THE COST OF RAISING AND PLANTING CONTAINERISED TREES IN CANADA1/

A.H. Vyse and D.E. Ketcheson 2/

Abstract.--Decisions on the widespread use and development of container reforestation systems in North America demand, at a minimum, an appreciation of the cost of such systems. Mini-container types have been used in Canada on an operational scale for several years and costs from Canadian container nurseries and planting operations are furnished to meet this demand. They are accompanied by the interpretations of the underlying cost factors and assessments of potential cost developments over the next five years. The usefulness of simple models for cost prediction is questioned on the grounds that an astonishingly wide variety of factors influence costs. Instead, the cost of an efficient and effective mini-container reforestation system, operating under Canadian conditions, is offered as a goal for reforestation workers and a yardstick for comparison with alternative systems. The significance of the mini-container cost estimate is drawn out by reference to the problems of reforestation planning and program implementation. At the tactical level of planning, mini-containers compare favourably with other regeneration techniques because of a low expected cost of achieving forest stands suitable for intensive timber production. At the strategic level the effects of mini-containers on the time from deforestation to reforestation, the degree of effort required to distribute plant material on the reforestation site, and the degree of control over the conditions under which the plant material develops, are suggested as being at least as important as total cost in reforestation decision making.

INTRODUCTION

More than a century ago people who used statistics to develop their arguments were sharply rebuked by a famous British politician. Disraeli remarked that "there are three kinds of lies: lies; damned lies; and statistics". This contemptuous aphorism is as valid today as it was then, and it is with some trepidation that we report on the cost of container reforestation systems in Canada. Reforestation costs like any other form of statistic are subject to unthinking abuse. It is quite common to hear foresters bandy about figures like $20 per thousand and $50 per acre without reference to the conditions under which those costs were incurred. It is pointless, for example, to compare the cost of planting trees by different methods without referring to the type of site on which each was used. Frequently this type of error is of little moment, but when important decisions are to be made, imprecise cost information can have unfortunate results. And with the concept of containerised tree seedlings poised at the "take-off" stage in North America, good cost data are needed to buttress the systematic analyses that will guide the concept's evolution from today's novelty to tomorrow's old stand-by.

We will attempt to meet this need in small part by answering the question what do small

1/Paper presented at North American Containerized Forest Tree Seedling Symposium, Denver, Colorado, August 26-29, 1974.

2/Alan H. Vyse, Research Forester, British Columbia Forest Service, Williams Lake, B.C.
Douglas E. Ketcheson, Economist, Great Lakes Forest Research Centre, Environment Canada, Sault Ste. Marie, Ontario.

volume3/, container reforestation systems cost in Canada? We hope to remove any suspicion that the costs have been massaged and manipulated unwittingly, or to support our biases, by explaining why the costs are at their present levels, and by estimating how those levels may change in the next decade. But we are unwilling to leave the costs to speak for themselves, and we conclude by speculating on their significance for reforestation planning.

Canadian Costs.--Of the six types of mini-containers that have been tested in nursery and field (Cayford 1972) only three are now being used on a reasonably large scale: Styroblock '2'; Spencer Lemaire Book Planter (Ferdinand); Ontario tubeling 3/4". The Styroblock reforestation system has passed through an intensive development stage and now is being extended into operational use as a major support for British Columbia's expanding reforestation program. And while the Book Planter is still in the development stage, the Ontario tubeling was employed on a wide scale in its native province and in Alberta during the late sixties, but has now fallen into disfavour. All three provide most of our cost data. The remaining container types--Paperpot, Bullet and RCA peat sausage--are increasing in use, on the way down, and almost out, respectively. They receive only passing attention.

Table 1 presents a sampling of the recorded costs of growing and planting mini-containers in Canada since 1971. Like the snapshots taken by a favourite Aunt the costs are slightly askew, a trifle blurred, and underexposed. The nursery costs require a great deal of interpretation and explanation because development work on container nurseries is still proceeding and the people who run the nurseries are still learning how to grow trees in containers. The planting costs are also less than informative because of the incredibly wide variety of conditions under which work can take place. Consequently, the following sections delve into the factors behind the costs in an effort to produce a final cost portrait that corrects the faults of the original snapshot.

Nursery Operations.--The Canadian experiments in container growing have resulted in a wide range of costs, expressed as cost

3/Less than 100 cc or 6 cu. in. of rooting volume. Larger volume containers have not been used at operational scale.

Table 1.--Recorded costs of growing and planting mini-container seedlings in Canada.

Container type	Nursery phase						Planting phase
	Nursery location	Facilities	Year	Stock age	Production of plantable seedlings	Operating cost	Cost range
					MM	$/M	$/M
Styroblock '2'	Surrey, B.C.	germinator shadehouse	1971-72	½-0 +1-0	5.6	27.80	
"	"	"	1972-73	"	2.1	50.40	25-50
"	"	"	1973-74	"	4.8	26.33	
Tubeling 9/16"	Swastika, Ont.	greenhouse	1971	½-0	1.6	13.50	15-35
"			1971-72	1-0	1.3	22.00	
Tubeling 3/4"	"	"	1973	½-0	1.0	22.60	20-40
			1973-74	1-0	0.8	47.00	
Spencer-Lemaire "Ferdinand" book planter	Hinton, Alta.	greenhouse	1973	½-0	2.4	21.70	not available
"	Oliver, Alta.	"	1973	½-0	3.6	27.50	not available

per unit of plantable seedlings produced. A number of factors are responsible for this variation, not the least of which are regional differences in climate and wage rates. But underlying this variation there is a cost structure common to all container nurseries. In industrial engineering terms, the operations for the most part are based on 'batch' processing rather than 'continuous' processing. In the container nursery the basic growing unit is a batch of from 100 to 500 individual containers, encased in a solid block (styroblock) or held by trays (other container types). All the present operations treat this collection of containers as one, with the exception of the styroblock packaging operations. As a consequence the cost structure of a container nursery can be described by the following, extremely simple, equation:

$$\text{cost per unit of plantable seedlings} = \frac{\text{cost of operations per batch}}{\text{no. of cavities in block} \times \text{percent recovery of plantable seedlings per block (crop \%)}}$$

At this point, simplicity disappears, and the easiest way of unravelling the complex of interdependent factors that influence the three variables of our equation is by the use of examples. Table 2 serves this purpose, and the following sections discuss the cost categories and factors displayed there in detail.

Containers .--Most of the small volume containers used in Canada show surprisingly little variation in their unit cost. This indeed may be one of the reasons so many have been tried in so short a period of time. The reason for the lack of variation, despite marked differences in materials and manufacturing processes, is that other factors reduce the impact of these differences. Thus the containers which are inexpensive to manufacture (e.g., tubes, book planters, paperpots) require accessories to keep them in solid form for loading, sowing and tending. Styroblocks, on the other hand, are more expensive to manufacture, but require no aids, and are reuseable. Bullets are the exception because of an expensive injection moulding process, a relatively high

Table 2--Annual operating costs for two Canadian mini-container nurseries

Cost Categories	Tubeling -Swastika Nursery				Styroblock '2' -Surrey Nursery	
	9/16"-1971		3/4"-1973		1971	
	Cost per thousand (M) tubelings or cavities sown					
	$/M	%	$/M	%	$/M	%
Container	2.38	21	3.25	20	7.54[1/]	47
Seed	.24	2	.18	1	--	--
Sowing	3.03	27	5.71	36	3.60	23
Tending	3.37	30	3.01	19	2.03	13
Supervision	1.02	9	1.23	8	1.09	7
Materials and Maintenance	.96	9	.85	5	1.72	11
Utilities	.18	2	1.77	11	--	--
Total	11.18	100	16.00	100	15.98	101
	Cost per thousand (M) seedlings recovered and shipped					
	Crop Recovery	Cost	Crop Recovery	Cost	Crop Recovery	Cost
	%	$/M	%	$/M	%	$/M
Packaging	--	--		--		4.95
½-0	83	13.47	72	22.22	70	22.83
1-0	51	21.92	34	47.05		
Total						27.78

[1/] Cost does not allow for reuse of block; average reuse rate of 2.0 plus recycling costs would reduce container cost by 40 percent.

plastic use (a point made more telling by the recent plastic shortages) and the need for returnable holding trays.

The relatively small differences in container costs are further reduced in significance when compared to the overall cost of container systems. And as Table 2 shows, the container cost differences can easily be obscured by other cost factors. Some part of this effect is due to the characteristics of the containers, and the best example is the bullet. Trials in British Columbia have shown that its rigid shape enables planting crews to increase their productivity on certain sites to a point where even a $10 per thousand cost difference between bullets and styroblocks would be nullified. In the case of styroblocks compared with tubelings, the regular spacing of cavities in the block has encouraged greater mechanization of loading and sowing operations so keeping operational costs down despite the higher B.C. labour rates.

One important feature of mini-containers that varies substantially in the range of types explored but which does not have any noticeable effect on operational costs, is spacing. The styroblock '2' for example has a spacing of 98 cavities per square foot, the 3/4 tubeling approx. 375 tubes per square foot. One might expect that a higher density of containers would reduce batch processing costs, and to a limited extent this is true. A recent design change in the Styroblock '2' increased the number of cavities per block from 192 to 240 by increasing density slightly (from 98 to 102 cavities per square foot) increasing the dimensions a little, and using waste space. This minor modification, if available in 1971, would have reduced the costs shown in Table 2 by 10 percent. However, tighter and tighter spacing tends to increase loading and sowing problems, and the reduction in available space for shoot growth may decrease the number of plantable seedlings produced from a batch. Spacing differences have a more substantial impact on capital costs, a topic which is dealt with in a later section.

Sowing.--The filling and sowing of containers has proved to be a major operating expense and logistical headache in Canadian nurseries. With current growing schedules, materials, equipment and labour all must be assembled to work for a short period of time in the early spring of each year. Most nurseries have had to rely on hand filling and sowing, and in some cases local people have contracted to do the jobs at home. In the large British Columbia nurseries, three machines are used to speed up and improve the filling of containers with soil mix, the distribution of seed, and the application of grit co the sown containers. As a result, the effect of high labour costs has been reduced by a relatively efficient production process. The similar but commercially available paperpot production line (Scarratt 1974) has the same effect.

Besides the actual cost of the sowing operation, the accuracy with which seeds are placed in the containers, combined with the viability of the seed, has a strong influence on the output of plantable seedlings and the overall production cost. Imperfect sowing procedures have reduced output of B.C. container nurseries by at least 10 percent (Vyse and Rudd 1974), and have increased tending costs because extra germinants are removed from each container. The Ontario tubeling nurseries suffer from thesame defects.

Tending.--This is not a major item--Our data tend to overemphasize this point because a substantial proportion of the supervision cost should be allocated to the tending category. Nutrition and watering are almost completely automated in the large container nurseries and the housekeeping jobs of weeding and thinning germinants account for most of the cost.

The important effect of tending on cost is indirect: thus it is not the cost of water use that is relevant but whether water was applied in the right amounts at the right time to produce seedlings of high quality and keep post germination mortality to a minimum The same point applies to nutrition and the application of insecticides or herbicides. Our example drives the point home with the disastrous effect of over wintering losses on tubeling costs. Good tending practices cost little more than poor practices but the cost of seedlings produced can be much less.

Shipping and Storage.--For all types of seedlings the shipping costs from nursery to planting site depend upon the distance travelled, the method of transportation and the number of transshipment points. Some differences emerge among container types because of the wide variation in seedling spacing and container dimensions but the fixed cost per unit of space is usually so low that they are not significant.

Most of the container seedlings are shipped in the containers in which they grew, but with styroblocks in British Columbia, all the stock is removed from the block and packaged. This is done for four reasons:

1) the seedlings are 'culled' before leaving the nursery and only the trees that meet minimum standards of size and vigour are planted.

2) the space occupied by seedlings in transit and in storage is much reduced, lowering costs, but more important reducing logistical problems associated with acquiring transportation and storage facilities.

3) seedlings can be cold stored thus introducing greater flexibility into the planning of planting programs.

4) reuse of styroblocks is greatly simplified and improved.

Thus, while costs are raised by adding a labour intensive operation which consumes expensive packaging materials, other cost categories are reduced and the potential success of the system improved.

Nursery overheads.--Every nursery requires administrative, supervisory and maintenance staff and supplies. In container nurseries the emphasis is more on maintenance than work organization, and the supervisors supervise plants more than people. But the staff require the same combination of mechanical talents and biological skills as they do in a bareroot nursery and their lack of either reflects on the nursery product in the same way.

In Table 2 the overhead costs are very low in each example. This leads us to suspect that some nursery overhead costs are 'hidden' in the costs of other sections of the parent forest management agency. For the styroblocks this is more than a suspicion because the sample nursery is on the same site as much larger bareroot nursery, and staff and facilities are shared.

Capital costs.--The capital investment required to start a large scale container nursery is substantial. Unfortunately, satisfactory recorded costs are not available so two estimates (Table 3), one for styroblock nursery in B.C. and the other for a paperpot nursery in Ontario must suffice. They indicate that prospective producers must be prepared to invest $15-$20 per thousand (capacity) in areas of favourable climate and $30-$50 per thousand (capacity) when temperature control through the use of greenhouses is crucial for successful growing. These costs can be depreciated over many years thus reducing the cost per M seedling produced in any one year to a cost of between $3 and $8/M. Nevertheless they do cause a large initial expenditure, which may have a significant effect on the plans of small private growers, and government departments operating with limited budgets. Any agency with skilled and ingenious workers can reduce these costs

Table 3.--Estimated capital costs for mini-container nurseries in Canada.

10 Million Capacity

	BC CFS Styroblock Nursery		308 Paperpot Nursery	
	Basic Outdoor Growing	Heated Greenhouse plus Shadehouse	Unheated Houses	Heated Houses
	dollars		dollars	
Growing	15,000	15,000	15,000	15,000
Faciltiy	60,000	355,000	192,000	320,000
Office Working Area	75,000	75,000	75,000	75,000
Equipment (5 year life)	35,000	35,000	35,000	35,000
Total	185,000	480,000	317,000	445,000
$ per M[1] (excluding land)	$3.10	$7.80	$5.16	$6.70

[1] Facilities, except equipment, are assumed to be fully capitalized in 10 years at 10 percent interest rate.

Sources: Anon (1973); N. Sjoberg, Forester, B.C. Forest Service, Reforestation Division, personal communication.

substantially by improvisation and by appropriating people and machinery nominally allocated other tasks. This has been done and indeed it may be desirable as a first stage before a commitment is made to a large scale nursery for the lessons learned from small facilities will be invaluable in designing large ones. However the costs shown in Table 3 will be unavoidable for large facilities.

Planting Operations.--Planting costs are influenced by many factors besides container type and size . A poorly organized crew, working slowly and inefficiently can make nonsense of any claim to lowered planting costs by the proponents of any container type. Differences in easily overlooked variables such as the number of hours worked by a crew in a day, or the spacing of trees can render comparisons of costs meaningless. Even when discussion is restricted to one container type, costs are influenced by the method of planting (Scarratt and Ketcheson 1974).

Unless planters are paid on a piece rate basis (e.g., 5 cents per tree) the cost of a day of planting is fixed by the number of hours worked plus any paid travel time, the wage rate, the cost of transportation, and the cost of supervision. Control of planting costs therefore is limited to control of the productivity of the planters. Productivity or output (number of trees planted) per unit of time has been found to be influenced by the following factors4/: site; planting method; planting quality; competancy of work force. To simplify our discussion of planting costs Table 4 presents information for two container types planted under several specified sets of conditions. The styroblock '2' and 4 1/2" (11.4 cm) bullet containers were chosen to demonstrate the range of labour productivity and cost due to differences in planting method. In general we can say that the hard plastic shell of the bullet increases productivity and decreases cost because 'thrust' planting can be used.

4/Results from a series of work studies of planting operations in British Columbia have been summarized in three unpublished reports to the Reforestation Division B.C. Forest Service: Vyse A.H. and G.A. Birchfield 1972. Labour Productivity of Planting Operations in B.C. Productivity Report #1 Victoria B.C. Pacific Forest Research Centre Canadian Forestry Service Vyse A.H. 1972. Performance standards for planting operations. Productivity Report #2 Victoria B.C. Pacific Forest Research Centre, Canadian Forestry Service. Vyse, A.H. and D, Wallinger. 1974. Planting performance studies Nelson Forest District 1973. Report #3. Victoria, B.C. Reforestation Division, B.C. Forest Service.

Table 4.--Comparison of planting costs for two mini-container types.

Planting conditions			Planting Methods1/					
			Styroblock '2' with Dibble			4½" Bullet with gun		
Planting site	Total crew cost2/	Spacing	Productivity3/	Cost per tree	Cost per acre	Productivity	Cost per tree	Cost per acre
	$/Planter	trees per acre	trees per man per day	$	$	trees per man per day	$	$
easy	40	400-600	1590	0.025	12.60	2860	0.014	7.00
"	50	"	"	0.031	15.70	"	0.017	8.70
difficult	"	"	1010	0.050	24.80	1810	0.28	13.80
easy	40	900-1100	1850	0.22	21.60	3760	0.011	10.60

1/We expect that paperpot and book planter costs will be comparable to styroblock '2' with dibble costs. Tubeling (3/4") costs will fall between the two examples.

2/Total crew cost includes cost of labour, supervisor and transportation.

3/Productivity rates are based on the actual performance of well organized and trained crews with good morale working an 8 hour day.

'Dibble' planting of containers such as the tubeling with a soft or open-bottomed plastic shell is not as rapid as thrust planting because the planter has to perform two or three additional actions each time a tree is planted. However, the plastic shell does aid handling, and planting rates are faster than if seedlings are dibbled into the ground after removal from the container (e.g., styroblock, book planter).

Potential Cost Developments

Surprise developments are always possible but there is a great deal of room for forecasts ranging from projections of trends already evident to outlandish speculation. Our forecasts are based primarily on information gleaned from colleagues and bear the hallmark of caution. Nevertheless, the developments that are underway do not lack in interest or importance.

Overriding all container system developments is the current, seemingly uncontrollable, economic phenomenon of general inflation. Labour and material costs are rising steadily at rates of between 5 and 15 percent per year. The costs quoted in earlier sections can be expected to keep pace, if cost conditions stay the same. We see no reason to suppose that one container type will suffer disproportionately from general inflation. However it is possible that the recent leap in plastic prices will hold and force up long term plastic container costs relative to containers made from other materials.

Several improvements in the efficiency of container nursery and planting operations seem likely to offset inflationary trends in the short-and mid-term future. Among them are efforts: 1) to increase seedling crop recovery in nursery stage; 2) to mechanize sowing and packaging operations; 3) to increase use of growing facilities; 4) to mechanize planting operations.

One more revolutionary development underway seeks to eliminate the nursery phase altogether. The research effort is attempting5/ 5) to develop containers for direct seeding.

Increasing seedling crop recovery.--Between the sowing operation and the shipping of container stock, many events can reduce the crop recovery from the maximum 100 percent. Recovery rates of between 50 and 80 percent at Canadian container nurseries are evidence that the events are real and their cost is evident in Table 2. Inadequate sowing rules, low seed viability, and poor tending techniques increase the number of container cavities without potential seedlings, and germinant and seedling mortality.

In a study of current British Columbia sowing operations Vyse and Rudd (1974) suggested rules for keeping the germinant recovery rate at 90 percent or higher with existing equipment. Improved sowing machinery and seed sorting devices will make the improvement in germinant recovery rate more probable As nursery staff gain greater experience in cultural techniques, germinant and seedling mortality should be kept well within 10 percent and overall recovery above 80 percent. Another, complementary, approach to improving recovery rates is to replace blank container cavities, and mortality, with spare germinants grown in containers that can be inserted into the original container.

The effect of these improvements on nursery costs will be considerable. Reductions of from 10 to 20 percent in 1973 costs are possible almost immediately with the prospect of further but smaller reductions as better equipment and replacement containers are developed.

Mechanizing sowing and packaging operations.--Increased automation in both operations holds some hope for reducing costs. They induce surges in the demand for nursery labour and increased mechanization would substitute capital investment for labour. This in itself could reduce costs, but more likely cost savings would arise from the increased productivity of the remaining, more stable work force.

Increased use of growing facilities.--When expensive greenhouse facilities are required for reasons of seedling quality and flexibility in crop production (i.e., avoiding long growing periods), capital costs per unit of output can be reduced by intensifying facility use. The Reforestation Division, B.C. Forest Service has developed complex schedules for raising 3 crops of 3 species over periods of from 6 to 18 months in heated greenhouses and shadehouses-6/. The biological feasibility of these schedules has yet to be tested, but the potential cost advantages are clear.

Mechanizing planting operations.--Mechanized planters for use on flat and rolling farmlands have been available for decades but it is only recently that major efforts have begun to replace hand planting on the majority of cut-over lands. Containers offer some hope of simplifying the mechanization problem and

5/J. Walters, personal communication.

6/N. Sjoberg, Forester, Reforestation Division B.C. Forest Service personal communication 1974.

speeding its solution. This contribution may be sorely needed because studies by Backstrom and Wahlqvist (1973) have shown that mechanized planting will have to be done 3 rows at a time and at rapid speed to compete with the best manual planting. The prime contribution of mechanized planting may well be to relieve situations where the cost of manual planting is unavoidably high because of labour supply problems.

Containers for direct seeding.--The potential of direct seeding in reforestation has long been recognized. However problems associated with the lack of control over seed distribution and environmental conditions during germination have left the technique 'on the shelf' in Canada, and severely reduced its use in the United States. As with the case of mechanized planting, the concept of containerization offer some hope for resolving the outstanding problems. Encapsulated or containerized seed is already available in several forms and according to Mann and Taylor (1969). The presence of the capsule would greatly aid control of seed distribution. Nevertheless the lack of control over subsequent germination has delayed the use of capsules. In response to this situation Walter 5/ is presently developing a miniature bullet to enclose a single viable seed for distribution control, in conjunction with a seed treatment to speed germination immediately the container reaches the ground.

The cost advantages of aerial distribution, the elimination of nursery operations and the greatly increased flexibility of reforestation planning are attractive. We suggest that they are sufficiently high to warrant further investigation despite the problems that lie between the concept and implementation.

A final cost portrait-1975.--From the standpoint of a 'customer' considering a move into mini-containers on a large scale, a simple model for cost prediction would be highly desirable. Coefficients would be multiplied by the appropriate values of two or possibly three variables and a reliable total cost figure would make its welcome appearance. Unfortunately a cost portrait of simple abstract design is not possible. The Canadian cost records we examined produced a picture that was blurred by variations of over 100 percent, and subsequent investigations revealed an astonishingly large number of significant cost variables. To produce order from chaos, therefore, we have had to resort to the school of 'magic realism' for our final portrait.

Table 5 displays standard cost for a large scale mini-container operation in 1975. The standard cost is real in that it is obtainable, but it could be considered magical (especially by harried administrators of reforestation programs) because it assumes an efficient operation. This is in direct contradiction to Murphy's law--if anything can go wrong, it will. One of the reasons this aphorism is so applicable to a mini-container reforestation operation is that 'people' are so crucial to its success. Poor nursery practices can drastically reduce the proportion of plantable seedlings recovered and in the planting phase the crew foreman exn-rts a marked influence on the work rate of his planters. The cost standard is therefore built on the twin assumptions of competent staff and good working conditions. It also assumes a minimal facility for growing seedlings because the more sophisticated the environmental controls, the more likely a single human or mechanical error can have disastrous results.

The standard should serve as a target or goal for reforestation workers in Canada as they strive to improve the efficiency of their operations and the quality of their product. It is also useful as a yardstick of reasonably accurate length against which other reforestation systems can be measured.

Table 5.--A standard cost for large-scale mini-container reforestation operations in Canada-1975

Cost category	Cost per M potential seedlings	Cost per M seedlings	Cost per acre	Remarks
	$	$	$	
Nursery phase:				
Operating costs	15			Labour cost = 50%
Capital charge	4			Minimal facilities
Subtotal	19	22		Crop recovery = 85%
Packaging, transportation and storage phase:		5		Trade-off between packaging to reduce volume and other costs in large-scale operation
Planting phase:		40		1250 trees per man per day. Crew cost $50 per day
Total		67	47	700 trees per acre

THE SIGNIFICANCE OF MINI-CONTAINER COSTS

We began this paper by intimating that good cost data are needed in the process of converting containerized reforestation systems from a concept on trial to a fully fledged part of reforestation operations. Having tried to satisfy this need some comments on the significance of the costs are in order. Reforestation planning can be broken into two major segments. Using military parlance, there is the essentially short term 'tactical' view of choosing a reforestation method to fit a unique field situation, and there is the longer term 'strategic' view of planning the provincial, state or regional reforestation program for the next five or ten years.

In the first field planning situation cost is important because it forms one half of the decision-making equation which balances resources expended against achievements. We look for the reforestation method that will yield the greatest net benefit in a given situation. However this process is more easily described than applied. There are problems of cost estimation, some of which we have already exposed, and of benefit estimation. The benefit measures proposed by economists are too ponderous for practical use (usually some form of discounted value of future wood yield) but the popular alternative of survival percent some time after planting has more serious limitations. Sadly, the use of survival borders on the ridiculous when minor differences are exaggerated out of all proportion to their effect on the future development and value of the reforested area. A clearer picture of the tactical significance of costs is obtained if the concept of satisfactory restocking is used to measure reforestation success. With some modification this concept fits the whole range of possible objectives a forest manager can have in mind for a particular reforestation job. The desired stand conditions at a selected point in stand development and the expected cost of reaching those conditions are combined to form a decision criterion (Vyse 1974).

When the stand objective criterion is applied to the use of mini-container reforestation methods, how do they fare in comparison to other methods? At the risk of generalizing when site by site case studies would be preferable, we can say that the use of mini-containers would produce superior results on a wide range of Canadian sites. Matched against the bareroot system our investigations indicate that the total system cost is lower primarily because of savings in the planting phase. There is no evidence to suggest that site preparation costs would be higher for mini-container operations and so the total regeneration cost forecast is lower. The rosy picture is completed by reports from field performance trials which suggest that stand development is only marginally improved, if at all, when high quality nursery stock is used. Matched against conventional direct seeding or natural regeneration, the reduced cost of using nursery stock simply increases an already marked superiority when intensive timber production is planned.

The field planning situation is only a part of the broader strategic planning that is required for the successful execution of reforestation program. At this level of planning, questions of seed supply, staff training, the relationship of regeneration practices to other forestry practices and many others tend to envelope hard field decisions based on cost and stand objectives with a filmy veil of uncertainties. Indeed, about the only satisfactory way of introducing neophytes to the intricacies of high level reforestation planning would be to devise a training game patterned after a combination of the fire simulators used to train fire control specialists, military war games, and the more complicated modern parlour games. Trainees could then attempt to develop strategies for coping with the multitude of stand objectives and the many ways in which they can be met, sudden surges in the demand for reforestation efforts, and the uncomfortable reality of changing weather conditions. In doing so three attributes of mini-container reforestation systems are sure to catch the eye:

1) increased level of control over the development of plant material from seed to an element of the future stand, thus increasing the probability of reaching any given stand objective.
2) reduced length of time from deforestation to reforestation, thus increasing flexibility or the ability to respond to new situations.
3) reduced effort in terms of manpower required to distribute plant material at the reforestation site by increasing labour productivity and easing the task of mechanizing planting.

While each of these improvements influence system costs they are more important than the one dimensional measure of cost in the context of strategic planning. Combined with significant effect of mini-container costs on the site by site choice of reforestation method they assume that the container revolution in reforestation has only just begun.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance provided by staff of the British

Columbia Forest Service, Ontario Ministry of Natural Resources, Alberta Department of Lands and Forests, Northwestern Pulp and Power Limited and Nova Scotia Forest Industries Limited who provided cost data for the paper. We also wish to thank our former and present colleagues at the Pacific Forest Research Centre and the Great Lakes Forest Research Centre who made this paper possible.

LITERATURE CITATIONS

Anon
1973. Analysis of nursery production and distribution systems. Phase II. Toronto, Ontario: Management Services Division, Project #258, Treasury Board, Government of Ontario.

Backstrom, P-0 and A. Wahlqvist
1973. Systems analyses of artificial regeneration. Stockholm, Sweden: Logging Research Foundation, Report No. lE.

Cayford, J.H.
1972. Container planting systems in Canada. Forestry Chronicle 48:235-239.

Mann, W.F., Jr. and H.T. Taylor, Jr.
1969. Aerial row seeding possible. J. of Forestry 67:814-815.

Scarratt, J.B. and D.E. Ketcheson
1974. Japanese paperpots for containerized planting of tree seedlings. II. Preliminary evaluation of planting tools. Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-204.

Vyse, A.H.
1974. The economics of direct seeding: a comparison with other regeneration techniques. Direct Seeding Symposium. Timmins, Ontario, Sept. 11-13, 1973. Dept. Environ., Can. For. Serv. Publ. No. 1339. Ottawa, 1973.

Vyse, A.E. and J.D. Rudd
1974. Sowing rules for container nurseries. p. 164-169, In worth Am. Containerized For. Tree Seedling Symp. Proc. Great Plains Agric. Publ. 68.

Question: Did you say that bare-root seedlings of the same height and diameter should be compared with the container stock used? Why not plant more but smaller container seedlings to get equal numbers of survivors at age 5?

Ketcheson: It may be better to plant more container than bare-root seedlings, or it may not. I am a hit concerned that we have concentrated so much on gadgetry at this meeting. We must stop hiding behind gadgetry, because it confuses the issues. Instead, we should ask what kind of stand do we want and how do we get there. You can't talk about surviving seedlings or sowing cost until you know what the resulting stand is worth, what you are going to do with that stand, and how it is going to serve you. Then you can start talking about rational costs of reforestation and merits of different reforestation systems.