

Report on an Experimental Plantation of Several Species of Larch in New York

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European larch, (*Larix decidua* MILL.), and to a lesser extent and more recently Japanese larch; (*L. leptolepis* SIEB. and Zucc.) have in the last three or four decades become important species in the reforestation programs of some of the northeastern states, notably New York. The variability of the European larch and the existence of well-defined geographic and local races are well known, and their study has produced a voluminous literature, principally in the writings of German and Scandinavian investigators, which have recently been summarized by McCOMB (9). In Great Britain, though an introduced species, larch has become of major importance as a forest tree and has been intensively studied there, particularly with respect to the natural crossing of European with Japanese larch, which has produced the famous „Dunkeld hybrid“, (*X L. eurolepis* HENRY). In North America HUNT's work at Harvard Forest (5) and with the New York State Conservation Department (4) served to attract interest in the species and to establish a basis for planting procedure and silvicultural practice under our conditions.

Japanese larch has always been considered to be a rather homogenous species, geographically, but SCHÖBER's recent work (11) has indicated the existence of local races.

In New York, European larch was used as early as 1909 but was not planted extensively until 1923, and Japanese larch was not planted in any quantity prior to 1929. No particular attention was paid to seed-source of European larch prior to HUNT's work, but starting about 1930 attempts were made to procure seed insofar as possible, of either Scottish or Silesian (Sudeten) origin. At about this same time the Department embarked upon a rather extensive program of nursery and planting investigations which included provenance tests of species which exhibited tendencies toward racial variation, such as Douglas-fir, Scotch pine and larch. These experiments have been outlined in a report by the present authors in 1953 (8), and the study described here represents on phase of this program.

In the spring of 1937, an experimental planting was made on Saratoga, =1 State Forest, near Saratoga Springs, N. Y., with six European and Asiatic larches represented by three geographic races of the European larch, the Japanese larch, the Dunkeld hybrid, and the Dahurian larch, (*L. gmelini* PILGER).

The experiment was designed primarily, to obtain a direct comparison between the Dunkeld hybrid and the

other larches, both European and Asiatic, then in general use in the New York reforestation program. The European larch from the Dolomites and the Dahurian larch, of somewhat obscure Asiatic origin, may be regarded merely as "curiosa". Dunkeld larch had been planted in New York as early as 1932 (7) in a small test plot with trees of the original cross; and in 1934 propagation was undertaken on a larger scale at Saratoga State Nursery with seed obtained from Benjamin Reid Co. of Aberdeen, Scotland, and believed to have been collected from plantations representing the F₁ generation. In the fall of 1935 and the spring of 1936, 2-4 stock from this nursery sowing was distributed for planting on a number of State Forests in different sections of New York and to several private individuals. The most successful in this latter category are the plantations set out respectively by D. B. COOK at Coorox Forest in Rensselaer County, and by HUNT in Otsego County. About 2600 of the Dunkeld larch remained in the nursery bed following the 1936 shipping, and were lined out in transplant rows. In 1937 some 1100 of these were available for planting as 2-4 stock and were used in the experiment.

Saratoga, =1 State Forest in the Town of Greenfield, eight miles north of Saratoga Springs, lies at an elevation of some 900 feet above sea level, along a ridge on the southeastern edge of the Adirondack mountain region. Soils are stony sandy loams of the Gloucester series and most of the area is well drained. The climate is moderately severe, with a growing season of 144 days and a mean annual temperature of 45 degrees F. Mean temperature from June 1 to Sept. 30, is 65.7 F. Precipitation averages 40 inches annually with 69 inches of snowfall.

The wooded portions of the area, where not occupied by brush types, are second-growth northern hardwood. The sites selected for the planting were old fields typical of the abandoned farms in this locality. Abandonment had been recent, however, so that fields were relatively free from brush. Planting arrangement was based primarily on the number of trees available for the experiment rather than on an attempt to establish a completely symmetrical plot layout. Such tests, notwithstanding, often give indications of considerable practical value, and we believe this to be true of the study in question.

Two series of plots were established. Block A contained randomized plots of several hundred trees each in bands of from 4 to 8 rows, each plot being separated by bands of Norway spruce. The trees were planted on a 6 X 6 foot spacing. Block B contained randomized square plots of 25 trees each. The plots are in three rows of four plots each, the rows being separated by bands of Douglas fir. The trees were planted on a 10 X 10 foot spacing.

Planting was done the last week in April by a selected crew of Civilian Conservation Corps personnel under the immediate supervision of the senior author; planting stock was taken directly to the area from the nursery by truck; all the lots had started to break out of bud, excepting the

Table 1. — Species of larch used in experimental planting on Saratoga, =1 State Forest (N. Y.) in 1937.

Species	Seed Origin	Class of Stock
European larch (<i>L. decidua</i>)	Scotland	2-0
	Silesia	2-0
	Dolomites (Italian Alps)	2-0
Japaneselarch (<i>L. leptolepis</i>)	Japan	2-0
Dahurian larch (<i>L. gmelini</i>)	Mandhuria (?)	2-2
Dunkeld hybrid larch (<i>X L. eurolepis</i>)	Plantations, in	2-2-1
	Perthshire, Scotland	2-1

Table 2. — Comparison of survival and growth in different species and types of larch planted in Saratoga County, N. Y. in 1937.

Species of larch	Plot No.	No. trees planted	End of 5th year		End of 17th year			
			Percent survival	Av. height (feet)	Percent survival	Av. height (feet)	Av. d. b. h. (ins.)	Max. d. b. h. (ins.)
<i>Block A: Planted with 6 × 6 — foot spacing</i>								
Dunkeld hybrid	1—N	414	79	7.5	73	43	4.8	10
	1—S	248	52	5.4	52	37	5.0	11
Dunkeld hybrid	2—2	424	98	8.8	91	39	4.2	9
European (Scotland)	2—5	235	83	5.2	80	35	3.4	7
(Silesia)	2—3	430	71	5.5	66	33	3.5	7
(Dolomites)	2—4	98	—	2.5	42	19	2.2	5
Japanese	2—6	212	75	5.3	72	39	4.5	9
Dahurian	2—1	419	67	3.8	63	30	3.0	7
<i>Block B: Planted with 10 × 10 — foot spacing</i>								
Dunkeld hybrid	4—1	25	92	7.0	92	42	6.9	9
	4—7	25	100	9.0	100	42	6.9	9
	4—12	25	100	6.3	96	42	6.6	10
European (Scotland)	4—4	25	100	8.0	100	34	5.2	7
(Silesia)	4—2	25	80	3.7	80	32	4.7	7
	4—11	25	88	4.1	88	32	4.1	7
(Dolomites)	4—6	25	96	4.1	96	28	3.7	7
Japanese	4—10	25	80	6.8	80	35	7.1	9
Dahurian	4—3	25	72	3.1	68	26	4.0	6

*) Based on 275 trees, excluding the two exterior rows; average including exterior rows was 4.5 inches.

Japanese larch, which was still dormant. Planting was done in holes dug with a shovel. Particular care was taken with respect to spacing and row alignment. The ground at the time of planting was quite moist and Block A, plot 2—1 (Dahurian larch), had standing water in spots. The season of 1937 was generally favorable for plantation survival.

In 1941, the plantations were examined by A. E. KOPP and HENRY LATOUR, who obtained survival counts and height data. In the winter of 1953—54 height and diameter measurements were taken, preliminary to a thinning, and observations made on stem form. This work was done principally by MORGAN P. SMITH and RICHARD E. WILSON of the Conservation Department, under the authors' direction. Diameters were taken by caliper, except for designated crop trees which were measured by tape. Heights were taken on felled trees insofar as possible. In the case of the Dunkeld larch in Block A, it was found that notwithstanding the adjacent bands of Norway spruce, the larch had made such rapid initial growth that the two exterior rows were for all practical purposes without competition; these trees were accordingly not included in computing average diameter.

Data on survival and growth over a period of 17 years from planting, are presented in Table 2.

A glance at this table will reveal (a) that the Dunkeld and Japanese larches are on the whole growing faster than the European in both height and diameter; (b) that the European larch of Scottish origin (at least, in Block B) is growing in diameter at a somewhat faster rate than that from Silesia; (c) that the European larch of Dolomites origin, as well as the Dahurian larch, are definitely inferior types under the conditions prevailing here; and (d) that all stocks reacted significantly to the wider spacing, with respect to growth in diameter, though not in height.

Analyses of variance were performed on the 17-year height and diameter data. According to these analyses there were significant (at the 1 percent level) differences due to seedlots in both height and diameter growth. There were significant (at the 1 percent level) differences between blocks in diameter but not in height growth.

Height growth at the end of the fifth year reflected the same general tendencies as those which became apparent later; there was a significant correlation ($r = 0.798$, significant at the 1 percent level with 15 degrees of freedom) between fifth year and seventeenth year height.

The question will be raised, as to whether the Dunkeld larch planting stock, being 2—1 transplants, was comparable with the European and Japanese larch, which were 2—0 seedlings. From our experience with larch, it would seem doubtful whether this difference would have been a factor of any great consequence.

Cook's (3) observations on the plantation in Rensselaer County, set out with 2—0 stock of the same Dunkeld larch as that used in the experiment, gave an average height of 10.98 feet in five years, compared with 9.90 for Japanese larch. In HUNT's planting¹⁾, in 1936, where the 2—0 Dunkeld larch was planted alongside the Silesian, the Dunkeld had an average height of only 7.8 feet at the end of five years, compared to 8.1 for the Silesian; it may be remarked that these plantations, while on a good site, were affected adversely by the 1936 drouth which was not a factor in the Rensselaer County plots.

As regards stem form, the trees were classed in three groups:

- "A": without recognizable crooks;
- "B": with one well-defined crook;
- "C": with two or more crooks.

In this respect, the superiority of the Dunkeld hybrid was outstanding, and the field tally merely serves to substantiate what has been clearly evident to all who have visited these plantations.

The percentage distribution of the trees in the tree stem form groups is given in Table 3.

Table 3. — Percentage distribution of larch trees with respect to stem form.

Species of larch	Group "A" (no recognizable crook)	Group "B" (one crook)	Group "C" (two or more crooks)
Dunkeld hybrid	74	17	9
European (Scotland)	68	24	8
European (Silesia)	33	35	32
Japanese	59	27	14

¹⁾ Unpublished data, New York State Conservation Department.

In addition to the excellent form exhibited by the Dunkeld larch, the superiority of the Scottish larch is to be noted, particularly in comparison with the poor form of the Silesian.

The results from this experiment tend to confirm what has long been recognized in Europe with respect to (a) the superiority of the Scottish strain of European larch; (b) the relatively rapid growth of the Japanese larch as compared to the European; and (c) the excellent form of the "Dunkeld hybrid", combined with a rapid growth-rate. There has been relatively little investigation or controlled experimentation previously, of these larch races and hybrids under American conditions. PATON(10) reported on a plantation of Dunkeld larch in Ohio, established in 1934, and compared the growth-rate at the end of nine years with that of nearby plantations of Japanese and European larch of similar age (10 years). The seed-origin of these latter was not stated. He found the growth in height and diameter of the Dunkeld to be not significantly better than the others, and the form of the Dunkeld while good, was not any better than the Japanese or European. The report ends on a negative note, to the effect that because the typical old-field planting site is not suitable for larch, its use in Ohio "has been largely discontinued". As for the Dunkeld larch it was considered "not greatly superior to its parents" and "will not play a very important part in the reforestation program in Ohio".

STOECKELER (12) made a test, in northeastern Wisconsin, of European larches from a number of known seed-sources in continental Europe, together with Siberian larch from Finland. At the end of 5 years, the best height-growth was made by the stocks from Proskau in Silesia, and from Czechoslovakia; while the poorest was made by those from the Italian Alps and from Finland. A surprising feature here was that the trees in a plot of the native tamarack (*L. laricina* [DuRoi] K. KOCH) grew faster than any of the European larches, other than the two named above; this despite the fact the planting site was an open sodded field on a soil ranging from fine sandy loam to silt loam — a far cry from the acid sphagnum swamps or other moist areas characteristic of the native habitat for tamarack.

Recently, AIRD and STONE (1) examined a number of European and Japanese larch plantations in New York, ranging in age from 15 to 45 years. While the principal purpose of the study was to develop a means of estimating site index from soil characteristics, the observations did bring out once again, the familiar fact that the Japanese species had made consistently better growth than the European.

As indicated previously, extensive experimentation had been under way in New York for some 25 years, with larch and other species of exotic conifers, but little has been done in the way of observation beyond 5-year measurements, some of which were reported by LITTLEFIELD (6) in 1939. Further observations, both on State Forests and on private plantations which were established with experimental stock furnished by the Conservation Department, should prove significant. In this connection, may be mentioned the more recent experimental plantations established in New Hampshire and New York with seed obtained by BALDWIN (2) through the International Union of Forest Research Organizations.

Summary

An experimental plantation of several species of larch established in Saratoga County, N. Y., in 1937 by the New York State Conservation Department was examined in 1941 and again 1953. In 1941, observations were made on survival and height. In 1953, both height and diameter were measured, and the trees in each plot were grouped into one of three stem-form classes, based on incidence of crook.

The Dunkeld hybrid larch and the Japanese larch had made the most rapid growth, both in height and diameter, and the Dunkeld in addition, exhibited a clear-cut superiority of stem-form. The European larch of Scottish origin slightly exceeded the Silesian in growth-rate and was far superior to the latter with respect to stem-form. European larch from the Dolomites (Italian Alps) grew very slowly here, as did the Dahurian larch.

The data obtained from this experiment are substantiated in some degree by preliminary observations made on plantations in other parts of the state, which were established from the same seed stocks. Comparable data, if secured from these other plantations in the near future, will increase the significance of the results.

Zusammenfassung

Titel der Arbeit: *Bericht über eine Versuchsfläche mit verschiedenen Lärchenarten im Staate New York.* —

Eine 1937 in Saratoga County, N. Y., vom New York State Conservation Department begründete Versuchsfläche verschiedener Lärchenarten wurde 1941 und 1953 kontrolliert. 1941 wurde der Anteil der Überlebenden sowie die Höhe festgestellt, 1953 wurden Höhe und Durchmesser gemessen. Außerdem wurden die Bäume jeden Teilstücks je nach dem Grade ihrer Krümmtheit in drei verschiedene Stamm-Formklassen eingestuft.

Die Bastardlärche aus Dunkeld sowie die japanische Lärche wiesen das rascheste Höhen- und Durchmesserwachstum auf. Darüber hinaus zeichneten sich die Dunkeldlärche durch außerordentlich gute gerade Stammformen aus. Die Europäische Lärche schottischer Herkunft war im Höhenwachstum etwas besser als die schlesischer Herkunft und übertraf diese letztere in Bezug auf die Stammform bei weitem. Die Dolomitenherkunft (Italienische Alpen) der Europäischen Lärche, sowie *Larix Dahurica* waren am wüchsigsten.

Die von dieser Versuchsfläche gewonnenen Werte wurden bis zu einem gewissen Grad noch durch vorläufige Beobachtungen an anderen Stellen der Staaten auf mit dem gleichen Saatgut begründeten Flächen erhärtet. Sobald vergleichbare Werte dieser anderen Flächen aufgenommen sind, wird sich in nächster Zukunft die Signifikanz dieser Ergebnisse noch erhöhen.

Résumé

Titre de l'article: *Résultats d'une plantation expérimentale de plusieurs espèces de mélèzes dans l'Etat de New York.* —

Une plantation expérimentale de plusieurs espèces de mélèzes, établie dans le Saratoga County, N. Y., en 1937, par le New-York State Conservation Department, fut étudiée en 1941 et à nouveau en 1953. En 1941, les observations ont porté sur la proportion de plants vivants et sur la hauteur. En 1953, on a mesuré la hauteur et le diamètre, et les arbres de chaque placeau furent groupés dans une

des trois classes d'estimation de la forme des tiges d'après la flexuosité.

Le mélèze hybride de Dunkeld et le mélèze du Japon ont eu la croissance la plus rapide en hauteur et en diamètre, et, de plus les mélèzes de Dunkeld sont nettement supérieurs en ce qui concerne la forme des tiges. Les mélèzes d'Europe d'origine écossaise dépassent légèrement les mélèzes de Silésie pour la vitesse de croissance et leur sont nettement supérieurs pour la forme des tiges. Les mélèzes d'Europe des Dolomites (Alpes italiennes) poussent ici très lentement, de même que le *Larix dahurica*.

Les résultats de cette expérience sont confirmés jusqu'à un certain point par des observations préliminaires faites sur des plantations ou d'autres parties de l'Etat, plantations établies à partir des mêmes graines. Si ces plantations donnent dans un avenir proche des résultats comparables, la valeur de deux de l'expérience s'en trouvera renforcée.

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The Design, Layout and Control of Provenance Experiments

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A number of experiments to compare the growth of trees of one species grown from seed of different provenances had been laid out in Scotland before 1930. They were of a very simple type, consisting of a single plot of plants from each seed source, and though the ground on which they were planted no doubt seemed reasonably uniform at the time of the planting, it has not always proved so in practice. In such experiments there is the unavoidable fact that one plot must always be more exposed to prevailing winds, while the others shelter in its lee, or alternatively one is more exposed than others to damage from other directions. These cast some doubt on the validity of the results obtained.

These difficulties can be overcome by modern statistical techniques, in which replication of the plots of each provenance plays the leading part. Scottish experiments from 1930 onwards employed this device, but the next essential, that of randomising the plots within the experiment, did not at first invariably follow. Only when these two principles are observed is it possible to segregate the variance between the plots, in respect of whatever characteristics are being assessed, into errors due to differences in the environment and errors due to variation between the provenances on trial. This is necessary in order to determine whether the differences between the two sets of errors are likely to be significant, or only due to chance. A well designed experiment is therefore essential.

Some notes on the lessons learned from the conduct of old experiments have been collected, with a view to the guidance of future experimental work.

The Object of the Experiment

The term "provenance experiment" is used to describe an experiment with seed from stands of trees, either native

to their place of growth or introduced from elsewhere. Provenance experiments are to be distinguishable from "progeny trials", which term is used to describe trials of the progenies of individual mother trees (The paternal parent may or may not be known) (c. f. VEEN, 1954b). STRAND (1952) recognizes three classes of progeny test: "I. Individual seed trees; — II. Several individual seed trees in each of a number of stands; — III. The progeny of groups of seed trees in each of a number of stands . . ." but even in the last case he refers to comparisons between the progenies and the mean values for the groups of selected trees, and not the mean for the parent crop. It is this distinction between selected trees and the whole stand which makes the difference between progeny trials and provenance trials. The latter refer to comparison of seed from complete crops.

The precise objects of the experiment must be clearly defined and the kind of experiment will vary according to the definition of the object, but in general, most experiments are required to compare the growth of stands of trees. They are *crop* experiments and aim at the raising and comparison of different crops, not individuals. They will accordingly be conducted along normal silvicultural lines and the best practical methods of raising crops for the normal objects of management will guide the tending of the experiments. This general rule of conduct needs to be written into the working plan for the experiment, and if deviations from it are required by the particular object of any experiment, they must be clearly specified.

The Seed Collection Stage

It follows from the general object of the experiments that seed must be collected from all the seed bearing trees in a stand if the parcel of seed is to be a sample of