × average height growth (cm). Performance ratings higher than the a erage for all plantations (1819 for pine and 484 for spruce) were considered successful and appear in bold type.

[2] 2-0 for jack pine, 4-0 for white spruce.

In 1974 the Great Lakes Forest Research Centre, Canadian Forestry Service, undertook field testing in Ontario of white and black spruce seedlings grown in HF 308 paperpots (44-cm^3 cavity size). The paperpots were planted with the paper sleeve in place. Assessment of the survival and growth of seedlings was made at the time of planting and for three autumns after planting. There were 8 000 paperpot and 800 bare-root seedlings assessed on an individual basis in this test. Results are reported in the *Great Lakes Forest Research Centre, Forestry Research Newsletter,* fall-winter 1978.

Survival of spring-planted white and black spruce paperpot seedlings was 75-90% and 65-80% in 1974 and 1975, respectively; summer planting survival was 55-80% and 30-60% for those years. Survival of HF 308 paperpot-grown spruce seedlings was superior to that of bare-root stock planted in the spring but inferior to that of bare-root stock planted in the summer. Growth was superior for the paperpots, particularly with summer planting. Paperpots were not considered suitable for extending the spring planting season because of the relatively poor survival.

In spite of unacceptable summer performance to date, paperpot-grown seedlings have shown sufficient evidence of survival and growth capability to encourage further research into paperpot performance throughout the planting season on specific sites, under specific treatment regimes, and for wider ranges of size and weight of stock.



FH 408 paperpot.

There is still some concern among foresters and researchers that paperpot performance, especially on dry sites, is being inhibited by leaving the paper sleeve on when planting. The sleeve may reduce the plant's access to moisture and nutrients by acting as a barrier to moisture movement and lateral root growth.

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