TRIALS OF MECHANICAL COLLECTION OF BLACK SPRUCE AND JACK PINE CONES

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The trials were carried out in the Iroquois Falls Division of the Abitibi Paper Company Limited, and living accommodation for the personnel was provided by the Company. Seed was extracted from most of the cones at the tree seed plant of the Ontario Department of Lands and Forests at Angus. Other seed samples were extracted and tested by the Petawawa Forest Experiment Station of the Department of Forestry and Rural Development. This assistance was vital to the success of the project and is gratefully acknowledged.

Frontispiece *General view of first prototype machine (truck-mounted) showing cone-bearing tops being fed into trough at upper left.*

ABSTRACT

In 1967 and 1968, time-production trials were carried out to compare the relative efficiency of mechanical and hand collection of black spruce and jack pine cones. Comparisons were also made between the yield and viability of seed obtained from machine-collected and hand-picked cones. For both species, the rate of cone collection by machine was considerably faster than by hand, but the yield of seed per bushel of cones was somewhat lower. In both years, the calculated cost of black spruce seed obtained from machine-collected cones was less than that of hand-picked cones. For jack pine this was true only in 1967. For both species and in both years, the germination levels were similar for seed collected by both methods. These results suggest that mechanical collection of black spruce and jack pine cones is feasible, and may reduce the cost of seed required for reforestation purposes.

INTRODUCTION

Reforestation activity is increasing rapidly throughout Canada. In 1967, for example, the Ontario Department of Lands and Forests planted or seeded about 85,000 acres; and within a few years the annual rate of artificial regeneration is expected to reach 150,000 acres (MacKinnon, 1968). At present, Ontario's reforestation program requires the collection and processing of about 20,000 bushels of cones per year, and no doubt this requirement will increase as the program expands. Because the collection of seed represents a significant portion of the total effort and cost of reforestation, promising methods of increasing the efficiency of seed collection are being investigated.

Recent work has shown that black spruce cones up to 5 years of age contain viable seed (Vincent, 1966). Jack and lodgepole pines also have cones that retain seed. This suggests that by collecting older cones (as well as those of the current year) it might be possible to reduce seed collection costs for these species. A satisfactory yield of seed from older cones would permit collecting at almost any time of year and would reduce dependence on good seed years. Extending cone collection to the older age classes appears particularly attractive if it can be done mechanically, because the speed of machine collection might offset the lower yield of viable seed from older cones. Mechanical collection might also be feasible for species with non-serotinous cones, but of course for these species, collection would have to take place at the time of cone ripening in a good seed year. Perhaps the most important point in favour of mechanization is that it would reduce dependence on the large and uncertain labour supply normally required for hand picking.

In view of the potential advantages of mechanical cone collection, a contract was negotiated in 1967 with Horton Forestry Services Limited, Stouffville, Ontario, for the design, construction, and testing of a machine to separate cones of black spruce and jack pine from slash. A second contract was arranged for a series of operational trials to compare the efficiency of collecting cones by hand and by machine. On the basis of the results achieved in 1967, further trials were carried out in 1968 with a second machine developed by the same contractor. This report describes the work carried out in both years, and summarizes the results obtained.

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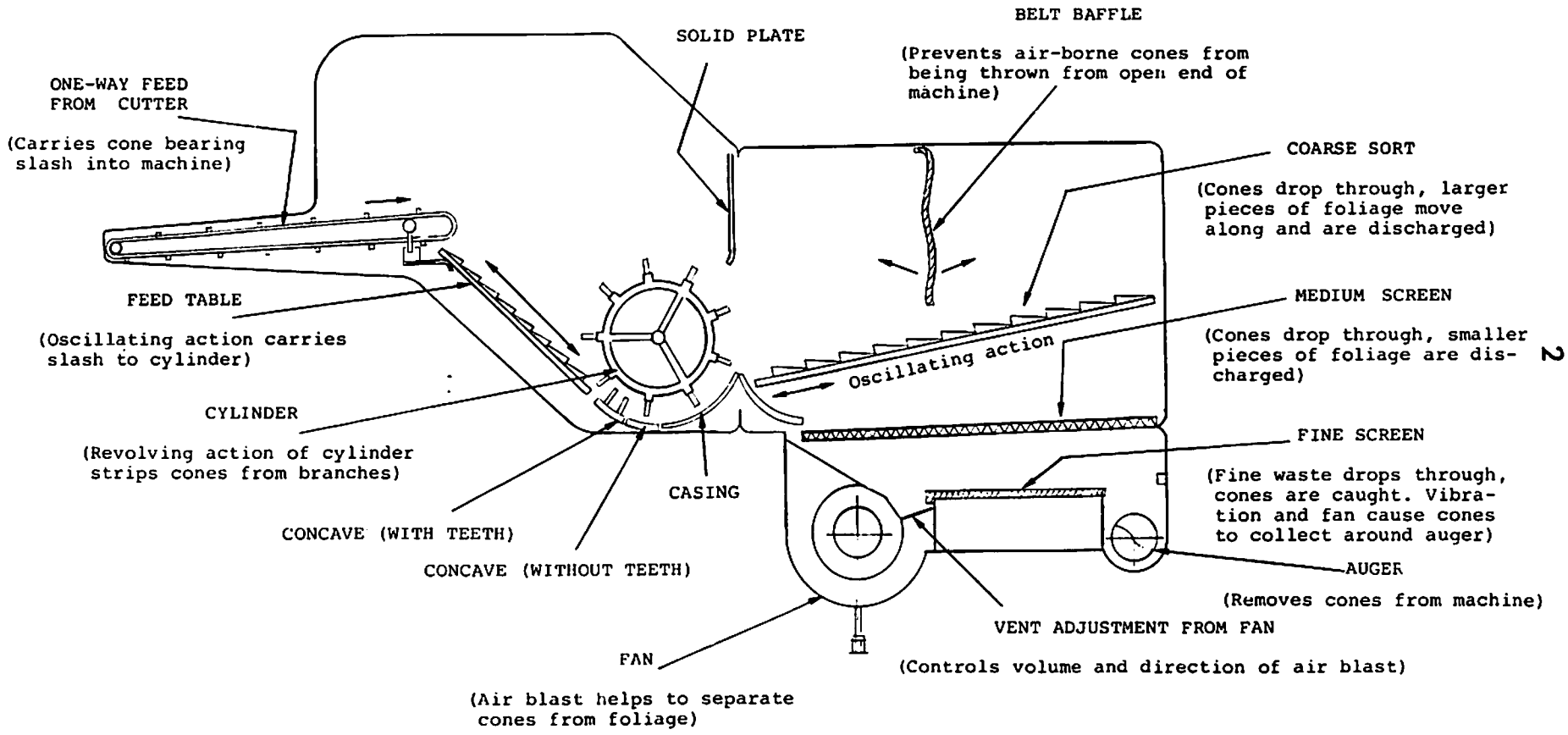
Fig. 1 Schematic Cross-Section View of First Prototype Machine Tested in Trials of Mechanical Cone Collection, Iroquois Falls, 1967-68.



METHODS

Both black spruce and jack pine cones are normally picked from fresh slash resulting from recent logging operations. Picking takes place in early fall, and is limited to cones ripening in the current year, although collections from jack pine usually contain a substantial proportion of older cones. These points were taken into consideration in planning the current trials.

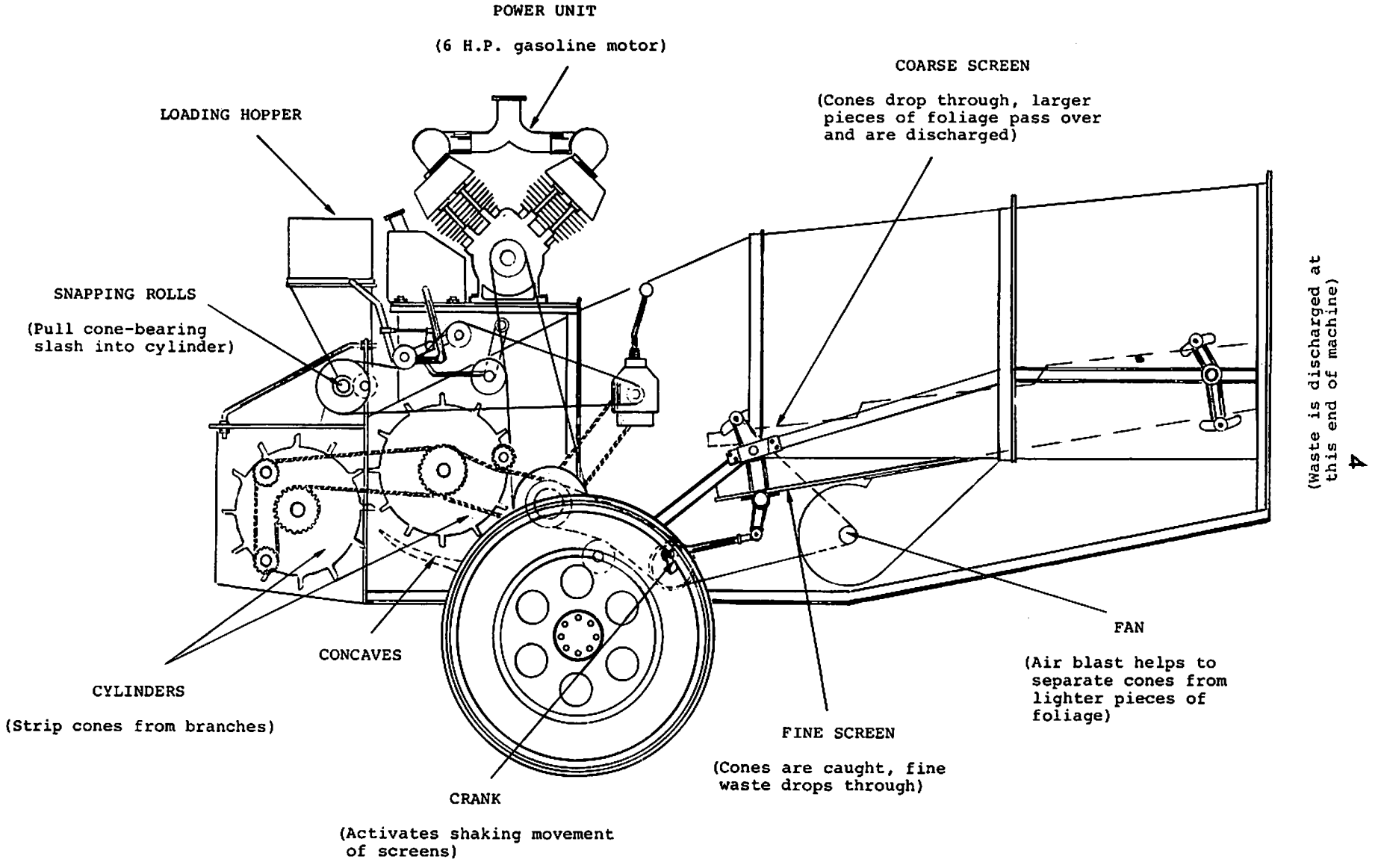
By September 1967, the contractor succeeded in developing a prototype, operating on the principle of a thrashing machine and powered by the motor of the 1-ton truck on which it was mounted (Frontispiece, Fig. 1). Suitable slash conditions were located in the Iroquois Falls Division of the Abitibi Paper Company Limited, and with the cooperation of the Company, arrangements were made to carry out the trials.

In September 1968, similar arrangements were made for the testing of a second prototype developed by the contractor (Fig. 2, 3) and the following description of methods is applicable to the trials carried out in both years.

In each hand-collecting trial, from 1 to 5 bushels of cones were collected and the man-hours required to pick them were recorded. The data from the individual trials were then pooled to produce averages for each species and year. In 1967, a heavy seed year for black spruce, picking was confined to current cones only (Fig. 4). However, as there was virtually no black spruce cone crop in 1968, the bulk of the cones collected that year belonged to the previous year's crop (Fig. 5). There appeared to be no great variation in the jack pine cone crops, and in both years cones up to about 3 years of age were picked along with current cones. However, although "old" cones made up over half of the total, current cones represented the largest single age class in all hand collections.

The first prototype machine was truck-mounted, the second was on a trailer, but in both cases it was necessary to gather cone-bearing slash by hand and transport it to a roadside point where it was lopped and fed into the machine (Fig. 6, 7). Both prototypes operated on the principle of the common, agricultural thrashing machine normally used in the harvesting of grain. The first machine was essentially a modified thrasher, whereas the second was a modified combine. In both cases, the cone-bearing slash encountered the teeth of a revolving cylinder (or cylinders) and these teeth stripped the cones from the branches. The mixture of loose cones and broken foliage then passed over a series of vibrating screens, while at the same time it was subjected to a blast of air from below. The cones dropped through the upper coarse screens, and were caught by the fine screen below. Meanwhile the foliage moved along over the coarse screens and was discharged from the end of the machine.

Fig. 2 Schematic Cross-Section View of Second Prototype Machine tested in Trials of Mechanical Cone Collection, Iroquois Falls, 1967-68.



From 3 to 23 bushels of cones[1] were harvested in each time-production trial of the machines and man-hours and machine-hours were recorded for slash gathering and lopping, as well as for the actual cone separation phase of the operation (Fig. 8). Because the machines were prototypes rather than production models, the frequent stops for repairs and minor adjustments were not recorded as part of machine operating time.

Values of $6.00 per hour for the machines and $2.00 per hour for labour were used to calculate the approximate cost per bushel of cones collected by both methods. The yield of seed per bushel of cones was determined for these trials and for an additional collection of black spruce made with the first machine at Geraldton, Ontario. These calculations permit comparisons of the cost of seed obtained from cones harvested by machine with that of seed from cones picked by hand.

Finally, it was necessary to determine the quality of seed extracted from machine-picked cones, relative to that from hand-picked cones. Small sub-samples of the cones harvested by both methods were processed in the laboratory, and the number of seeds per cone and the viability of the seed were determined.

RESULTS AND DISCUSSION

Time-production Trials

For each species and method of collection, Table 1 shows the time recorded in man-hours and machine-hours, for each phase of the operation. The total quantities of cones harvested each year by each method are listed together with the average rate of production per man-hour and machine-hour.

For black spruce, cone production was much faster by machine than by hand, and there was little difference between the rates in 1967 and in 1968 (Table 1). This is significant, because the results are for two different machines and for two cone crops that varied greatly in size. The calculated cost of collecting black spruce cones was in the order of $10.00 and $3.00 per bushel for hand- and machine-collecting methods, respectively. Although the lower yield of seed from machine-collected cones partially offset their cost advantage, the cost of seed was about $3.60 to $7.00 per pound less for machine collection than for hand picking.

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[1] The material collected by the machine included twigs and bits of foliage as well as cones of several age classes.

Fig. 3. General view of second prototype machine (trailer-mounted). Note stock-pile of tops at left.

Fig. 4. Hand picking black spruce, current cones only.

Table 1. Yield and cost data. Trials of mechanical collection of black spruce and jack pine cones, Iroquois Falls, 1967 and 1968

Sp.	Year	Method of collection	Man-hours				Machine-hours	Cones (bu)	Production rate (bu/hr)		Cost/bu of cones[a]			Seed/bu (oz)	Seed cost[b] /lb
			Gather	Lop	Separate	Total			Man	Machine	Man $	Machine $	Total $		
bS	1967	Hand			37.0	37.0		6.6	0.2		10.00		10.00	6.0[c]	27.00
		Machine	13.5	6.5	14.0	34.0	3.5	30.0	0.9	8.6	2.22	0.07	2.92	2.0[d]	23.36
	1968	Hand			6.8	6.8		1.0	0.2		10.00		10.00	3.7	43.00
		Machine	13.5	1.2	6.6	21.3	3.3	22.1	1.0	6.7	2.00	0.90	2.90	1.3	35.96
jP	1967	Hand			28.4	28.4		7.4	0.3		6.67		6.67	4.6	23.34
		Machine	15.3	11.5	4.5	31.3	1.5	18.0	0.6	12.0	3.33	0.50	3.83	2.9	21.06
	1968	Hand			4.0	4.0		1.6	0.4		5.00		5.00	5.8	14.00
		Machine	24.5	4.2	7.8	36.5	3.9	16.2	0.4	4.2	5.00	1.43	6.43	4.6	22.50

[a] Calculated on basis of $6.00 per hour for operation and maintenance of machine and $2.00 per man-hour for labour.

[b] Cone collection only, does not include extraction cost.

[c] Average yield of hand-picked current cones, Geraldton District, Ont. Personal communication from Q.F. Hess, Supervisor of Reforestation, Ont. Dept. of Lands and Forests.

[d] Machine-collection, 1967, Geraldton District. Extracted at Angus Seed Plant, Ont. Dept. of Lands and Forests.

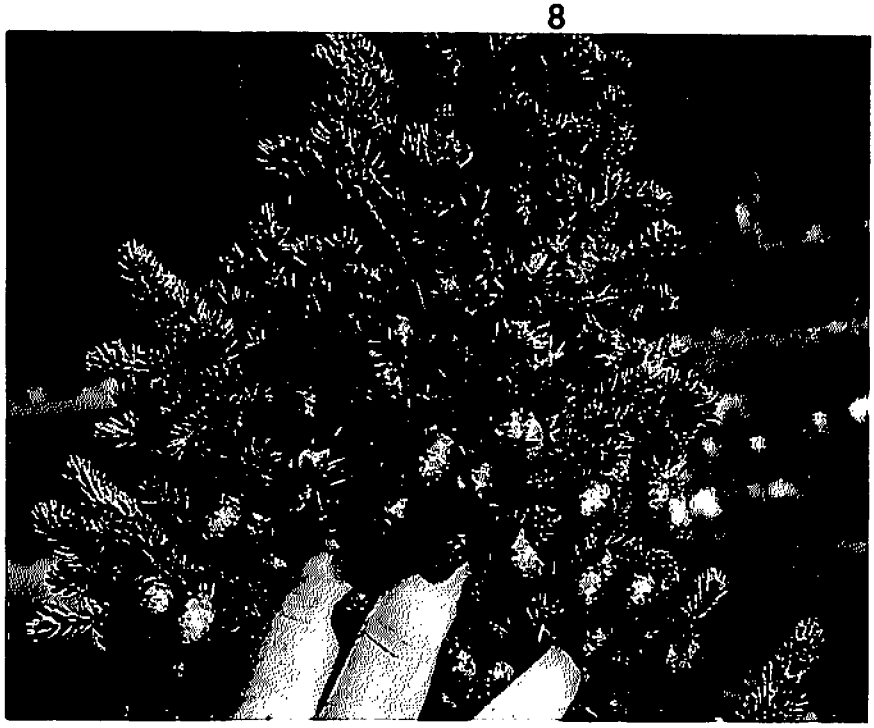

Fig. 5. Typical cone-bearing black spruce top. This top has no current cones (1968) but has heavy 1967 crop, as well as cones of at least three older age classes.

Fig. 6. Gathering black spruce tops for trials of mechanical cone collection.

For jack pine, cone collection was faster by machine than by hand, but there was a big difference between the rate of machine collection in 1967 and 1968. Although the machine used in 1968 produced a cleaner product, i.e., fewer bits of foliage and extraneous matter (Fig. 9), for collecting jack pine it was somewhat inefficient in that many of the larger cones passed over the separation screens and were ejected with the waste.

The calculated cost of seed as shown in Table 1 represents the cone collection cost only, and does not include an allowance for the cost of extraction. However, the lower seed yield from machine-collected cones would obviously mean somewhat higher extraction costs than for hand-picked cones. For black spruce, the cost of seed obtained from machine-collected cones would be less than that from hand-picked cones, if extraction costs did not exceed 69 cents per bushel in 1967 or 87 cents per bushel in 1968. For jack pine, machine collection showed a cost advantage in 1967, and would retain an advantage if extraction costs were less than $1.14 per bushel.

For both species, the man-hours required for gathering slash represented a large part of the total time and cost of cone collecting by machine. For black spruce, a minimum of 40 per cent of the total man-hours was spent gathering cone-bearing tops and branches, whereas for jack pine the comparable figure was 49 per cent. This suggests that the cost of machine collecting could be substantially reduced by location on a site where cone-bearing slash is concentrated during the normal course of logging operations. A full-tree harvesting operation would provide optimum conditions for mechanical cone collection, because the necessity for slash gathering would be virtually eliminated. A similar reduction could not be made in hand-picking costs, as the gathering of slash represents an insignificant part of these.

Seed Yield per Cone and Seed Quality

Table 2 presents information on the yield of seed per cone and the percentage germination of seed extracted in the laboratory from sub-samples of machine- and hand-collected cones.

For black spruce, the yield of seed per cone was somewhat less for machine- than for hand-collected cones. In 1967, a heavy crop year, nearly all hand-picked cones belonged to the current crop, whereas about half of the machine-collected cones were more than 1 year old. In the light crop year of 1968, nearly all cones collected by both methods were "old", but whereas most of the hand-picked cones were from the previous year's crop, about half of those collected by machine were older. Probably these cones had shed some of their seed before collection took place.

Fig. 7. Cone-bearing jack pine slash being fed into second prototype machine.

Fig. 8. Ten bushels of black spruce cones collected by machine in 92 minutes.

Table 2. Seed yield per cone and seed quality. Trials of machanical collection of black spruce and jack pine cones, Iroquois Falls, 1967 and 1968

Sp.	Year	Method of collection	No. of cones in sample	Cones		No. of sound seeds/cone	Germination %
				Current %	Old %		
bS	1967	Hand	585	91.4	8.6	20.2	85.1
		Machine	600	51.0	49.0	12.7	82.9
	1968	Hand	100	4.0	95.0	10.0	80.5
		Machine	100	0	100.0	5.6	71.0
	Averages	Hand				15.1	82.8
		Machine				9.2	77.0
jP	1967	Hand	186	33.0	66.0	24.2	65.5[a]
		Machine	164	16.0	84.0	22.2	65.0[a]
	1968	Hand	200	-[b]	-[b]	22.8	64.5
		Machine	400	-[b]	-[b]	23.3	51.4
	Averages	Hand				23.5	65.0
		Machine				22.8	58.0

[a] Test made at Petawawa Forest Experiment Station, Ontario; others at Forest Research Laboratory, Sault Ste. Marie, Ont.

[b] Not recorded.

Fig. 9 Machine-collected jack pine cones. Note that some twigs and bits of foliage are included.

For jack pine, the yield of seed per cone was virtually the same for both methods of collection. Samples from the machine collections contained a somewhat larger percentage of "old" cones, but because of their serotinous nature, these cones were almost as productive as those of the current crop.

For both species, germination levels were quite similar for both methods of collection. The slight advantage shown for hand collection probably reflects the fact that seed from these collections contained a higher proportion of younger seed.

SUMMARY AND CONCLUSIONS

In 1967 the Ontario Region of the Department of Forestry and Rural Development entered into a contract with a private forestry firm for the design and construction of a portable machine capable of separating cones of black spruce and jack pine from slash. In the fall of that year, time trials were carried out to compare the cost of collecting cones mechanically with the cost of conventional hand picking. A second prototype machine was developed independently by

the contractor and similar trials of this machine were carried out under contract in the fall of 1968. The yield of seed per bushel of cones was determined for the cones collected each year by both methods. From smaller sub-samples of the same cones, seed yield per cone and germination levels were determined also. By applying values of $6.00 per hour for the machine and $2.00 per man-hour for labour, the relative costs per bushel of cones and per pound of seed were calculated for both methods of collection.

The results of these trials and the conclusions drawn are as follows:

(1) For black spruce the rate of machine collection of cones was 8.6 bushels per machine-hour when the current cone crop was heavy and 6.7 bushels when it was very light. In both years the rate per man-hour for machine collection was about 1 bushel, whereas for hand picking it was only 1/5 of a bushel. The calculated cost per bushel of cones was about $3.00 for machine collecting and $10.00 for hand picking.

(2) In both years the yield of black spruce seed per bushel of cones collected by machine was about one-third that of hand-picked cones.

(3) As a result of a faster rate of cone collection, and in spite of a lower seed yield per bushel, the calculated cost of black spruce seed obtained from machine-collected cones was $3.60 to $7.00 per pound less than that obtained from hand-picked cones.

(4) For black spruce, the germination of seed from machine- and hand-collected cones averaged about 77 and 83 per cent, respectively. For jack pine the comparable figures were 58 per cent for machine collection and 65 per cent for hand picking. Thus it would seem that there is little difference in the quality of seed collected by the two methods.

(5) For jack pine, the rate of machine collection of cones averaged 12.0 bushels per machine-hour in 1967 but only 4.2 bushels in 1968, chiefly because the machine used in the second year did not remove all of the cones from the material handled. The rate per man-hour for machine collection was .6 bushels in 1967 and .4 bushels in 1968: for hand picking it was .3 and .4 bushels, respectively. The cost of cone collection by machine was $3.83 per bushel in 1967 and $6.43 in 1968, and for hand picking it averaged $5.83.

(6) The yield of jack pine seed from machine-collected cones ranged from about two-thirds to three-quarters of that from hand-picked cones.

(7) In 1967 the calculated cost of jack pine seed obtained from machine-collected cones was about $2.00 less than that for hand-picked cones, but in 1968 it was nearly $9.00 more.

(8) In these trials the high labour requirement for slash gathering represented a major part of the cost of cone collecting by machine. Obviously, the efficiency of machine collection can be greatly increased by location on sites where cone-bearing slash is concentrated during the normal course of logging operations.

(9) Although the prototype machines used in these trials were not sufficiently rugged for continuous operation, the results indicate that machine collection of black spruce and jack pine cones is feasible, and may reduce the cost of obtaining seed for reforestation purposes.

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