Forest Tree Breeding in Japan

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Introduction

Japan is a country of abundant forest, as 68% of its land (ca. 37 million ha) is under forest. But, owing to its large population, forest land per capita is only 0.24 ha. About 31% of the forest area and 40% of the growing stock belong to the state and under the control of the Forestry Agency, Ministry of Agriculture, Forestry and Fisheries. About 40% of the total wood demand of the country can be met by the domestic forests while the balance relys on the wood imported from many countries located in frigid or tropical regions.

As Japan has a wide stretch of the land north to south more than 3,000 km, its forests have also different features according to the climates and human activities in the different regions. In Hokkaido, the second largest island of Japan, natural sub-frigid forests are dominated and there are tree species such as *Picea, Abies, Quercus, Betula* and others. In Honshu, the main island, there prevail natural cool temperate forests having tree species of *Crytomeria, Chamaecyparis, Pinus, Abies, Tsuga, Fagus, Quercus* and others, and man-made forests mostly consist of *Crytomeria, Chamaecyparis* and *Pinus* spp. In Sikoku and Kyushu with warm temperate climate, broad-leaved tree species such as *Castanopsis, Cyclobalanopsis* are dominant naturally. In these districts, *Cryptomeria* and *Chamaecyparis* are planted mostly.

As the domestic wood production has been in shortage as mentioned above, streneous efforts have been made to promote productivity of forests. The target figures of the improvement of the country's forest resources were established by the Basic Plan Regarding Forest Resources authorized by the Cabinet on 16th February 1973 and which are presented in Table 1. In the final stage, the area of artificial forests will become 54%, and growing stock per ha and annual cutting per ha will be increased up to 1.7 and 2 folds respectively.

For this purpose, forest tree breeding activities have a very important role in our forestry. Not like in the case of agriculture,

Table 1. The target figures of improvement of forest resources by the Basic Plan Regarding Forest Resources authorized by the Cabinet on 16th February 1973

		Present stage	Intermediate stage		Final stage
		1971	1991	2021	
Ratio of man-made forest to total forest	(%)	37	53	54	54
Growing stock per hactare	(m^3/ha)	86	118	148	149
Annual cutting per hectare	(m^3/ha)	2.7	3.1	4.9	5.2
Forest road milage	(1,000 km)	70	238	267	267
Rate of self-supply	(%)	46	40	62	—

it can not easily be expected to improve or to reform the forest land itself, so that the forest tree breeding and forest road making are only two activities which contribute to the basic improvement for wood production. In other words, it may say that forest tree breeding is a typical technique to utilize natural energies such as sun shine, precipitation, soil fertility etc., and to enrich forest environments to the highest possible extent through genetical improvement of trees. But, owing to the huge size of the trees and their longevity under little harnessed natural conditions, it needs long time and laborious works for practicing the forest tree breeding. An effective system for the forest tree breeding has to be developed.

Forest tree breeding by means of selection

At present, the most important procedure of forest tree breeding is the selection breeding, and it can be easily incorporated into practical reforestation through the supply of planting materials from seed orchards and scion gardens established with selected plus trees. In agriculture, new varieties are bred at research institutions and their adaptability is tested at different sites with varying environmental conditions for several years. After they have passed the varietal tests, newly developed varieties are distributed for practical cultivation. So that, it may happen in some districts that old varieties are expelled completely within one or two years. However, if the similar procedure is employed in the forest tree breeding, we have to wait more than 50 or 100 years or even more for the use of newly bred forest tree varieties. Moreover, we can not replace immature forests with new forest tree varieties even if they were extraordinarily excellent, and we can only plant them after the harvest of the former standing trees. The forest tree breeding might be said that it is a regeneration procedure of continuous promotion of genetic nature of the planting materials that can only be done within practical forestry. We have to use more improved materials for reforestation all the time. Thus genetic quality of the trees are gradually and steadily improved and the forest lands will be replaced with more economically superior materials year after year as shown in Fig. 1. The height of the promotion waves in Fig. 1 depends on our techniques for plus tree selection and frequent sending of the promotion wave is really hoped. If we are more successful in selecting true plus trees a tide may be higher. Thus forest tree breeding should be carried out with an expectation of genetic progress to some extent (this will be

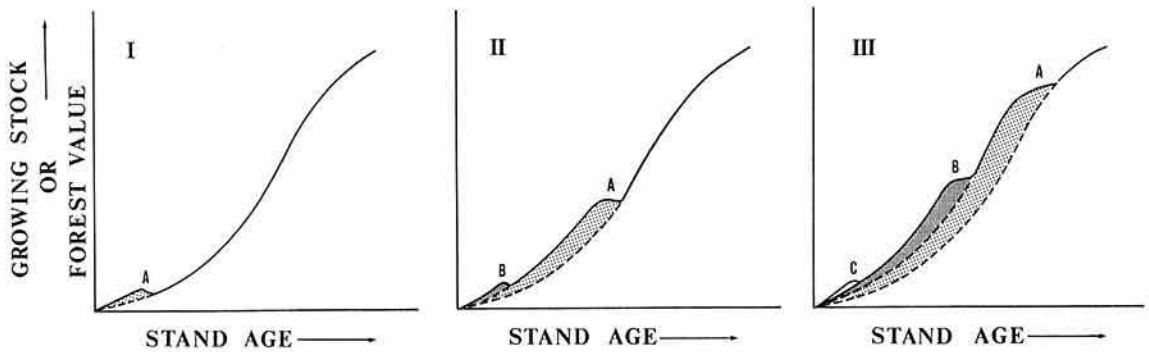

Fig. 1. Schematic diagrams of replacement of forest land with bred materials in an unit organization of forestry management.
I, II, III ; Successive stages of regeneration.
A : Early Stage of utilization of seeds and scions from plus-tree orchards.
B : More improved seeds and scions are used after rouging inferior clones in the plus-tree orchards.
C : Utilization of seeds and scions from the second generation plus-trees.

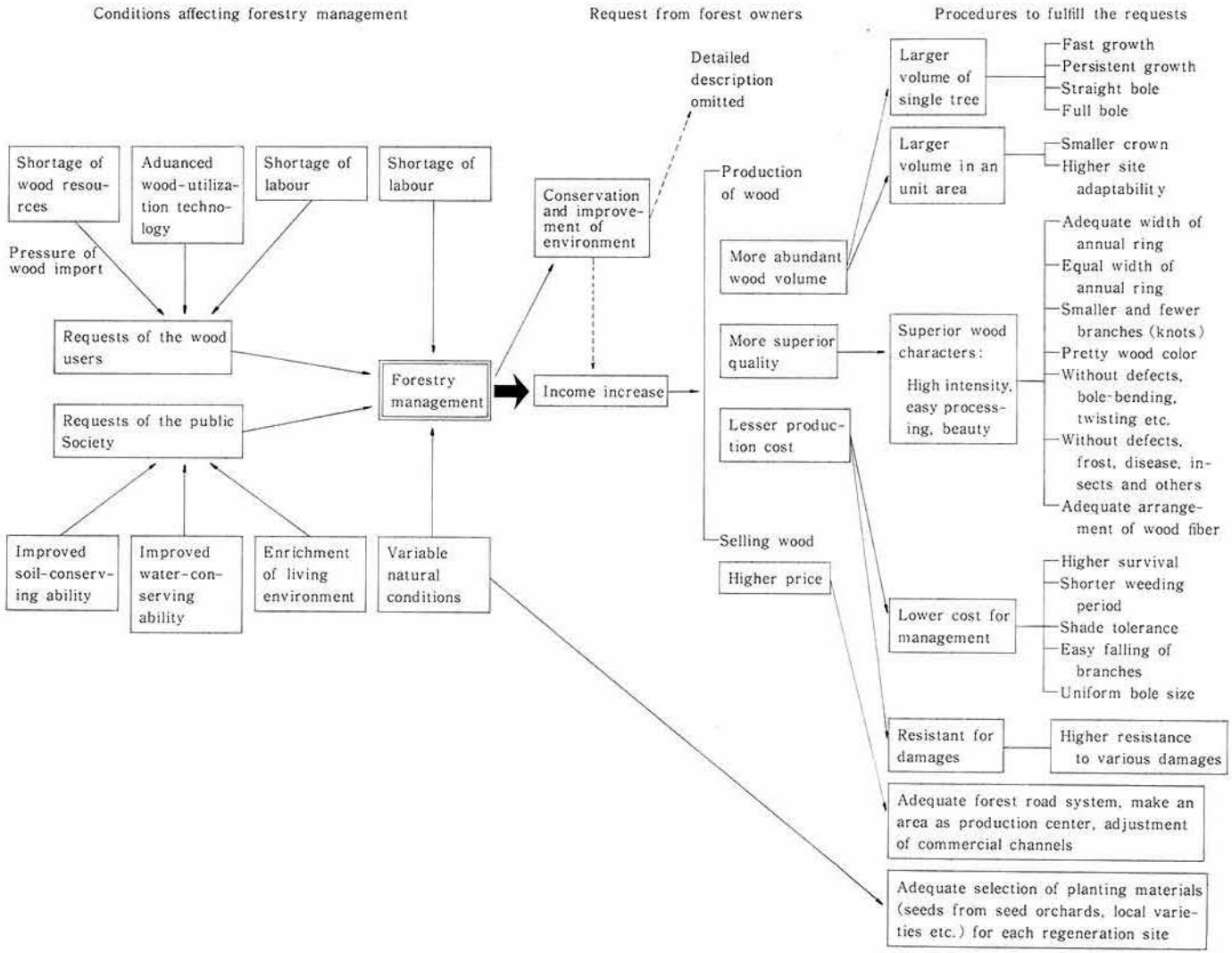

Fig. 2. Objectives of the forest tree breeding and procedures to achieve them. This original scheme was made by Niga, T. (Rinboku no Ikusyu No. 91/92, 1975)

proved after progeny test), whereas agricultural crop breeding proceeds with certainty of genetic progress.

In the natural regeneration, it is primarily important to keep superior trees or to rouge inferior trees expecting to have improved progenies in following generation, and this selection should be made before harvest. If we fail in this selection, we will have deteriorated forests in comparison with those in the former generation. Even in the artificial regeneration regardless clear cutting or non-clear cutting, we should add newly selected plus trees to the seed orchard and the scion garden continuously to create the waves of improvement frequently as shown in Fig. 1. For this purpose, selection of plus trees before harvest is highly required. And it is believed that the value of a tree (wood) is most easily and perfectly judged at its felling, so that the selection of plus trees before harvest should be made as a routine work of regeneration as a rule.

At present, active and successful works in forest tree breeding have been done in the tree species being regenerated artificially. It is quite probable from the facts that, in artificial regeneration most of the tree breeding activities except plus tree selection are carried out at the convenient sites where we can concentrate our investments (money, manpower and etc.) in relatively narrow areas. If we expect to have successes in tree breeding activities for natural regeneration, further cooperative works among people in the field of silviculture, pedology and so on, are needed.

Objectives and procedures of forest tree breeding

Objectives of the forest tree breeding and procedures to achieve them are illustrated in Fig. 2. Impacts of natural and social conditions for each tree species may differ in items and needs, and procedures to fulfil the requests may also varied in different tree species.

Cooperating organizations for forest tree breeding in Japan

A simplified diagram of the organizations involved in forest tree breeding in Japan is presented in Fig. 3. Owing to the difficulty in

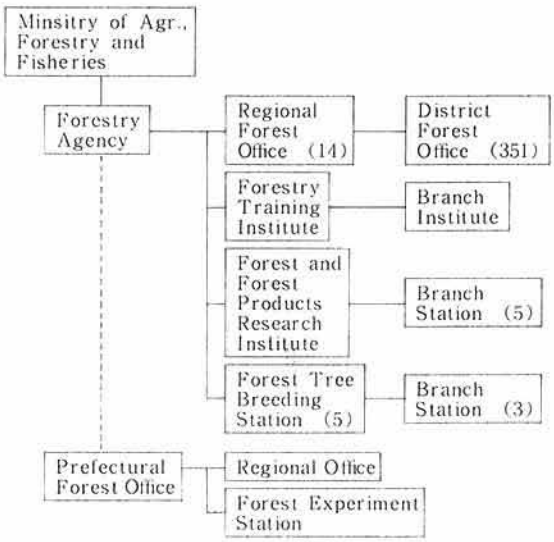

Fig. 3. A simplified diagram of the organizations involved in the forest tree breeding in Japan.
—— Direct control
····· Indirect control

undertaking the forest tree breeding, as it needs large area, long term and much labour, and the inseparability from practical forestry, the scale of the tree breeding works can not be circumscribed to only Forest Tree Breeding Stations, but close cooperative works with other research organizations and administrative offices both in national and private forests are required. The nation-wide plannings of the practical forest tree breeding were made at the Forestry Agency with technical aids of Forestry and Forest Products Research Institute. Detailed plans in each district were made at the National Forest Tree Breeding Stations after consultation with respective organizations concerned in their districts.

Activities of the forest tree breeding

1) Forest tree breeding by means of plus-tree selection

In 1956, a nation-wide forest tree breeding by means of plus tree selection was started in Japan. After about 10 year's selection activities, about nine thousand plus trees of different species were registered as shown in Table 2. For this purpose, five National

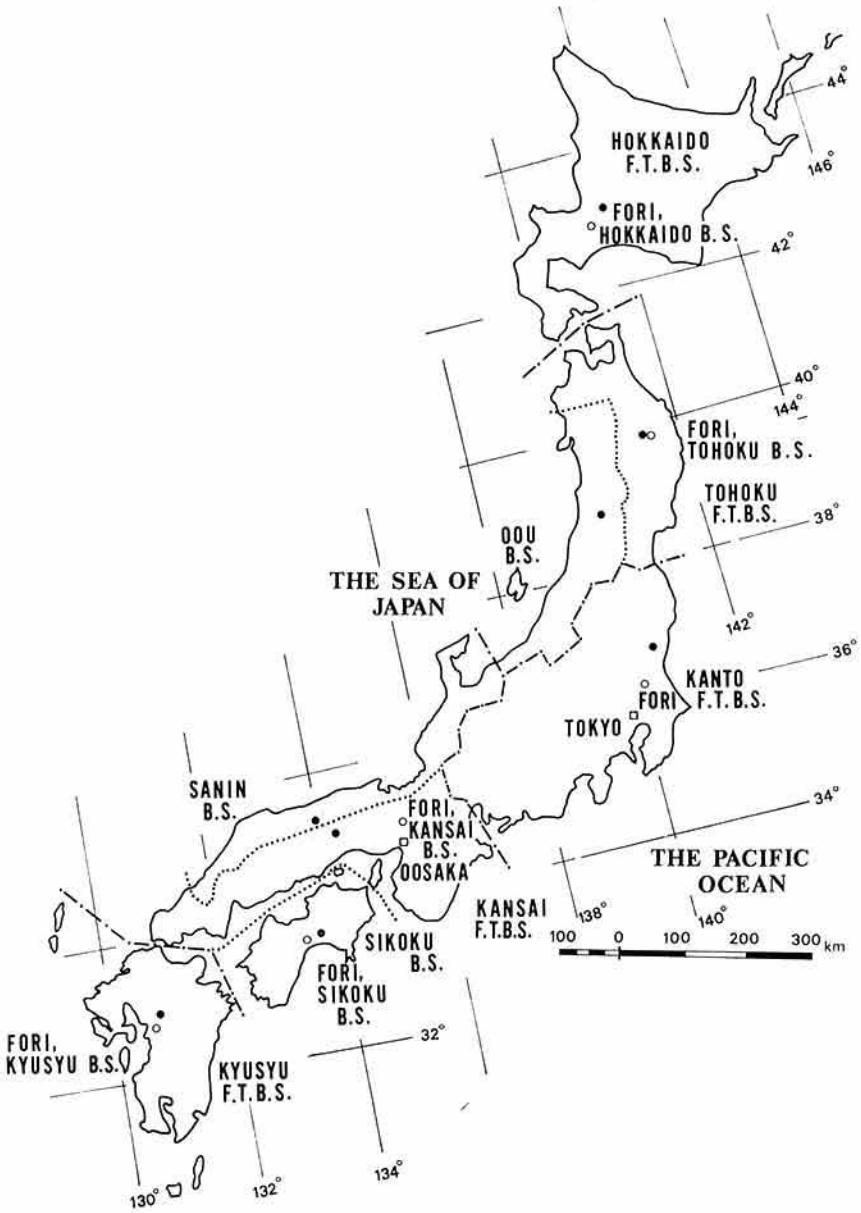

Fig. 4. Research-and breeding stations in forest tree breeding and their coverage in Japan.
FORI: Forestry and Forest Products Research Institute.
F. T. B. S: Forest Tree Breeding Station
B. S.: Branch Station of F. T. B. S.

Table 2. Number of plus trees registered

Unit : tree (Nov. 1976)

Tree species	National forest	Private forest	Total
Cryptomeria japonica	1,016	2,540	3,556
Chamaecyparis obtusa	251	664	915
Pinus densiflora	252	765	1,017
Pinus thunbergii	87	444	531
Larix leptolepis	272	373	645
Picea jezoensis	476	53	529
Abies sachalinensis	526	263	789
Other conifers	255	148	403
Broad leaved trees	392	22	414
Total	3,527	5,272	8,799

From data of the Afforestation Division, Forestry Agency, Ministry of Agriculture, Forestry and Fisheries.

Table 3. Seed orchards and Scion gardens established

(Nov. 1976)

	National forest	Private forest	Total
	ha	ha	ha
Seed orchard	625	1,084	1,709
Scion garden*	460	447	907
Total	1,085	1,531	2,616

From data of the Afforestation Division, Forestry Agency, Ministry of Agriculture, Forestry and Fisheryies.

* Mostly for *Cryptomeria japonica*

Forest Tree Breeding Stations with three Branch Stations were established and each station covers its district as shown in Fig. 4. These key stations made close cooperation with regional state forest offices and prefectural forest offices for the selection of the plus trees and establishment of seed orchard and scion garden as presented in Table 3. Soon after the establishment of them, practical supply of the seeds and scions from these plus tree materials was started. In 1969, a project of progeny test with a ten-year plan was initiated. Some of the progeny test plantations reached the age of about ten years already, and valuable data are being obtained steadily.

2) Forest tree breeding for climatological resistance

Since 1970, selection of individuals phenotypically resistant against climatological damages such as frost, cold wind, and crown-snow pressure was started under nearly the same regimes of the plus-tree selection. Seed orchard and scion garden will be established after artificial early testing of the materials except for snow-resistance, and field tests of the propagated plants for the resistance were also planned to certificate the characters. And these materials were expected to be used for artificial plantations in a little more severe climatic sites than as usual following the expansion of artificial plantation areas.

3) Other tree breeding projects started

Selection works of pine-wood nematode resistant individuals was initiated for *Pinus densiflora* and *Pinus thunbergii* in south-western districts of Japan in 1978. Since around 1940, some low land pine forests have been attacked by many kinds of bark beetles to death, and recently the damage reached about one million cubic meter annually. Some years ago, it was proved that the pines were killed by one species of wood nematodes, *Bursaphelencus lignicolus*, carried by a vector species of long horn beetles. The candidate individuals will be selected in the heavily attacked pine forest with less than 10% survival. They are propagated by grafting for artificial inoculation tests using the nematodes which are being cultured in the artificial potato-agar medium. The test is expected to be done twice for the clones, namely, a preliminary test and the final test. The final test will be made for those candidate individuals selected by the preliminary test.

A tree breeding project for deciduous oaks, *Quercus acutissima* and *Q. serrata* as bed log for edible mushroom culture, *Lentinus edodes*, was also started in 1978. This mushroom is very famous for its economic importance in the forest-provinces. The oak logs were used as culture beds for the mushroom after the

artificial inoculation of cultured hyphae. Characters to be improved in this project are fast growth, straight bole, smaller crown and thin bark with dense net-furrows. Adaptability for less fertile forest land is also requested.

Research activities on forest tree breeding

To support several active projects of forest tree breeding and to exploit further development in the forest tree breeding, intense research activities are in progress at the Forestry and Forest Products Research Institute, National Forest Tree Breeding Stations and Prefectural Forest Experiment Stations respectively. Basic problems such as breeding methods and inheritance of traits, economic and non-economic, are dealt at the Forestry and Forest Products Research Institute, and the National Forest Tree Breeding Stations share researches on applied fields such as propagation techniques of plus trees, managements of seed orchard and scion garden, measurements of progeny test plantations and others. Prefectural stations are also responsible for research on practical problems as a rule.

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