GEOGRAPHIC VARIATION IN JAPANESE LARCH[1]

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The need for a definition of the genetic variation throughout the range of a tree species is one of the most obvious problems presented to the forest geneticist. Foresters have long been aware of this problem, and considerable effort has gone into establishing seed source studies, or the investigation of *in situ* variation throughout the range of a species. Despite the apparent simplicity of the problem, we find that we still have much to learn about most species in regard to the total population variation available. The answers are obscured by soil site differences, and general and specific environmental differences; as well as by the problems of adequate sampling and design. In general the individual researcher finds his desire for total information about the performance of a given species thwarted by the size of experiment that is required, and thus many "provenance" or "geographic variation" studies are a compromise to determine broad patterns of variation without intensive intra-ecotypic sampling. The most informative studies of geographic variation are usually those obtained by the cooperation of several interested scientists working in different regions with coordination of the entire study. In this manner seed of a given species may be collected throughout its natural range and replicated field trials established on a variety of planting sites.

Our present status of knowledge concerning geographic variation in Japanese larch reflects the foregoing discussion. There have been several individual studies of geographic variation in Japanese larch as well as more recent cooperative studies. It may be somewhat premature to intensively evaluate all of the studies currently in progress because of their recent origin. Nevertheless, certain generalizations are becoming apparent and it is within the terms of reference of this paper to examine these broader concepts:

DISTRIBUTION OF JAPANESE LARCH

Japanese larch has a small natural range (fig. 1), and in terms of latitude or longitude differences one would not expect larch population differentiation. However, within the range of this species there are strong environmental differences. Its range of natural distribution is limited to the island of Honshu and extends over the southern part of Miyagi Prefecture and the Shidzuoka Prefecture, on Mt. Manokami (about 38° 5' N.L.) and Mt. Yamazumi (35° 8 N.L.). In addition fairly large stands can be found in the Oze-Nikko Mountains, Mt. Asama, Mt. Shirane in Joshu, the Chichibu Mountains, the Yatsugatake Mountains, and Mt. Fuji (Hayashi, 1951). Within this range it occupies elevations of 900-1850 m, in the north, and 1000-2800 m. in the central and southern areas; with the best growth found between 1400-1800 m.. in the north and between 1400-2100 m. in the central and southern regions. Soils in this region are principally of volcanic or limestone origin (Hayashi, 1951). Rainfall within the region varies between 50 and 140 in. per year while the range in mean annual temperature is from 34° to 45° (Lines, 1962). The species range is not a single sympatric population but is made up of several genetically isolated, smaller populations. In reference to the United States, the latitude comparison approximates a line south of Pennsylvania across Kansas, to central California.

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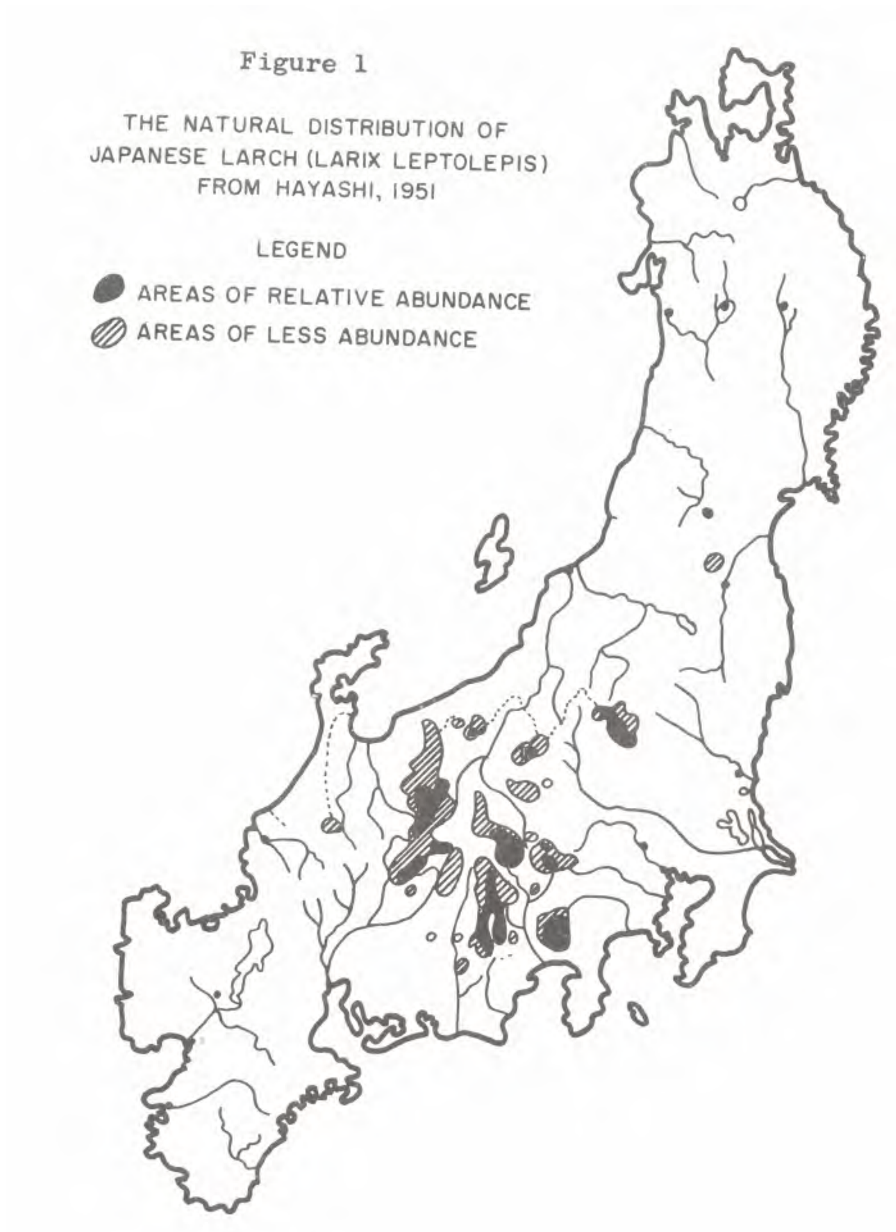

Figure 1

THE NATURAL DISTRIBUTION OF JAPANESE LARCH (LARIX LEPTOLEPIS) FROM HAYASHI, 1951

GROWTH RESPONSES IN JAPANESE LARCH

Taxonomic races or forms of the species are not usually recognized with the exception of a high altitude dwarf form (var. _minor_ Sarg). Rheder (1956) suggested that the dwarf form reverts to the normal form under cultivation, an indication that the dwarf condition is principally an environmental response. In addition certain foliage types have been recognized although these types appear to be unrelated to geographic origin. The foliage types suggested refer to the character of secondary branches and range between two extreme types: "fine-slender", and "coarse-stiff" (von Schrotter 1954, and Lines 1955). Both authors have suggested that the "fine-slender" type of tree is more vigorous but has a higher proportion of wavy stems, whereas the "coarse-stiff" type contain a higher percentage of straighter stems. In a study of six seed sources of Japanese larch, Lester (1964) found genetic differences in the time of bud setting, along with variations in needle angle that were attributable to seed source. Early analysis of provenance studies in England have shown various form differences; among these were a correlation of poor or wavy form with certain provenances (Lines and Aldhouse, 1961) and differences in autumnal color (Wood, 1960). Langner (1960) also found a genetic correlation between seed source and fall needle retention or autumnal coloration.

Japanese larch is considered a "fast growing species", and in relation to other larches it has usually shown equal or superior growth rates. In a comparison of 29 larch species and provenance trials, between 8 and 45 years old, Schober (1958) reported that Japanese larch was consistently among the best species in terms of height growth. It is significant to note that immunity of Japanese larch to the canker Dasyscypha willkommii was reported as contrasted to a high susceptibility of European larch at many localities. In plantings in New York State, Eliason and Carlson (1963) compared volumes of Japanese, European, Dahurian, and Dunkeld larches growing in adjoining plots, Although not statistically replicated the data showed Japanese larch to be superior to all other species, and approximately equal to the production of the Dunkeld hybrid The foregoing study corroborates an earlier report by Littlefield and Eliason (1956) which also indicated that Japanese larch and the Dunkeld hybrid were consistently the fastest growing larch species in New York State, A similar report of Japanese larch growth potential in comparison to other larch species in England was reported by Edwards (1952). In Germany Langner (1951) reported an overlap of the best Japanese and European larches in height growth, but with a trend of superior height growth for the Japanese; again the Dunkeld hybrid was somewhat above the other two species. Gotbe (1952, 1953) in a small breeding study of European and Japanese larch, found little difference between the two species, although the hybrid was noticeably superior during the first two years. A Japanese larch seed source study in Minnesota utilized a border planting of European larch (Pauley et al. 1965) and a comparison of the two species showed a marked superiority of the Japanese larch after 5 years in the field

Growth variations within the species relative to seed source have been reported in many of the aforesaid studies. The trend has been for reports of significant differences between provenances, but without consistent correlation with altitude, latitude, or environment. As previously noted Hayashi (1951) suggested that the best growth within the natural range was obtained between about 4500-6900 ft. Wood (1960) reported the best height growth of the species in England was obtained by sources originating from below 6,000 ft.; Kepler (1962) found the best height growth in Iowa from provenances above 5,600 ft. while Lester (1964) found no apparent association with altitude or latitude of sources in Wisconsin. The latter report was confirmed by observation of the same seed sources planted in Minnesota (Pauley et al. 1965). Comparison of these latter two studies is confounded by environment, time, and design; only fair correlation may be noted between the two in terms of seed source ranking. Nevertheless, it is significant to note that the best two sources were the same, although reciprocally arranged, in both studies. Langner (1961) also reported a lack of altitude or latitude correlation with growth rate in a German trial. The latter report is from a well designed international Japanese larch provenance study (see Langner 1958, 1961) planted in several countries, and contains 25 seed sources collected throughout the species range. A report by Wright (1962) substantiated the inefficacy of altitude or latitude as a predictive factor in a replicate of this study planted in Michigan, while significant differences were noted between sources. The best sources thus far found by Langner were not the fastest growing in Michigan and correlation between the two studies is low, A replicate of the study is planted at the N. Y. College of Forestry Experiment Station and preliminary height growth data have been obtained (table 1). Inspection of these data indicates a trend similar to that found in other regions, but with a rather poor correlation regarding performance of specific seed lots. An analysis of variance for height growth showed a significant difference (F.01) between seed lots in 1965, although considerable variation may be seen in the ranges of the individual lots. It is also evident in table 2 that the relative mean ranking of several lots had changed during the period from 1962 to 1964.

INTERNATIONAL SEED SOURCE STUDY — Table 1

LARIX LEPTOLIPIS - SYRACUSE EXP. STA.

Seed Source	Latitude (N)	Elevation (m)	Mean Height In Meters 1960	1961	1962	1964	(Height Range)1962 Lowest - Highest	(Height Range)1964 Lowest - Highest	Rank Greatest to Least	
2785	35°25'	1,320m	0.20	0.38	1.13	3.26	0.46 - 1.58	1.82 - 4.32	9	9
2786	35°24'	1,760m	0.15	0.28	0.94	2.59	0.78 - 1.37	1.34 - 4.48	19	19
2788	35°57'	1,500m	0.19	0.32	1.24	3.38	0.78 - 1.56	0.76 - 4.57	3	3
2789	36° 2'	1.750m	0.25	0.41	1.47	3.81	1.36 - 1.58	2.77 - 4.17	1	1
2790	36° 0'	1,700m	0.16	0.31	1.08	3.35	0.66 - 1.54	1.18 - 4.57	10	6
2791	36° 5'	1,600m	0.15	0.25	0.98	3.29	0.65 - 1.34	2.74 - 4.26	17	8
2792	36° 2'	1,700m	0.19	0.31	1.21	3.41	0.88 - 1.51	1.85 - 3.84	5	3
2793	35°56'	1,450m	0.24	0.28	1.08	3.20	0.90 - 1.47	2.34 - 4.42	10	10
2794	35°56'	1,750m	0.15	0.33	1.22	3.32	0.87 - 1.52	0.88 - 4.17	4	7
2796	35°26'	1,900m	0.22	0.36	1.19	2.95	0.87 - 1.37	1.40 - 4.05	7	14
2797	36°46'	1,360m	0.22	0.32	1.14	3.17	0.77 - 1.59	1.52 - 4.14	8	11
2798	36°47'	1,480m	0.15	0.29	1.01	2.89	0.79 - 1.18	1.58 - 3.99	16	15
2799	36°47'	1,700m	0.27	0.26	0.94	2.71	0.61 - 1.09	1.00 - 4.02	19	17
2800	36°38'	1,700m	0.22	0.34	1.07	3.04	0.83 - 1.36	0.85 - 4.17	12	13
2801	36°24'	1,900m	0.23	0.33	1.06	3.41	0.84 - 1.25	3.01 - 4.20	14	3
2802	36°24'	1,400m	0.15	0.25	0.98	2.50	0.74 - 1.23	1.40 - 3.59	17	20
2803	36°23'	1,700m	0.18	0.29	1.07	2.86	0.86 - 1.28	1.06 - 5.64	12	16
2807	35°47'	1,818m	0.29	0.31	1.21	3.50	0.85 - 1.39	2.22 - 4.48	5	2
2808	35°54'	1,380m	0.30	0.39	1.06	3.10	0.67 - 1.33	0.94 - 4.35	14	12
2809	36° 3'	1,920m	0.38	0.46	1.28	2.65	0.94 - 1.52	1.76 - 3.32	2	18

AN ATTEMPT AT CORRELATION

The foregoing review has established that significant geographic variation is found in Japanese larch, despite a relatively small (Ca. 150 sq. miles) species range. The range of variation found is usually not large, and may indicate several equally good seed sources. Thus the tree breeder may be more concerned with avoidance of a poor seed source than the selection of the absolute best. The pattern of variation appears to be discontinuous since the correlation between growth rate and seed source latitude and altitude has usually been non-significant. In addition, the limited evidence from investigations replicated in differing environments suggest a strong genotype-environment interaction. However, in appraising these factors one must keep in mind that there have been relatively few well designed multivariate studies of the collection zone environments in relation to subsequent seed source performance. We are in a similar state of data paucity concerning reports from replicated studies of the same seed lots planted in different environments. The question of normality of distribution within sub-populations of Japanese larch also deserves additional research. It is quite possible that these small, isolated populations have not retained the innate genetic capacity to resist fixation or elimination of a part of their normal variance. While statistically significant variations may be found between seed sources, one often finds considerable overlapping in comparing the within source ranges for a given character.

Two standard approaches to tree improvement work may be recommended for the genetic improvement of Japanese larch. These may be summarized as: (1) the establishment of classical seed source studies, replicated in all of the general environments where it is desired to plant the species; and (2) mass selection within the "best" existing plantations to provide seed for planting while interim seed source or breeding studies are in progress.

In reference to (1) above, the classical seed source studies should be followed by subsequent selection and breeding within the best sources. In addition, intra-source crosses may be made to determine the extent of non-additive (or additive) variance available by this method.

The long term nature of provenance and breeding research makes it imperative that concurrent mass selection be initiated within existing plantations. Despite the lack of seed source knowledge in most older plantings, the performance of such material provides a measure of confidence for future breeding work. This is especially true when the plantings are growing in the regions where planting is anticipated, or when replicated plantings provide a basis for estimating genotype-environment interactions. These selected plantings may be converted into seed production areas and also used in more intensive breeding studies. Sample seed lots from selected plantations should also be included in any seed source studies that are initiated. The ability of larch species to form natural hybrids indicates a need for caution when dealing with plantations. Taxonomic evaluation should be a part of pre-selection practice; in seed collection work care must be taken to see that foreign pollen has been excluded during the previous pollination season,

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