Strategies for a Balanced Tree Improvement Program Based on Gene Conservation

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It would be presumptuous for me to present to you a tree improvement program based on the developments of forestry in Taiwan, because one has to become thoroughly acquainted with all aspects in the operations involved to recommend effective methods and approaches that will be adapted to local conditions. The forest ecosystems in Taiwan are diverse; consequently, practical constraints are many and vary greatly. In view of the current philosophy of conservation developed around the world, however, one could certainly discuss the problem on a broader scale, instead of following previous efforts in concentrating on techniques about how to produce genetically superior materials for reforestation.

As long as man has been on this planet, forests have been part of his environment, and yet, from time immemorial, forests also have been mined rather than managed by man. Only recently have foresters recognized that natural resources, including forests, not just in any particular region, but preferably all over the world, must be conserved and managed in perpetuity.

Modern forestry accentuates man-made forest plantations, as indicated in the report published in 1967 by the Food and Agriculture Organization of the United Nations that in 1965, the global area of man-made forests was estimated at about 80 million hectares and was expected to double in the next twenty years; practically all these man-made forests were established with the idea of increasing the productivity of the forest land and to meet future demands of the world for not just wood products, but other amenities derived from the forests. Meanwhile, an ecological conscience is by no means a neglected concept or movement and hence the upsurge of global actions in exploration and conservation of all natural resources. For a forester, a forest geneticist in particular, the conservation of forest genetics materials should be viewed as an integral part of a dynamic forest resource management plan and a part of the program for improved utilization of gene resources.

Adequate information has been published dealing with different breeding methods, including techniques of various kinds, in assessing and producing superior tree specimens for reforestation or afforestation (Shelbourne 1969, Wright 1976). Nevertheless, our view should be broadened, as reassessments of many genetics improvement programs indicate that one should place emphasis not only in the limited number of species currently enjoying the attention of tree breeders, but they and other species should be conserved and utilized in the context of long-term planning and also broad in scope of distribution and testing.

With the premises mentioned above, this paper outlines broadly the facets of strategy that might affect the success of the program: research, production, and economic factors. Because genetic diversity is a well known biological reality, the first step in applying genetic principles in modern forestry practice naturally comes in the form of assessing genetic variation within available tree species. Next step would be to maintain a large genetic basis for selection and breeding programs. These two important steps require two simultaneous and overlapping operations, namely, research and production. These operations can be described in the following manner.

Research

In regions where a diversity of productive species is available, a knowledge of the vegetative and reproductive cycle of various valuable commercial tree species in different ecosystems is of paramount importance. The data could help in elucidating various phenomena that control growth processes and in solving problems related to seed orchard establishment, such as clonal arrangement, contamination of pollen, and inbreeding experiment with stocks carrying marker genes.

Guidelines for researchers in understanding and outlining different aspects of the diverse ecosystem have been formulated by many workers (Roche 1975). In essense, they are basically human-oriented endeavours. Study and assessment of ecosystems are classified currently into *in situ* and *ex situ*.

A. *In Situ*

The method entails using information gathered through vegetation surveys, land inventory and taxation data, aerial survey photographs, and records obtained by the civilian and military sources so that representative samples of species and their distributions can be efficiently delineated in various forest ecosystems. Populations selected subsequently can be regenerated naturally or artificially in place of origin.

Constraints on the effective action in carrying out this kind of research, naturally depend on the complexity of the forest ecosystems involved and on the genetic variability and breeding systems of species in question. The exploration and conservation of these genetic materials, beside the utilitarian viewpoint, is to safeguard those natural stands at the limits of the species range or in isolated blocks. For example, *Pinus morrisonicola* in Taiwan is listed as an endangered species with extinction or severe depletion of the gene pool likely (FAO 1975).

Some of these materials thus conserved may not have any immediate use in the applied or production phase of the tree improvement program, but technological changes in the future might change the utilization picture entirely. Therefore we must keep our options open, and as one works through the first round of exploration he can sharpen his senses and increase the knowledge of the existing natural variation, delimit endangered populations or species, evaluate new environments and then plan for further exploration, conservation, and perhaps eventual utilization of the preserved materials, as evidenced by the large numbers of afforestation projects with many indigenous tree species all over the world.

In general, a balanced tree improvement program should begin with well-understood silvical characteristics and genetic background information of the species. In situ conservation measures include seed zone designation, retention of rare or unique genes, and maintaining the particular gene frequency distribution characterizing the gene pools of existing populations, in dynamic balance with the diverse climates in which the species have lived and survived.

B. Ex Situ

For certain species, such as *Pinus albicaulis*, *Tsuga mertensiana*, *Abies lasiocarpa* and other high-elevation trees in the Pacific Northwest, for example, the setting aside of forest lands in national parks, wilderness areas, or the equivalents, may be adequate to protect and preserve gene pools of some tree species. But some disturbing news, especially that from subtropical and tropical areas where forest exploitation, overharvesting, or developments for recreation or agriculture are rules rather the exceptions indicates that one may not have much time to maintain the natural ecosystems intact and allow the tree species to survive. In these situations, conservation *ex situ* must be employed immediately. In other words, populations of the tree species should be sampled, studied, identified, and planted and should be perpetuated artifically at locations other than the original areas. In *ex situ* conservation, matching planting sites with the conserved species, along with the developments of techniques of planting and caring, are just as important to maintain high efficiency of planning. The simplest way to conserve those species that are in great danger of being eroded, especially when the biology of the species and silvicultural techniques have not been thoroughly studied, is seed and/or pollen storage.

Production

The main purpose of forest tree breeding and selection is to develop better varieties. But the benefits of improved varieties either for higher yield or for specific purpose at a designated location can not be realized until enough seed or plant materials have been produced to allow the new varieties to be grown on a commercial scale over the entire area to which they are adapted.

Commercial seed production is the responsibility of seedsmen and seed orchardists who have the experience and equipment to grow and market large quantities of genetically superior seed. Meanwhile, newer technologies such as tissue and cell culture, and somatic hybridization, soon will become routine in the genetic improvement of forest trees. The special issue of New Zealand Journal of Forestry Science on vegetative propagation amply reflects the future trends and their potentialities. Kleinschmit and other workers have reported that successful large-scale cutting propagations (rootings) of Norway spruce have already been through two selection stages, and are being used in practical forestry (Kleinschmit 1974).

Administrative Aspects

It is quite common for tree geneticists to underestimate the importance of the attitude and mentality of the administrators as the tree improvement program is being formulated. The testing generation, that is, the length of time required to test the genetic potentialities of trees, may be much shorter than is commonly presumed, nevertheless, the so-called "administrative fatigues", namely: forming of the idea of long generation length per se, and the endless inquiries for information on costs and benefits may actually rate of progress more than any other factor. Therefore, breeders must work very closely with administrators. The former must prepare research plans with great justification of how to proceed to obtain productive results, and the latter should have better training and knowledge of biological phenomena so as to help in deciding the research needs and means of financing the program.

Among the many additional activities that fall into this category is the dissemination of information. Quite often, practicing foresters consider that information obtained by researchers either is difficult to understand or is not available to them. Therefore, administrators should work jointly with researchers so that experimental results will be translated into terms of economic returns or whatever forms so that the public as well as foresters at all levels can understand and appreciate the value of the breeding work.

Overall coordination is another pertinent facet in any balanced program. In a country where foreign advisors are invited to review or recommend steps to be followed in a forest genetics program, a clear picture of direction and objectives to be obtained should be presented to them, so that there will be no unnecessary changes in the long-term goals. Of utmost importance is the avoidance of contradictory suggestions and comments by various advisors on approaches and methods used in the program.

Economic Factors

Success of the balanced forest genetics program depends on many of the aforementioned factors, such as what priorities to set as far as species and conservation methods are concerned, the man-power problem, and the availability of data on the genetics and ecology of tree species and ecosystems.

One of the methods to economize expenditures is to utilize what is known as the Computerized Information Retrieval Service, where indexes and abstracts can be searched to prepare custom bibliographies to meet various needs. Most governmental agencies and universities have such a well-organized program in addition to excellent Computer Service Centers, which provide speedy data compilation and analyses. The recent development of organizing a data bank among workers from the IUFRO Working Party on Douglas-fir provenance study certainly will become a valuable vehicle for their research work for the small sum of $5,000.

Although each country may have its own problems and vary in costs in handling the genetic program, the best way is to view a successful tree improvement program not for a short term and a local or regional need, but for the long-term conservation of genetic resource conservation and utilization, with the program as an integral part of the global plan for the species in question. Under these circumstances, financing could come from the country where the program is being implemented or could be shared by some international sources such as the United Nations Environment Programs and the International Board for Plant Genetic Resources.

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