Tree Planter's Notes, Volume 42, No. 3 (1991)

Economics of Mechanical Bulk Lifting at an Ontario Bareroot Tree Nursery

Gerald Racey and Alan M. Wiensczyk

Integrated resource management specialist and special projects forester, Northwestern Ontario Forest Technology Development Unit, Ontario Ministry of Natural Resources, Thunder Bay, ON

Mechanical bulk lifting at the Thunder Bay Forest Tree Nursery in 1990 was a cost-effective alternative to manual lifting, sorting, and packaging black spruce (Picea mariana (Mill.) B.S.P.) seedlings. The mechanical bulk lift produced cost savings of approximately $15.38 per thousand (in Canadian dollars), representing a savings of approximately 29% relative to conventional lifting costs. The capital cost of the harvester was not included in the cost analysis. Nursery cultural practices, procedures for handling cull seedlings, and approach to handling seedlings at the planting site may have to be modified to accommodate mechanical bulk harvesting. Tree Planters' Notes 42(3):13-15; 1991.

Bulk lifting refers to harvesting seedlings or transplants from nursery beds and packaging them directly into containers for shipment to the planting site without sorting, culling, counting, or bundling. This system reduces both the number of personnel required and the amount of seedling handling, which in turn reduces the risk of seedling damage (Trewin 1976) and lifting costs at the nursery.

In a conventional seedling harvest at an Ontario bareroot tree nursery, seedlings are first undercut by an Egedal lifting blade. Workers follow the machine, cull inferior seedlings, and bundle shippable seedlings in groups of 10 or 25. The bundles of seedlings are packaged into containers and placed in cold or frozen storage until they are shipped to the field for planting. This conventional lifting procedure is labor intensive, often involving over 200 workers, and has a high variable cost but low capital cost. Daily production levels at the Thunder Bay Forest Nursery during the 1990 spring and fall conventional lifts averaged 550,000 and 767,000 seedlings, which translates to 735 and 788 seedlings per worker per hour.

In mechanical bulk lifting, the counter-rotating lifting heads (figure 1) grip the seedlings near the root collar and remove them from the ground. The seedlings are separated and soil is removed from the roots by machine action. The seedlings are manually removed from the belt and packed in polyethylene-lined boxes, which are later sealed and transported to the cooler. This process requires approximately 8 to 12 workers, resulting in lower variable costs. Bulk harvesting at another Ontario nursery lifted an average of 180,000 seedlings during a 7.67-h day by a crew of 10 (Cameron 1988). This is equivalent to 2,347 seedlings/worker/h.

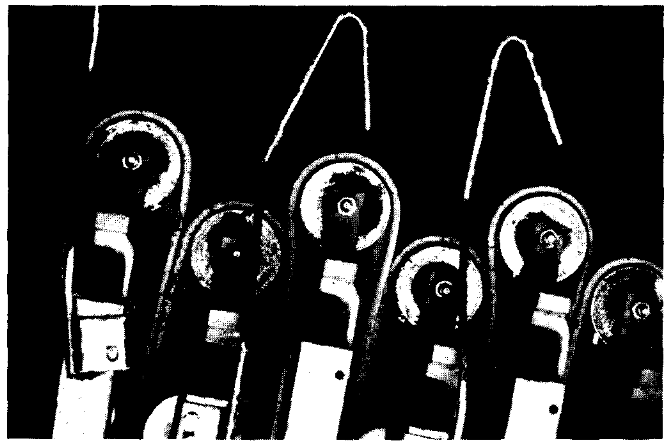
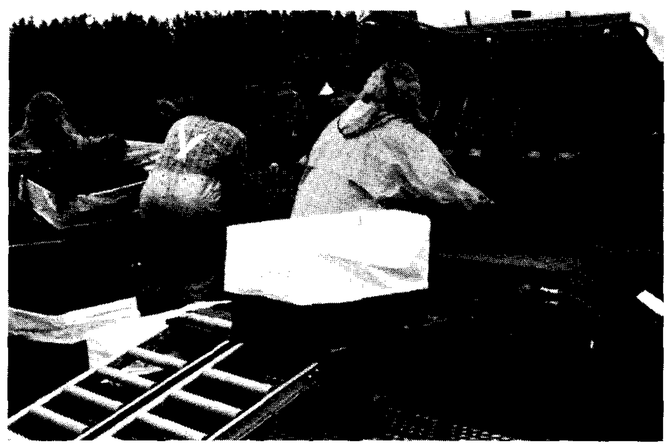


Figure 1—*Hovey eight-row mechanical belt seedling harvester in use at the Thunder Bay Forest Nursery in the fall of 1990. Note the counter-rotating belts on the lifting heads (**top**) and the positioning of the lifting crew (**bottom**).*



This note summarizes the economic analysis of bulk lifting during the first operational trial of the mechanical bulk lifter at the Thunder Bay Forest

Nursery. Full details of the trial are described elsewhere (Wiensczyk 1991).

Materials and Methods

Mechanical bulk lifting at the Thunder Bay Forest Nursery was conducted on black spruce (*Picea mariana* (Mill.) B.S.P.) techniculture (Klappratt 1990) transplant beds during the 1990 spring and fall seedling lifts using a Hovey 8-row mechanical belt seedling harvester. Techniculture transplants are produced in 5.7 cm^3 peat and polymer plugs and tend to produce uniform seedlings with compact root systems after transplanting into nursery beds. A total of 13,000 transplants were mechanically bulk-lifted in the spring and 177,648 in the fall using the bulk lifting approach.

Lift productivity for the mechanical bulk lift was determined by counting the number of full boxes of transplants harvested over known lengths of nursery bed and time periods. An estimate of the number of trees that could have been lifted during the spring trial, in the absence of mechanical breakdowns, was based on the total length of time the machine was in operation and the number of trees lifted during measured five minute intervals (table 1).

Table 1—*Cost comparison of 1990 spring and fall conventional seedling harvests and mechanical bulk lifting at the Thunder Bay Forest Nursery*

	Total no. seedlings	Total cost to Nursery	Cost/1,000 seedlings
Conventional lifting			
Spring	8,156,119	$431,481	$ 52.91
Fall	7,310,760	$384,442	$ 52.59
Bulk lifting			
Spring	13,000	$ 5,402	$415.55
Spring*	144,000	$ 6,318	$ 43.88
Fall	177,648	$ 6,611	$ 37.21

*Estimate based on potential productivity without equipment breakdowns; costs are given in Canadian dollars.

The numbers of contract and nursery employees involved in the bulk lift were recorded as were the numbers and types of equipment used.

Lift productivity for the conventional lift was determined by counting the number of boxes of seedlings as they were placed into cold storage at the nursery. The total numbers of lifters, packers, and support staff as well as the total time worked were recorded.

Boxes of bulk-lifted seedlings were selected and marked at random for seedling counts and cull assessment. Harvested trees were assessed for cull using the same Ontario standards as used for the conventional lift. Trees were considered cull if height was less than 15 cm, root collar diameter was less than 2.6 mm, roots were malformed, or the seedlings had been physically damaged. Boxes of seedlings were weighed before they were assessed. The empty box was also weighed to determine the amount of soil remaining in the boxes after trees were removed.

Results

The cost to the nursery of the spring and fall conventional and mechanical bulk lifts are summarized in table 1. The cost per thousand was similar for the spring and fall conventional lifts with a difference of $0.32/1,000 (Canadian dollars).

Only 13,000 of the intended 100,000 trees were lifted in the spring because of mechanical problems with the harvester. Estimates of productivity, based on the number of seedlings lifted during measured 5-min operating intervals, showed that 144,000 trees could have been lifted in the same time period had no breakdowns occurred. These estimates were used primarily to corroborate the results of the fall lift.

During the fall bulk lift, the mechanical harvester operated for a total of 11.75 h. In the 11.75 h that the harvester was in operation, 931 boxes containing an estimated 177V648 trees were harvested (table 1). An additional 5.2 h were lost to mechanical breakdowns (29.9% down time) and 0.45 h were lost to coffee breaks. This equates to approximately 1,000 seedlings/worker/h.

Two assumptions were made in estimating the cost of the bulk lift: that the mechanical harvest was a separate operation and there would be no crossover of employees or equipment to the manual lift should a mechanical breakdown occur, and that employees would be paid during equipment down time. The total payable time for the fall bulk lift was therefore 17.4 h. This figure was used in the cost analysis.

The cost saving for the fall bulk lift was estimated to be $15.38/1,000 seedlings, which represents 29% of the cost of the fall conventional lift. Assuming the nursery lifted 50% of its stock production target (7.5 million seedlings) using the mechanical bulk harvester, an annual cost savings of almost $119,000 could be attained. Note that the capital cost of the harvester (approx. $65,000) was not included in this cost analysis. The capital cost of the mechanical harvester was not included in the total costs because it will vary substantially with the number of machines purchased, the financing arrangements, and the extent of modification required to get the machines operational. In addition, it is not known how long the machines will last under normal use before replacement or a major refit is necessary. Capital costs were also not included for the conventional lift.

Nursery soil was not adequately removed from the roots of the mechanically bulk-lifted seedlings prior to packaging. The boxes weighed significantly more than boxes of conventionally lifted stock. The average weights of mechanically bulk-lifted seedlings from two compartments were 27 kg and 36 kg, compared to 19 kg average box weight from a stock lot harvested by conventional lifting despite a greater number of trees per box from the conventional lift. Excessive soil means fewer seedlings per box and increased shipping costs. Heavier box weights may also increase the risk of work-related back injuries, risk of boxes being crushed while in transport, and increased incidence of disease outbreak on packaged seedlings. In addition, it was estimated that approximately 14 tons of fertile nursery topsoil were shipped to the field in the boxes of bulk-lifted stock. Modifications to the soil removal system on the mechanical bulk harvester are planned to help alleviate this problem.

Discussion

One of the drawbacks of bulk harvesting is that harvest and shipping estimates are only as accurate as the nursery bed inventory, which is usually determined within ± 5 percent. In addition, the variability in the number of seedlings per box can be expected to vary with the stock lot, the average size of the seedlings, and the size variability of the trees harvested. Area-based planting (Guthrie 1990) may be necessary to enable the field to accommodate bulk-lifted stock and the inherent variability in shipping inventory (Wiensczyk 1991).

Based on the productivity figures for the fall bulk lift, up to 6 additional mechanical harvesters and 84 workers would be needed to harvest the 7 million seedlings lifted in the same time period as the conventional fall harvest, assuming no major mechanical breakdowns. It is fair to assume that productivity will increase as workers become more familiar with the equipment, or as the mechanical bulk-lifting process is streamlined as a result of increased experience with the process.

The cost of lifting seedlings using the mechanical harvester is dependent on machine efficiency. Several factors, including seedling density in the nursery beds, time of day, and mechanical breakdowns, were all found to affect harvester productivity (Wiensczyk 1991). Productivity increased as the day progressed.

The techniculture transplant system is particularly well suited to mechanical bulk lifting because the uniform seedlings with a compact root system minimize the need for culling or root pruning. Cull levels of the mechanically bulk-lifted stock averaged 8%. Less than one-third of the cull was the result of physical abnormalities or damage attributable to the mechanical bulk harvester. Boxes of conventionally lifted stock may contain up to approximately 5% cull seedlings, even after sorting and grading. Cull levels of the bulk-lifted stock could be significantly reduced if undersized seedlings were removed during hand weeding operations. Alternatively, cull levels and variation in the number of trees per box would be expected to be higher if lifted from less uniform seedling or transplant beds. High cull levels (>10%) may render mechanical bulk lifting impractical.

Conclusions

From this trial the following conclusions can be made:

- Mechanical bulk lifting provides a significant cost savings over conventional harvesting (capital costs not included).
- Mechanical bulk lifting requires uniform stock with low cull levels to be effective.
- Operational shipping and planting procedures that require precise estimates of the number of trees per container may need to be modified to accommodate bulk-lifted stock.

Literature Cited

Cameron, D.A. 1988. Bulk lift harvester trial at Swastika Tree Nursery. Swastika, ON: Ontario Ministry of Natural Resources. 30 p.

Guthrie, B. 1990. Introducing area base contract planting in northern Ontario: a review of the report by Dirk Brinkman,

Loki Reforestation Ltd. Sault Ste. Marie, ON: Ontario Ministry of Natural Resources. 17 p.

Klappratt, R. A. 1990. The production of greenhouse transplants in mini-cells at the Thunder Bay Forest Nursery. In: Proceedings, 1990. Northeastern Nurserymen's Conference: Seedling production in Quebec, Bareroot versus container seedlings. Montreal. 1990 July 23-26. 184 pp.

Trewin, A.R.D. 1976. An integrated system for the mechanical harvesting of pine seedlings. Rotorua, NZ: New Zealand Forestry Research Institute. What's New in Forest Research 42. 4 pp.

Wiensczyk, A. 1991. A cost analysis of the combined bulk lift area base plant system. Tech. Rep. 62. Thunder Bay, ON: Ontario Ministry of Natural Resources, Northwestern Ontario Forest Technology Development Unit. 100 p.