CORRELATIONS BETWEEN CONTROLLED-ENVIRONMENT AND NURSERY-GROWN SEEDLINGS OF JACK PINE PROVENANCES

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Estimates of genetic variation can be obtained from tree seedlings grown in a uniform environments If sound predictions of adult performance can be made from short-term tests, large numbers of seedlings and seedlots can be tested under stand conditions, and only relatively few selected lots need be carried forward for long-term testing in the field.

It was with this in mind that the dry-weight of four-month-old seedlings of a number of jack pine (Pinus banksiana Lamb.) provenances grown in a growth cabinet an in a greenhouse was compared with the height of the same populations grown for 3 and 4 years in an open nursery at the Petawawa Forest Experiment Station. The seed was collected from stands located throughout the geographic range of the species, from the Atlantic coast to the Mackenzie River in the Northwest Territories (fig. 1).

LITERATURE REVIEW

Werner Schmidt (1957) provided a comprehensive review of the diagnostic value of early tests in forest genetics and tree breeding. To be effective, predictions mus t be based on sufficiently high correlations between juvenile and adult characteristic Correlation coefficients should approach or exceed 0,8, the standard error of predic tion should be low, and the sample should be representative of the material being evaluated (Schmidt, 1963). Many years are required for the expression of adult characteristics in forest trees and useful information can be had from careful obser vation of seedlings in the laboratory or nursery. Callaham (1964) advocated combini long-term seed source studies with controlled environment test for the determination of the ecological importance of plant properties and of external factors. Webb (196 concluded that "Characteristics exhibiting strong parent-offspring heritability can be selected for or against fairly soon, and other characteristics that are critical at an early age can be evaluated at an early age."

In their discussion of racial variation in ponderosa pine, Squillace and Silen (1962) emphasized the importance of uniformity in cultural treatment and accuracy of measurement of seedlings if such data are to be of predictive values. Under these conditions, a highly significant correlation coefficient of 0.85 was found between average heights at 2 years and at 30 years. In another example, Kriebel (1962) concluded that second-year height measurements of sugar maple provenances grown in Ohio could not be used safely to predict the height at nine years. He suggested that other highly heritable characteristics such as drought resistance, tree form and growth period might be estimated at an early age.

In a report of the performance over 50 years of Douglas fir provenances grown six locations in Oregon and Washington (Anon., 1964), no useful correlations were found between juvenile and mature height records. The order of bud bursting remainedconsistent, but this was not related to tree height. A high degree of genotype X environment interaction among the six planting sites confounded correlations with seedling size- Also it was considered that differences in seed size had influence the height of the seedlings at the age of 2 years from sowing.

[1] Department of Forestry and Rural Development of Canada, Petawawa Forest Experiment Station, Chalk River, Ontario.

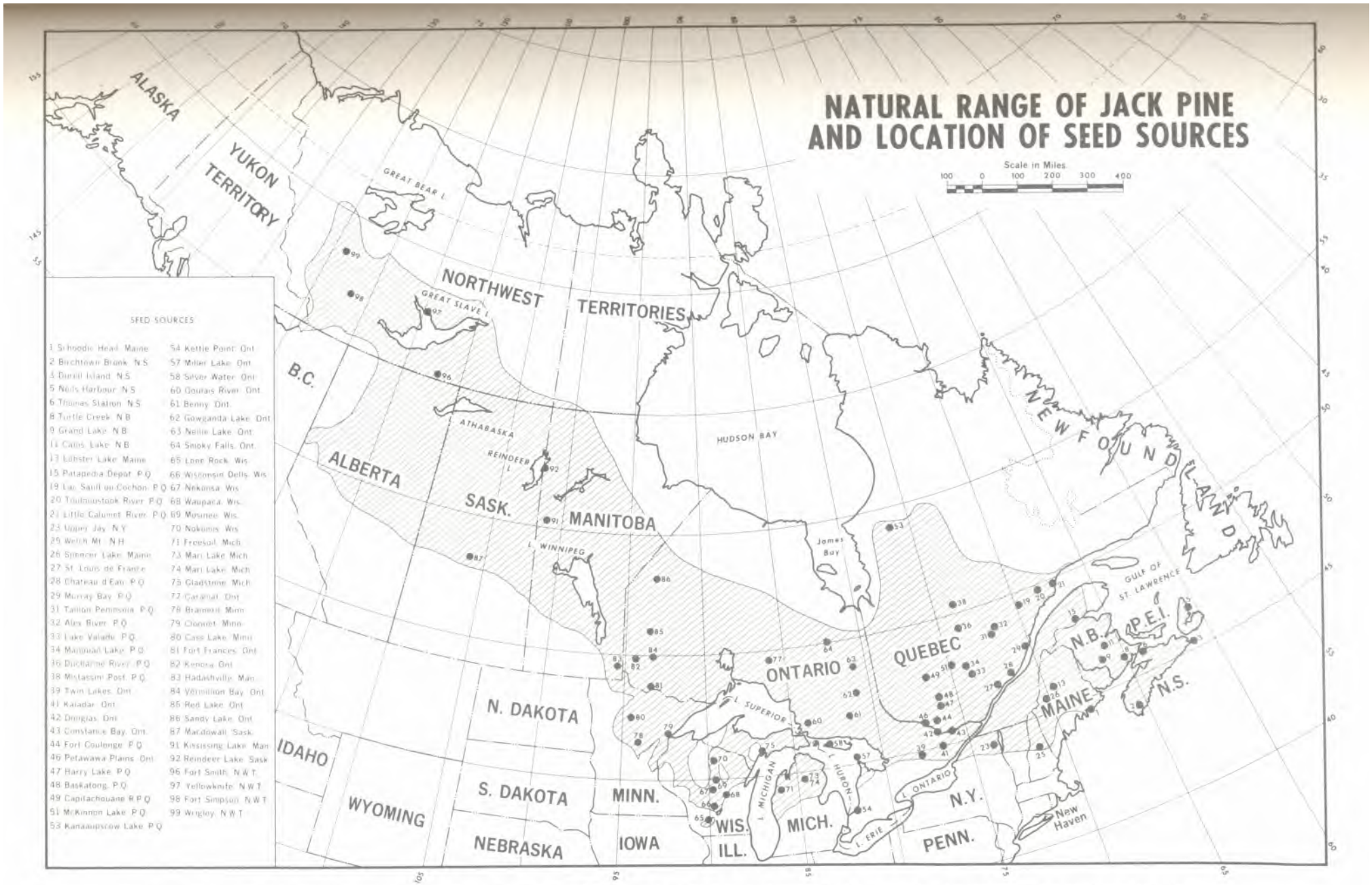

Figure 1.--The natural range of jack pine (Pinus banksiana Lamb.) in North America, together with the place names, reference numbers and locations of 71 provenance seed collections.

Few generalizations can be made concerning the predictive value of seedling studies for performance at a later age. Each problem must be dealt with separately to determine the appropriate limits for selection,

MATERIAL AND METHODS

Seed was collected from 100 stands of jack pine covering the entire range of the species (fig, 1). Geographic origin, stand descriptions and associated ciimati cdata were listed by Holst (1963). The seedlot numbers of the 71 provenances em ployed in the present study are given in figure 1.

Seedlings were grown in a controlled environment and a greenhouse at New Haven, Conn.[2] (Yeatman, 1966a), and in a nursery provenance experiment at the Petawawa Forest Experiment Station (Hoist, 1963).

For the New Haven experiments, seed was sown directly into plastic pots containing a uniform soil mixture, One month after sowing, seedlings for the controlle d environment experiment (50 provenances) were transferred to the growth cabinet where they remained for three months before being harvested. The growth cabinet maintained a 15-hour day (1,800 ft.c.) and 21/13°C day/night temperature regime. Seedlings for the greenhouse experiment (87 provenances) were grown on an open bench during four summer months, May to August. The values employed in the comparisons reported here are the mean dry-weights of three replications of 18 seedlings from the controlled environment test and mean dry-weights of three replications of 10 seedlings from the greenhouse experiment.

The nursery experiment was sown in the spring of 1962 with ten replications of 10 seed spots each of 98 provenances, The spacing within this experiment was one foot within and between the single-row plots. Extreme heterogeneity of site became evident in the second year of growth. At the end of the 1965 growing season three site classes, good, medium and poor, were designated and the boundaries established within the area of the experiment, The height data employed in the present study were derived from plots within the good site quality only, and include only those provenances for which at least three replicates were found within this site, and which, in addition, were common to the New Haven experiments (fig. 1). The provenance values were derived from the mean heights (cm) in 1964 and 1965 of three replications,

RESULTS

The correlations between mean seedling dry-weight and the mean height are listed in table 1. All were very highly significant, but a greater proportion of the variation in height of the provenances in the nursery experiment was accounted for by the data from the controlled environment compared to that from the greenhouse.

Seedling dry-weight (top + root) from the controlled environment was a better predictor of height in the nursery (r 0.86) than was top dry weight alone (r = 0.83). There was little difference between the correlation coefficients for height at three years (1964) and four years (1965), This would normally be expect- but it was thought that increasing competition among provenances randomly distribute in the experiment might have appreciably increased the error associated with the 1965 data.

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Table 1.--Correlations between the dry-weights of four-month-old jack pine seedlings and heights of seedlings of the same seed sources grown in a nursery at the Petawawa Forest Experiment Station.

Location of 4-month-old seedlings	Nursery measurement year	Number of provenances n	Correlation coefficient r	Coefficient of determination $100r^2$ percent
Growth cabinet	1964	38	0.86***	73
	1965	38	0.85***	72
Greenhouse	1964	71	0.73***	53
	1965	71	0.72***	52

Significance level: ***, 0.1%.

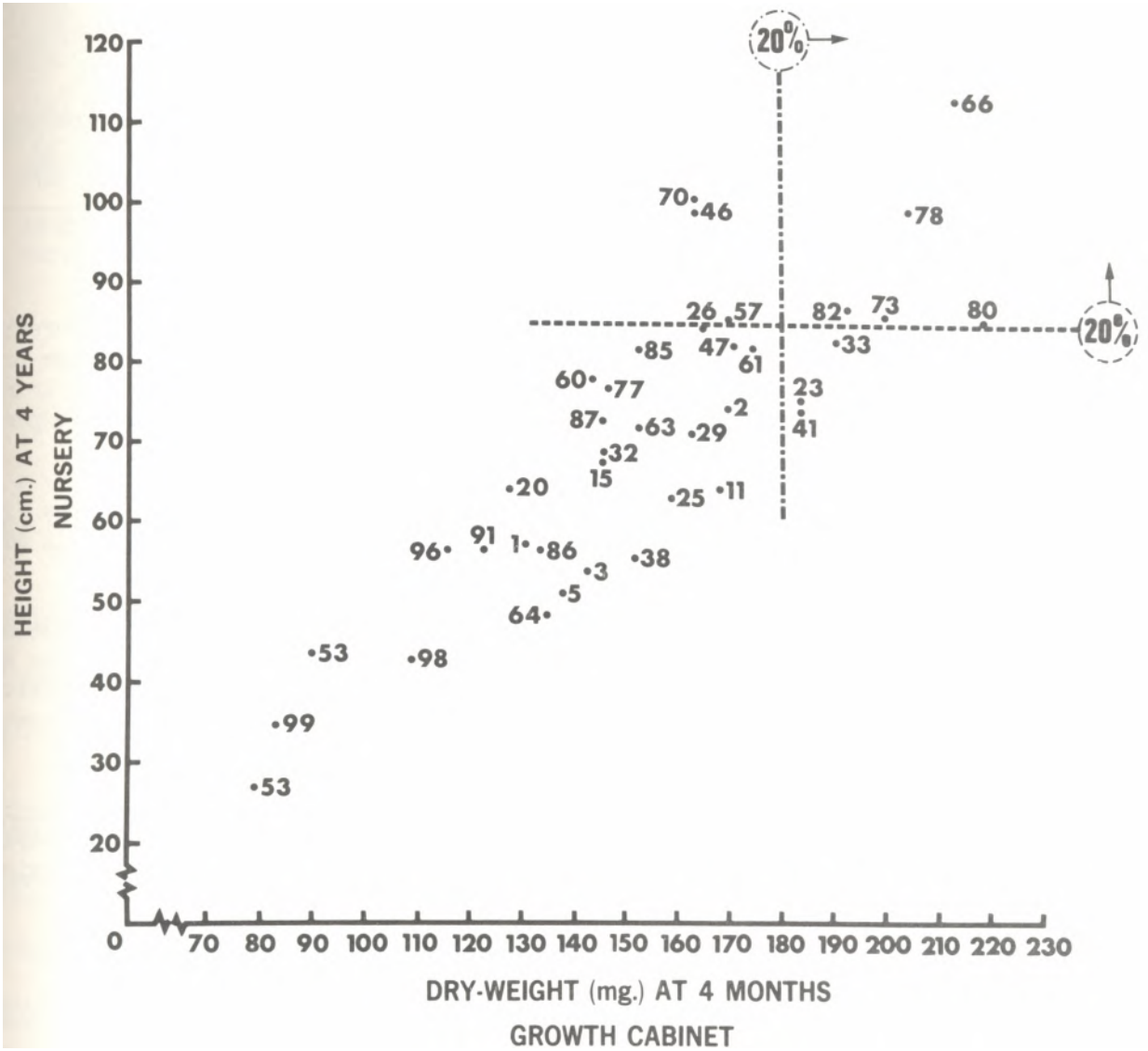

Figure 2.--Distribution of 38 provenance mean values in relation to seedling dry-weight at 4 months and height at 4 years. The numbers refer to those listed in figure 1.

Mean seed dry-weight was shown to be a significant factor in the early growth of seedlings of these provenances (Yeatman, 1966b) but it did not account for a significant portion of the variation in the comparisons between ages. This is shown by the following values for the multiple regression of 1965 height (Y) vs. seed weight (Xi) + seedling dry weight, controlled environment (X_2),

Standard partial regression coefficients		Coefficient of determination
Seed weight	Seedling weight	$100R^2\%$
b_1	b_2	
$0.136^{n.s.}$	0.796^{**}	74

Significance levels: **, 1.0%; n.s., not significant.

The top 20 percent of the provenances from the controlled environment included 5 out of the 8 in the top 20 percent of the 38 common provenances from the nursery test (fig, 2). The local Petawawa provenance (S.46) ranked fourth in the nursery but sixteenth in the growth cabinet. Selection of the top 20 percent of the 71 provenances in the greenhouse test reduced the number common to the top 20 percent in the nursery test to less than half (6 out of 14). The coastal and maritime sources generally lost rank and southern continental sources tended to gain rank in the nursery test relative to the early seedling tests.

DISCUSSION AND CONCLUSIONS

Although the correlations of performance of jack pine seedlings at different ages were very highly significant, the efficiency of selection at an early age for high performance at a later age was only moderate. The breadth of geo-climatic range included among these provenances accounted for the high correlation between experiment

The lower correlations associated with the greenhouse test were caused by a higher error variation than that in the growth cabinet test. The error in the former was increased by variation in crown competition between groups of seedlings in adjacent pots on the greenhouse bench.

The precision of the nursery test was greatly reduced by unforeseen variation in site quality which forced a drastic reduction in the numbers of replications and plants on which the provenance means were based. Considerable site heterogeneity undoubtedly remained within the 'good' site from which data for these comparisons were derived.

The importance of time for the adequate expression of genotype X environment interaction was illustrated in this instance by the generally bushy, semi-prostrate form of seedlings from east coast provenances when grown in the nursery. No evidence of this tendency was observed in the first growth period from germination.

Early tests of jack pine can be of value in screening genetic material for potential growth, but, at least until more experience is gained, the selection differential to be applied at the earliest age should not be too high. It is also apparent that the conditions of culture within a single experiment must be uniform and the numbers of seedlings per treatment adequate for both the seedling tests and for the field tests on which age correlations are based, Further correlations of this nature will be investigated when data are obtained from the plantation tests of these provenances.

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DISCUSSION

MTH- Mr. Chiasson, you said you used an isolation bag made of polyethylene. Did you have any difficulty with condensation in the bag?

CHIASSON - The isolation bags stood up in such a way that the moisture seemed to seep through the cotton wool. But there were some cases where the bags dipped down, and condensed moisture then remained in the bags.

CECH - One other question -- Did you separate the full seed from empty before you ran the germination test?

CHIASSON - Yes.

MONEY - I'd like to ask Mr. Yeatman about the length of day he used in his experiment. Your day length in your controlled environment in your greenhouse and field tests, did they match?

YEATMAN - Day length in the controlled environment was 15 hours which was comparable to the natural day length for the period May to August in the greenhouse at New Haven, 41°N latitude.

SWEANEY - I asked this because I read a paper that stated that jack pine will grow better on a continuous day length than it will on a day length of less than 14 hours.

YEATMAN - That is true, and this was illustrated in the 20-hour photoperiod treatment given these provenances. In this condition all provenances grew more than at the 15-hour photoperiod and the range of variation among provenances was much less, In the 10-hour photoperiod all provenances set buds early in the three-month period of treatment. Differences in time of bud formation were greatest in the 15-hour treatment and hence the range in shoot development was also a maximum. It was data from the latter treatment I chose to use in the comparisons reported here,

HOWE -Dr, Chiasson, you mentioned that you used a number of filler pollens with your various pollens. Which pollens did you use and would you care to speculate why the filler pollens alone seem to have an effect on ovulate cone development?

CHIASSON - The two controls that I mentioned were, first, an empty type of control, where no pollen whatever was knowingly introduced, and, secondly, the use of local balsamea pollen. The first condition would indicate whether or not there had been previous pollination in spite of our precautions. The second type of control would be a means of confirming that our methods were effective in bringing about pollination, especially if no results were obtained with "foreign" pollens, With a few exceptions where the isolation bags were found to be improperly placed, there was no seed production in the first instance, whereas there was a fair number obtained in the second.

BALSILLIE - I'd like to address a question to Dr, Chiasson. Did you find any correlation in the chromosome number of your injected pollens with your Abies species or in your hybrids? Did you find the number of chromosomes in the new hybrids; were there any polyploids?

CHIASSON - No, there were no polyploids in the suspected hybrids. From studies of dividing cells in needles, it was established that they were diploids. I should make it quite clear there are no differences in chromosome numbers between the species used in the present studies. We cannot report any gross differences in morphology but we have merely begun a search for these,

GABRIEL - What were the relationships of nursery differences and controlled environment differences in your provenance study? I'm getting at the effect of nursery on provenance performance, Did you find a relationship between provenance performance under controlled environmental conditions and provenance performance in the nursery?

YEATMAN Yes.

GABRIEL - Then "r" factors were based on your dry weight-height growth relationship?

YEATMAN - The mean dry weights of seedlings grown for four months in the controlled environment and in the greenhouse were correlated with the mean heights of the same provenances grown for 3 and 4 years in the nursery,