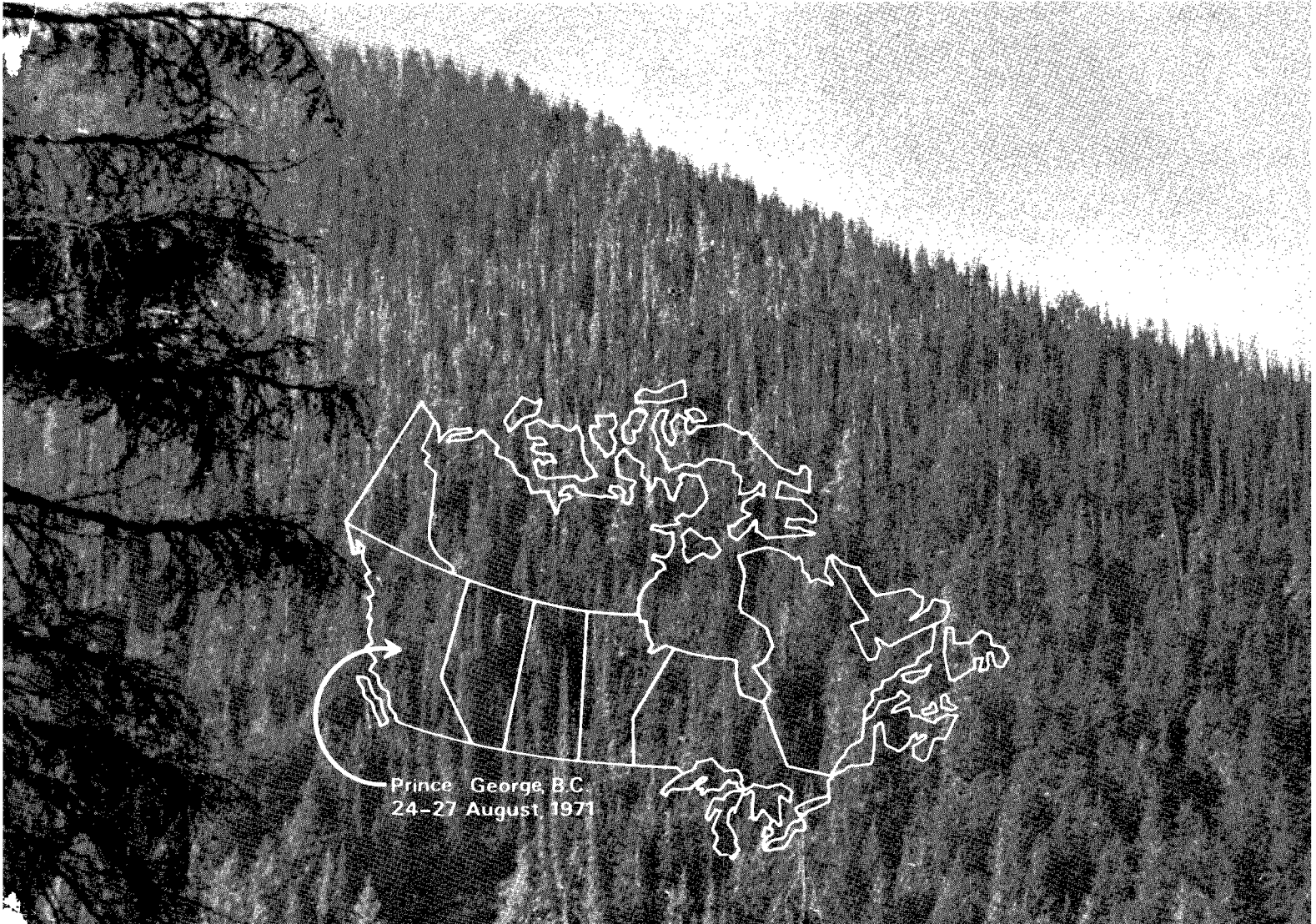


Proceedings of the thirteenth
meeting of the committee on
forest tree breeding in
Canada: Part 2

Comptes rendus de la
treizième conférence du
comité canadien d'amélioration
des arbres forestiers: Partie 2



PROCEEDINGS OF THE THIRTEENTH MEETING OF
THE COMMITTEE ON FOREST TREE BREEDING
IN CANADA

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PROCEEDINGS OF THE THIRTEENTH MEETING OF
THE COMMITTEE ON FOREST TREE BREEDING IN CANADA

PART 2

SYMPOSIUM ON THE CONSERVATION
OF FOREST GENE RESOURCES

Editors: D.P. Fowler and C.W. Yeatman

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INTRODUCTION

"The decades through which we are living are critical and disturbing ones. An increasing world population means increasing demands on its environment. This has resulted in an intensified exploitation of the biosphere, very often without long-term planning or the necessary research background, and without coordination between nations. As a consequence, there is an alarming deterioration of natural resources, which not only adversely affects the present human habitat but constitutes a threat to the well-being of future generations."

A.H. Boerma
Director-General (1970)
F.A.O. of the United Nations.

Gene conservation is no longer the reserve of a few agricultural plant breeders or geneticists seeking desperately for new sources of variation to enrich the gene pools of a few highly selected plant species. Scientists in many fields of biology recognize the need to conserve or preserve a sizeable portion of genetic variation of this planet so that man can continue to enjoy and further develop the living organisms upon which he is so dependent.

The gene pools available to tree breeders are, with few exceptions, "wild" and relatively unselected by man. Certainly when compared to the agriculturalist, tree breeders are in an enviable position, at least in respect to available genetic variation. Among the forests of the northern temperate zone, Canada's forests (250 million hectares of productive forest) are closer to the "wild" condition than the forest of any other nation. Why then should Canadian tree breeders give even lip-service to conservation of forest gene resources? There are a number of reasons. First, although the conservation of forest gene resources is not a pressing matter over Canada as a whole, there are parts of the country where the forests have been heavily cut for several generations, and where the local populations of tree species are being replaced with non-local ones. Certain populations of certain tree species, especially northern outliers, are in danger of serious gene depauperation. Canada is in the enviable position of being able to do something to prevent serious losses of genetic variability before the situation deteriorates further. To do this it is necessary to understand exactly what problems face us, to recognize species or populations before they are in serious danger, and to take what ever steps are necessary to conserve valuable populations.

The F.A.O. Panel of Experts on Conservation of Forest Gene Resources is exploring the problems of gene conservation at an international level and I.U.F.R.O. has formed a Working Party on gene resource conservation. The North American Forestry Commission (F.A.O.), Working Party on Forest Tree Improvement, has given consideration to gene resources on a continental scale. At the national level, in Canada, no single organization is concerned solely with conservation of forest gene resources. Programs such as the IBP-ct

program and the Canadian Institute of Forestry, Natural Areas Program, undoubtedly make a positive contribution to gene conservation. The logical question is, is this enough? If not, what further efforts are required?

The purposes of this symposium include an attempt to bring together knowledgeable people from several related fields to discuss gene conservation, to provide members of the C.F.T.B.C. with the background knowledge necessary for them to decide what role, if any, the Committee should play in this field; and how this role, if accepted, can be implemented. After the symposium, the C.F.T.B.C. held a discussion on the role it should play in conservation of forest gene resources in Canada. A policy statement was accepted by the members and is presented as Appendix I.

D.P. Fowler, Chairman
L. Roche, Secretary
Comm. Forest Tree Breeding in Canada

RESOURCE GENE POOLS AND THEIR CONSERVATION

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INTRODUCTION

In this gathering of distinguished forest tree geneticists, it may be prudent to confess my ignorance of forestry before it becomes obvious. Being a cytogeneticist working primarily with cultivated and wild cereal species, the honor of having been invited to this Symposium is probably due to my involvement with plant exploration. I have collected and studied cereal species along the Mediterranean and in the Middle-East, and have made their gene pools available for research and breeding. However, species are populations and populations are the reservoirs of gene pools regardless of whether they are annual grasses or perennial trees. Although different species, depending on their genetic and breeding systems, present somewhat different problems, the underlying genetic principles apply to all.

As the title of this Symposium suggests, genetic resources are components of our environment and their preservation is part of conservation. Conservation has traditionally included a broad range of activities from the top soil to the whooping crane and has been motivated by ethical, aesthetic, economic, and scientific reasons. It has recently become an emotional issue when we came to realize that man's survival still depends on the increasingly endangered balance between the human species and its environment. As we learn more about the disruptive effects of the overcrowding technological society on the biosphere, new items with new priorities are constantly added to the long list of the conservationist. Because of their fundamental economic and scientific importance, genetic resources should have high priority on this list. Yet I question the wisdom of putting them on the list at all. The conservation of genetic resources provide genetic variability, the essential raw materials for plant breeding in which lies the hope of meeting the demands of an all too rapidly growing human population. To deal with genetic resources requires careful analysis and an inventory by species and economic needs. We need a great deal more scientific information on how to preserve populations without losing their genetic variability. This is a national as well as a global issue, involving political sensitivities and resistance, particularly since many of the primary gene pools of economic species are in the underdeveloped part of the world. It is a job for geneticists with national and international cooperation sponsored by agencies at both levels. Save our forests may have emotional appeal and may have its usefulness, but save land races of wheat or potato would hardly capture public imagination. Specific problems such as forest gene resources may be swamped by the general war cry: emotional oversell usually invites public apathy. What is needed is to identify specific problems and priorities, to find efficient methods of conservation at a manageable level, and the enlist government support.

Canadian concern is reflected by the recently established Canada Committee on Plant Gene Resources and international action exemplified by the impressive volume published by IBP (Frankel and Bennett 1970).

Before discussing some of the scientific, technical and political aspects of preservation, it seems useful to consider briefly some of the characteristics of gene pools and their priorities.

Gene Pools and Resource Gene Pools

In this age of semantics, and to avoid confusion, it may be useful to define the term gene pool. It is increasingly used in the proliferating literature dealing with the conservation of genetic resources, yet hardly anyone bothers with its definition (cf. Frankel and Bennett 1970). The term was coined by population geneticists and it was defined by Dobzhansky (1951) as the total genetic information encoded in the sum total of genes in a breeding population existing at a given time. The sum total of genes determines the potential genetic variation within the population and the information encoded may be considered as the actual genetic variation exhibited at a given time. This in fact is the allelic variation which may be as high as 40 for certain loci.

The key word in this definition is breeding population because it is the carrier of the gene pool. It is the unit on which natural selection operates and produces a gene pool characteristic for each breeding population. The biological species concept, which incidentally is just as controversial as any of the other species concepts, is the most useful one for geneticists and breeders. The main attributes of the biological species are free internal gene flow and reproductive isolation from other biological species. Such a breeding population is the basic unit of the gene pool. It is important to note, however, that the gene pool used in a particular breeding program is usually just a small part of the whole pool of the biological species, and that it may also consist of genetic material contributed by two or more related species. This leads us to the anthropocentric or economic aspects of the gene pool.

Dobzhansky's gene pool applies to all breeding populations. Yet clearly not all gene pools should be classified as genetic resources. From a practical viewpoint, its economic importance, actual and potential, qualifies a gene pool as a genetic resource, that is, the raw material for plant improvement. This distinction is neither pedantic nor semantic because it is fundamental in setting priorities and in organizing collections and conservations. I suggest calling these *Resource Gene Pools* (RGP) whose economic importance and essential role in plant breeding set them apart from other gene pools.

Genetic variability is the prerequisite of plant improvement. It is stored in the RGP of land races or locally adapted indigenous populations and of improved cultivars. Further, gene pools of wild or weedy species which may provide alien genetic variation by introgression or by cytogenetic manipulation should also be included in the RGP of economic species. Let us take a brief look at these three components of RGPs.

Land Races - Indigenous Populations

From the neolithic agricultural revolution, which took place some 7000 years ago, until the advent of scientific plant breeding, some 100 years ago, land races provided food and other plant products for mankind. Perhaps most forest products still come from indigenous populations. These evolved under natural selection, shifted somewhat by the indirect and direct interference of man. Immediate fitness to their habitats with long range flexibility, and a great diversity of morphological and physiological types are their hallmarks.

Diversity is not uniformly distributed over the range of distribution. Centers of diversity, as defined by Vavilov, express the nonrandom distribution of gene frequencies, and are invaluable sources of variability. The identification of these centers greatly facilitates the exploration and collection of the richest parts of the RGPs. On the other hand, specific genes or adaptive gene complexes exist with high frequencies in certain ecological niches at the extremes of the range. Here variability is reduced by stronger and specific selection pressures. In fact, gene frequencies can readily be mapped. We know, for example, that the highest frequency of genes for resistance to oat crown rust is in Israel, for resistance to oat stem rust in Western North Africa. Most of the barley genotypes resistant to net-blotch disease originate from Manchuria, wheat genotypes with the best bread making quality from South-Eastern Europe, etc. In short, a sound knowledge of the phytogeographical distribution of diversity and gene frequencies is indispensable in the search for and collection of RGPs. If this kind of information is not compiled for forest tree species on a national and global basis as yet, it should be done to lay the foundation for efficient exploration and conservation of gene resources.

What is the status of the land races and local populations at present? Although it varies greatly by species the survival of many is endangered at an alarming rate. Wheat and rice, the two major temperate and tropical cereals, have reached the critical stage. The rapid spread of the Mexican wheat and Philippine rice cultivars, and concomitant improved management practices, particularly in and around their centers of diversity signals the disappearance of the land races. Other major economic species will follow suit if the five international plant breeding centers, proposed recently to UN, operate with success similar to that of CIMMYT in Mexico. Land races clearly lack the yield potential to provide food and other essential plant products for the human population now growing at a logarithmic rate. Thus, international breeding programs aimed at increased food production are inevitable. Yet, much of the readily accessible genetic variability is encoded in the land races which are invaluable resources for plant breeding. A sound course of action appears to be a two-pronged one: simultaneous implementation of extensive international breeding programs and preservation of land races. The time lag between the initiation of breeding programs and their practical impact should provide a margin of safety for saving the land races and indigenous populations.

Cultivars

Cultivars are the highly uniform final products of the plant breeding process. They must meet specific demands of the market place. Generally this is accomplished by rigorous selection which narrows the genetic base leading to the decay of variability. Genes unwanted in terms of the breeding objective are more or less eliminated from the initial RGP. Measured by the amount of discarded material, the breeding process on the whole is wasteful. Some of the discarded genes, apparently worthless today, may be potentially useful tomorrow when new techniques and demands arise. To save the part rejected in the breeding process, is not economically feasible. What can be done, however, is to preserve the initial pool and the cultivars that are replaced by better ones. The preservation of the initial material and the final product should offset to some extent the pauperizing effect of the breeding process.

The pauperizing effect of rigorous selection probably has been overestimated in the light of accumulating new evidence. A great deal of polymorphism as well as heterozygosity has been demonstrated by Allard and his group (1968, 1971) even in strictly inbreeding species such as barley and oats. In fact, little if any difference in genetic variability was found between inbreeding and outbreeding species. Thus, considerable genetic variation is stored in "highbred" cultivars in spite of inbreeding and rigorous selection. These results emphasize the importance of the preservation of cultivars.

Wild Related Species

Wild species from which genetic material can be introduced to economic species by introgression or cytogenetic manipulation should be included in the RGP of the economic species. These are important mainly for two reasons. Firstly, some are ancestral forms of the economic species and as such they hold the key to understanding the origin and evolution of the whole species complex. Secondly, some contain useful genes not available in the gene pool of the economic species.

The future of such related wild and weedy species is generally less endangered than that of the land races. The truly wild species inhabit undisturbed habitats where they can survive probably for a longer time. The survival of weedy species appears to be threatened by improved management of introduced cultivars. Wild species are less vulnerable though than land races also because of the combination of adaptive mechanisms for survival.

Conservation of Resource Gene Pools

The importance of conservation of genetic resources was concisely summed up by Hutchinson (1958) when he said "in the conservation of variability lies the hope of progress". If we add to this that variability is being eroded at an ever increasing rate by the process and very success of plant breeding and by the spread of improved management, the picture is nearly complete. Forest tree breeding and management are perhaps not the culprits as yet, but they will be at some time in the near future. The constant

displacement of the multitude of land races of field crops or indiscriminate logging at an accelerating rate are sparked by the same cause: overpopulation. Battles of the Green Revolution, conservation and the like may be won, yet the war for the survival of civilization will inevitably be lost without effective population control.

While conservation of resource gene pools no longer needs to be justified, the ways and means of how to do it are less clear. I shall be concerned with just a few general principles and a few of those aspects not covered in the IBP volume on conservation (Frankel and Bennett 1970).

Priorities

An efficient strategy of conservation rests on sound priorities determined by economic importance and urgency. The main attribute of the resource gene pool, as I have previously stated, is its economic importance but not all economic species are equally important. There is no conflict between economic importance and scientific interest, since the amount of research invested is generally proportional to the importance of the species in the national economy. This is borne out by the number of workers and funds allocated to research by species in the plant sciences.

Sound priorities are easy to establish for some species, more difficult for others. Of some hundred food crop species, only four: wheat, rice, corn, and sorghum, supply by far the largest part of the human diet. It is evident that these big four should enjoy the highest priority amongst food crops. This example also demonstrates how vulnerable is our dependence on our food providing species. As we go down the list of food crops, priorities are more difficult to set. Within global importance, national concerns and efforts are governed by regional interests. While wheat is vital to all countries in the temperate zones, the importance of corn is determined mainly by the heat units available, that of oats by a combination of soil, climate, and utilization. The allocation of limited funds and manpower for conservation make economic importance the highest priority. This principle, no doubt, applies equally to forestry and to agriculture.

Urgency should be the second priority. Economic importance being equal, the species whose land races or indigenous populations are in most imminent danger should enjoy highest priority. When drastic erosion of the RGP or extinction of its carrier in the near future is predicted, urgency should have first priority. Urgency in conserving certain species in the face of rapid technological changes and sharply increasing market demands, shifts quicker than economic importance, though this too is subject to change.

The importance of a species in any country's economy can readily be established. Wheat, barley, and oats are our main cereal crops in Canada, thus our primary concern is their RGPs at home and abroad, wherever they exist. I have no doubt that Canadian foresters would have no difficulty in listing their most important softwood and hardwood species. To estimate the relative urgencies for their conservation may not be easy in Canada, let alone in their centers of diversity and over their native ranges. This re-

quires a national inventory based on past history, present status, and future trends of population size and quality, technology, and utilization for each economic species. Further, it would require similar surveys in other countries with particular emphasis on centers of diversity, to provide the basis for a global estimate of the status of the species. This needs international cooperation. Action will have to face and overcome domestic and international political, financial, and organizational problems.

Political Implications

To save selected indigenous forest tree populations could hardly succeed without public support, sponsored by various levels of government and with the cooperation of industry. This kind of support demands sound priorities and information on the economic impact of conservation. In Canada, we have a wealth of indigenous forest tree populations. In contrast, all our agricultural species were introduced; the native ranges of most are on other continents. A quick look at the map of the centers of diversity shows that most if not all are in the underdeveloped part of the world. Those of our main cereals are, for example, in the Middle Eastern and Mediterranean countries. These countries are short of funds and know-how, in some even the need and urgency for conservation has not been realized. Some of the species, oats for example, are important in some of the developed countries including Canada, but their centers of diversity lie in those countries where they are of no or little economic importance. Thus, oats would be far down the list of priorities in those countries. Without the full cooperation of scientists and governments in countries where the centers of diversity lie, the conservation of RGPs is doomed to failure. Growing nationalism on the one hand, and often less than tactful approach by expeditions and international agencies on the other hand, make this an increasingly sensitive problem. Species, formerly considered wholly useless can surprisingly quickly become national assets when efforts for their collection are made. Conservation of RGPs cannot be but a global program made up by national efforts integrated under international sponsorship.

METHODS OF CONSERVATION

I shall not attempt to deal with techniques of collection and conservation but rather contrast conservation *in situ* and in gene banks and collections. Although these complement each other, preferences mainly depend on the purpose and utilization of the material. In general, as much genetic variability should be conserved as it is practically feasible to maintain since, in addition to plant breeding, resource gene pools serve allied research such as biosystematics, genetics, cytology, pathology, etc.

In situ Conservation

Land races, indigenous populations and wild species are at or close to their adaptive peaks relative to their habitats. Mutations, constantly sifted by different selection pressures in diverse habitats, resulted in adaptive gene complexes. This process, coupled with introgression within a crop-weed complex as described by Harlan (1956) forms the ecogenetic system

which allows for rapid evolutionary bursts, characteristic of the evolution of cultivated species. The important point is that wherever such plant communities remain undisturbed, this kind of adaptive system will continue to operate. These natural workshops of evolution are producing a steady flow of genetic material for the plant breeder and plant scientist. Selected on the basis of information on gene frequency and field studies, these sites can be mapped and should be included in the IBP list of preserved natural areas. Existing, but scattered, technical information should be brought together and the gaps as to locations, optimum size of sites, etc., should be filled by initiating new research.

Although natural sites, even when preserved, are subject to change whether in the West or East, *in situ* conservation interferes less with selection pressures under which indigenous populations evolved, than any other method of conservation. Yet this method of conservation appears to be the most difficult to make work. It requires the strongest support from outside of the scientific community. Governments and industries, local communities and village elders will have to be persuaded to legislate, to provide funds and to organize a network of cooperators. The problems are not insurmountable, however, if the necessity is properly presented and action is pursued with dedication.

Collections and Storage

Genotypic structures inevitably change when populations are grown outside of their natural habitats. Selections, outcrossing and particularly random drift will change the original populations regardless of the techniques of maintenance. This may not necessarily be disadvantageous, particularly if we can go back from time to time to populations conserved *in situ*.

The maintenance of large collections, possibly consisting of thousands of individual samples, is costly and labor consuming. The smaller the samples are, the more effective random drift will be in fixing most of the non-lethal alleles. In a few generations, although genetic variability is retained, the genetic structure of the populations will differ from that of the original. Long storage periods between rejuvenations will slow this process, but selection will still be active. Collections of individual samples are essential for evolutionary studies including biosystematics, cytogenetics, etc.

An alternative is to combine all, or groups of samples into bulks, creating panmictic populations. These can be grown and maintained by breeders as reservoirs of genetic variation. Such populations in time will become locally adapted under local selection pressures. This method is relatively inexpensive and extremely useful for breeding programs. Nature does part of the breeder's work. A modification of this is the production of hybrid populations by intercrossing morphologically and ecologically different types and growing parts of these in different locations. This method was initiated by H.V. Harlan in 1929 and refined in Suneson's composite barley crosses. By growing bulked or composite hybrid populations in different environments and preserving original samples and early generations in storage, the full

or nearly complete genetic variability can be conserved. The size of such populations minimize random drift and the method promotes balancing selection (cf. Allard and Kahler 1971). The practical value of composite crosses is attested by the number of commercially grown cultivars selected from them, and by the important observation of segregates outside of the range of the parental phenotypes (cf. Harlan 1956).

Gene banks too have their important role in the conservation of RGPs. The immense collections of crop species and some of their wild relatives maintained by U.S.D.A. at Beltsville and Fort Collins, and by Vavilov's old Institute for Plant Industry in Leningrad provide genetic material for breeding programs the world over. In Canada, we collected and now maintain the most extensive wild oat species collection in the world. The maintenance of such collections needs large storage facilities and costs a great deal of labour and money, although the keeping of records and handling the material has been made simpler and more efficient by the use of computers. Such central gene banks, however, during storage and rejuvenation, impose a rather uniform selection pressure on all samples even if the latter is done in several environments.

Central gene banks can be complemented by regional gene banks. These were proposed by FAO but at present, as far as I know, only one is operating in Izmir, Turkey. These, being in or close to the centers of diversity of particular economic species, should be better suited to maintain original population structures and their staffs should be better qualified to explore and collect materials and at less cost than expeditions coming from all corners of the world. Regional gene banks would also be the logical nuclei of the network charged with *in situ* conservation. The concept of regional gene banks deserves the full support of the developed countries and some of the funds of external aid programs.

Conservation of genetic resources is international in scope, built on coordinated national programs. A global program will emerge from national priorities which can then be integrated and regions and sites of importance identified. We need a few major central gene banks, primarily for cultivars, and a network of regional gene banks mainly for wild species, land races and indigenous populations. Staffs of these could also serve as "keepers" of preserved areas for *in situ* conservation. International cooperation is the key work and computers could provide speedy and efficient communication.

Each of the methods has its merits and disadvantages. Each species or species group should be examined separately on the basis of breeding systems, growth and life characteristics, economic importance and urgency of conservation. It is safe to say that only a combination of several methods will do the job. Time is running out; action is needed now. Words and volumes alone, however impressive, will not save the diminishing genetic resources on which so much of human welfare depends.

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GENE PRESERVATION BY MEANS OF A TREE IMPROVEMENT PROGRAM

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INTRODUCTION

It is axiomatic that all genetic or tree improvement programs result in gene preservation, whether it be through production of new gene combinations or by multiplying already established desired genotypes. However, the usual concept is that a tree breeding program will result in a drastic narrowing of the genetic base following rejection of the bulk of the "undesirable" genic combinations and acceptance of only a few choice individuals. If a tree improvement program is properly planned and organized, there need be no critical narrowing of the genetic base; in fact, with certain exceptions, the opposite will result, and from the program useful gene combinations will be developed and preserved along with a broad genetic base.

To satisfactorily explain the effect of tree breeding on the overall gene pool it is necessary to understand the various phases of a tree improvement program. This paper, therefore, will first explain the objectives and organization of a tree improvement program using our North Carolina State Cooperative as an example²; then brief comments will be made on the effect such a program has on the gene pool.

Objectives and Operation of a Tree Improvement Program

The primary objective of tree improvement is to increase economically the yield and quality of forest products. In many areas improvement is needed as soon as possible, often resulting in the bulk of activities appearing to be geared primarily toward short-range objectives. Immediate needs for improved seed are real and very important, especially in areas of operation such as ours; for example, members of our Cooperative plant 300,000,000 pine trees each year and a major objective is to soon obtain these from genetically improved stock³. Most publicity from tree improvement programs deals with the short-term effort but this can be misleading.

¹Member of the FAO Panel of Experts on Forest Gene Resources.

²The Pine Cooperative operates in 13 southeastern states, with 23 industrial and 3 state forest service members; the Hardwood Cooperative has 16 industrial and one state member.

³Good progress is being made. For example, in 1969 enough seed was obtained for 40,000,000 improved plants, while 100,000,000 trees will be obtained from orchard seed which was collected in 1970.

If tree improvement is to be successful it must also have long-range goals which are recognized and planned for right from the beginning.

A balanced improvement program has both production and research functions. The operational effort consists of intensive selection and breeding to produce large quantities of desired stock for immediate use, often with a resultant reduction in the genetic base for certain important characteristics. Specialty orchards are developed to overcome severe adaptability or growth problems or to produce specially desired products; this is accomplished by a strong selection toward a narrow range of genotypes. In contrast, the research orchards are not operational; they are long-term, having the objective of keeping the genetic base broad and purposely preserving genotypes that may not have an immediate use in the applied program.

The Short-Term Program

We often are warned about the degree to which the genetic base may be reduced following the intensive selection and breeding necessary to establish an improved production seed orchard. Strong measures are taken to reduce variability in certain growth and quality characteristics. For example, intensive selection for fast growth, straight stems, good wood, disease resistance, etc., must reduce the base if our goals are to be achieved. Meanwhile, however, the often overlooked fact is that genetic adaptability is enhanced. This most important broadening of the genetic base results from the selection of no more than one parent tree from a given stand⁴. The rationale in restricting selections to one tree per stand is to avoid inbreeding among parents within a seed orchard, but with the additional objective of keeping a broad base of adaptability. Therefore, trees within a production seed orchard come from differing, widely separated environments, making possible genetic combinations in their progeny never found in nature and insuring a broad adaptability.

Our objective in the production seed orchard program is to develop and maintain a few strains with broad adaptability, rather than to develop a whole series of small orchards specially good for specific narrow environments or products. Since most forest tree species initially have rather broad adaptability, we should be able to maintain broad, general purpose strains even when intensive selection for certain growth and form characteristics are used. Important genotype-x-environmental interaction among various families when grown in "normal" environments has not been generally found; thus, the fast grower on a 75' site is still the best on a 100' site; a straight-stemmed genotype produces straight trees under all the normal environments. Under extreme environments, such as when fertilizers have been applied, a genotype-x-fertilizer interaction is sometimes found. To exploit fully the added nutrients, some genotypes which do not respond or actually grow more slowly following fertilization must be discarded. However, we

⁴Stands are rarely less than 40 acres and usually are several to hundreds of miles apart.

regularly find clones that produce fast growing progeny both with and without fertilization. When enough of these are combined it will be possible to exploit a response to fertilizers while still keeping a suitable broad genetic base.

Despite the desire and preferences for widely adaptable strains, occasional genotypes are found that are highly superior for severe environments, pest resistance or specialty end-products. When these are used, an orchard is purposely developed with a narrow genetic base. We have a number of small specialty orchards already established for disease resistance, extra wet sites and unusually poor sites. In addition, two clone orchards are under development to take advantage of several outstandingly good specific combinations that we have found. Most such specialty orchards used to overcome particular problems are considered to be terminal; these cannot be the sole basis for ongoing improvement for advanced generations. To incorporate the specialty orchards into advanced generations, special crossing patterns need to be employed which will assure the necessary broad genetic base, when combined with infusion of new genetic material.

We also consider production orchards as "dead end" as far as future generations of breeding are concerned, although selected progeny and an occasional clone may be major components of advanced generation orchards. The main use of production orchards is to supply commercial seed until improved orchards are available.

The Long-Range Program

If a breeding program is not to come to an abrupt halt owing to a narrow genetic base and resultant inbreeding, plans for generating suitable material for future generations must be made right from the beginning. The seriousness of mild related mating is not yet known but, based upon deleterious results of severe inbreeding, discretion dictates related matings be avoided as much as possible. Because of this it is essential to have crosses of known parentage for advanced generation selection and breeding. Use of open-pollinated, top cross, or pollen mix crosses can lead to disaster; this danger is often overlooked because many persons are not aware of the strong general combining clones found in the pines as well as the occasional outstanding specific combinations. About 5 percent of the clones produce such outstanding progeny that if seed were collected randomly from an orchard and outplanted so that parentage were lost, at least 85 percent of the most outstanding individuals in the progeny would have one or both parents in common. Because of the superior specific combinations found, many of the progeny selected for use in second-generation orchards would be full sibs. We have abundant data to support these generalizations of outstanding general and specific combinations. It is essential, therefore, to use some form of pedigreed breeding to safely select for advanced generation orchards.

Since the long-term or research orchards must consist of trees of known and tested parentage, and because of the frequent strong general combiners, large base populations are needed to develop advanced generation

orchards if inbreeding is to be prevented and the number of unrelated clones is to be kept sufficiently large. When an organization has to develop a breeding program alone, a base population in the hundreds will be required. In a cooperative such as ours, even though each organization has only 25 to 35 clones in each orchard, a sufficient base of about 300 clones is available to draw upon when each of ten or more organizations supplies advanced generation selections.

Even a base population as large as 300 clones is not sufficient to prevent long-term relatedness as the breeding program progresses. Therefore, a conscious effort must be made to broaden, continuously, the genetic base. One major attempt to satisfy this objective has been to cross trees from widely separated geographic areas--Texas with North Carolina, drought-resistant with wet site types, high elevation with Coastal Plain; etc. This has been done with selected trees, and ten plantations of such wide cross progeny have been established throughout the Southeast from which to select for use in advanced generation orchards. The best trees of the wide crosses will be incorporated into advanced generation orchards which will both add needed genetic diversity and prevent inbreeding. Overall results from the wide crosses have been excellent, although disappointing in one sense--several strong general combiners were present in the parents used to make the wide crosses and their progeny greatly outperformed the other crosses, limiting the number of individuals that can be used.

Other special crosses have been made, especially among the good combiners, to broaden the genetic base. These come from parents within the same area as well as parents from the Piedmont crossed with Coastal Plain, northern with southern, etc. New selections are constantly being made from plantations and wild stands; the best phenotypes are tested by progeny performance before being used in advanced generation orchards.

Effect of Tree Improvement Programs on Gene Resources

There definitely will be some loss of genetic potential for certain characteristics following intensive selection and breeding in an applied tree improvement program. For example, slow growing trees and crooked trees will be rejected and some of their genetic potential will be lost. Practically speaking, this will not be serious because trees of this type are not desirable for any purpose. There is always the chance of loss of a good characteristic that is associated with tree crookedness, for example, but this danger is small. In most studies, we have found that the important economic characteristics have usually been inherited independently or have only been weakly related to one another. Therefore, it will be possible to retain desired characteristics such as adaptability or disease resistance in straight as well as in crooked trees, in high gravity or low gravity trees, etc.

A well-designed tree improvement program that includes both the short- and long-term approaches will result not only in preservation of the most desirable genic combinations but will produce many others never before possible in nature through selective breeding. The trend in routine forest management toward continuous removal of desirable trees and regeneration with

undesirable ones is strong and becomes stronger with the demands of the super-ecologists to use a selective system rather than clear-cutting. Ecological demands of this kind are made by persons who know nothing about genetics; they are, in effect, requesting a system which results in the removal of the best genotypes, leaving the least desirable, most disease-susceptible and poorly adapted to grow and regenerate the site. Therefore, tree improvement programs preserve many genes that would otherwise be lost when normal operational forest harvesting is done.

When discussing gene preservation, the opinion is often expressed that all possible genotypes should be preserved because one never knows which may have potential later value. This objective is noble but is impractical since it is not possible to preserve all genetic combinations, and we must therefore pick and choose those deemed most desirable. The objective of preserving the broadest base of genes cannot be achieved in the southern pines, using the often suggested method of setting aside natural stands. Historically, many natural stands of southern pines have arisen from seeding into abandoned fields, often from one or very few parents growing along fence rows, near farm buildings or along ditches. Because of this, the natural stands that often have had a second or third generation of selective cutting do not consist of widely differing, unrelated individuals but are made up of trees that are related. Preservation of a whole stand of such related individuals accomplishes little; however, the selection of no more than a single tree from each such stand, as is done in a tree improvement program, is very effective in preserving the species' genetic potential.

A very wide range of genetic material will have been created and preserved through seed orchards; and when combined with a conscious effort to broaden the genetic base by wide or selective crosses, the gene potential of a species such as loblolly pine is indeed enhanced by a tree improvement program. Because of the ease of vegetative propagation, any desired genotype can be preserved indefinitely and not be lost by death of the parent tree or genetically changed by the necessity of continuously generating seed crops to preserve the bank of genes available.

In the southern pines, a well planned and executed tree improvement program is a very effective preserver of genes. Indeed it creates and preserves combinations not possible in nature, even though genic potential for certain undesirable growth and quality characteristics will be reduced.

GENE CONSERVATION IN RELATION TO FORESTRY PRACTICE

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Canadian forests still retain much of the rich genetic heritage derived from natural evolutionary processes of mutation, migration, isolation and selection. Due to relatively recent and massive man-induced changes in forest composition and the accelerating rate of utilization of forested land, immediate action is needed to conserve and reserve adequate genetic capital for future seed production and tree improvement. My objectives are to discuss where and how gene pool conservation may be achieved effectively, at minimum cost and with the least interference with other forest values.

THE GENE POOL

For the sake of brevity we frequently talk of genetic conservation in general terms, yet the concept has very different biological and practical implications to different people. The agricultural breeder works with cultivars and is frequently concerned with the retention of particular units of inheritance (allele, block, chromosome or genome) that he associates with specific characteristics of cultivated and highly bred plant or animal races. The viability of breeding stock not currently in use must be maintained artificially or it is lost to future breeding. The forester, the zoologist and the botanist, however, generally work with wild populations composed of highly heterogeneous individuals. The primary concern is to avoid widespread loss or depreciation of gene pools rather than specific genes or genotypes. The gene pool refers to the "totality of alleles distributed among the members of an interbreeding population" (Lerner 1958). Gene pools of wild populations are adaptively balanced genic complexes that differ in gene frequencies and patterns of co-adaptation (linkage) but not necessarily in constituent genes (Dobzhansky 1951). Because of its dynamic relationship to the environment, a gene pool can only be maintained through successive generations within the environmental context in which it evolved. Once a population is lost through lack of regeneration, or it suffers a severe reduction in the type and number of breeding stock, or it is interbred with other populations, the original gene pool cannot be recreated. Thus in forestry we are not so likely to lose genes as to forfeit the integrity of populations in genetic balance with diverse environments.

WHY CONSERVATION?

The growth and health of our forests depends on maintaining both the environmental and genetic components of the ecological complex. By

advocating conservation of gene pools we do not argue against improvement through directed breeding. Rather we reinforce and insure the adaptive basis for genetic improvement. The task of the tree breeder is to improve on nature's best. Reliable standard populations must be maintained against which he can measure progress and from which he can continue to select new breeding stock to broaden the genetic base of selected strains and to meet new contingencies as they arise. It is logical that such populations be integrated with current seed requirements and with regional provenance and progeny tests. It will be of little comfort to find a population of high potential if the seed source no longer exists outside of a few trees growing in test plantations.

PRIORITIES

The greatest danger of loss, degradation or uncontrolled contamination of natural gene pools is within the major commercial species in areas of extensive utilization and where natural regeneration after logging is lacking or inadequate. It is for these species and in these areas where the greatest returns will accrue from genetic conservation and improvement and the greatest losses will be incurred from the disgenic effects of indiscriminate forest operations, e.g. widespread clear cutting followed by deficient natural regeneration and massive planting or seeding with sub-optimal seed sources. Forest land that is productive and readily accessible is vulnerable to over-cutting on the one hand and to expediency in acquisition of seed or plants for reforestation on the other. Under such circumstances of commercial and administrative pressure, the preservation of gene pools is most difficult, yet most urgent.

Many serious questions of forest gene conservation arise in relation to other activities of modern society, such as urban and industrial expansion, agriculture, organized recreation, dam construction, mining and road building. Small populations at the ecological limits of a species are particularly vulnerable to loss yet may be of considerable practical or academic interest. The variety of biological, economic and administrative problems involved in such cases means that the merits and solution for each situation must be determined separately. In any event, the majority of these problems are beyond the scope of this discussion since their solution will not materially affect the quantity and quality of industrial wood produced during the next century.

GENE POOL CONSERVATION *IN SITU*

There is no means that will ensure the complete purity and integrity, the "virginity", of gene pools anywhere in Canada. Changes occur in both gene flow from distant sources and in local environments to a greater or less degree as a result of man's activities. The natural forested areas, to be discussed in this symposium by Dr. Weetman, National Parks, and other ecological reserves can and will serve as valuable genetic reserves, as emphasized recently by Roche (1971). But it is unlikely these will provide adequate genetic samples of the important tree species within large areas

of commercial forest in Canada. Natural areas require future exclusion and a minimum of past disturbance (Weetman 1970). It will be difficult to make mass seed collections within ecological reserves and out of the question to manage them for seed production. Yet urgent forestry requirements are for closer control of the origin of seed used in reforestation now and for identification of the better populations for future seed supply.

Since it is genes, not trees, we wish to preserve, the strict criteria used for the selection and maintenance of natural areas do not apply to genetic reserves oriented to forestry practice and tree improvement. Normal forestry management can be followed, whether for wood production, amenity values, or protection forest. Regeneration following logging may be from natural seed fall or by planting or direct seeding. The only mandatory requirements are:

- 1) that the population be adequately maintained,
- 2) that new generations be derived from an adequate number of parental trees, and
- 3) that only natural regeneration or seed of local origin be used.

Under no circumstances shall seed or plants be introduced from another population of the species being reserved.

I shall not attempt to define 'adequate', but it refers to areas of land, density of stocking, and number and phenotype of parental trees, both seed and pollen, in relation to species and their silvical requirements. The term 'population', which has been defined as the "interbreeding community within which there are no discernible ecological groups or clines" (Schreiner 1968), is also open to academic argument which can only be resolved in the field. Guidelines in defining the boundaries of a genetic reserve, and hence, arbitrarily, the population, include: structure, size and distribution of forest stands; ecological boundaries and discontinuities; and direction of prevailing winds during periods of pollen dispersal. Natural physiographic features, roads, survey lines, etc., may be used to clarify boundaries but they must encompass the biological limits essential to achieve the goal of isolation and maintenance of the gene pool. Such a gene pool reserve may be very large, for example a watershed, or several townships. More commonly it might be one to several square miles in extent, but it should never be very small, say of one to a few acres. One or several species may be included in a single reserve, and in mountainous topography a number of sub-units within a single species could be defined, for example, by altitude and aspect.

SEED PRODUCTION

Since the objective is to provide reliable sources of good quality tree seed for forestry operations, areas chosen as gene pool reserves should include well stocked stands on high quality sites. Such stands can be developed for seed production as and when required. In very large even-aged

stands, such as on large burns, some premature harvesting and regeneration may be needed to diversify the age classes within the reserve. At the earliest opportunity, seed should be collected for regional population tests and for storage in a germ plasm bank for future regeneration within the reserve. Reserve seed will need to be replenished from time to time as the quantity and viability decrease. The quantity in storage should be adequate to re-establish the population in the event of a catastrophic loss of the gene pool. Until genetically improved stock is developed for local use and seed is available in quantity, seed production areas within genetic reserves will remain prime sources of seed for general reforestation.

RESPONSIBILITY

Responsibility for planning and instituting systems of forest gene pool reserves in Canada lies primarily with the provincial government forest services, although the cooperation must be sought of private owners of forest land and of major lessees and licencees. The establishment, operation and administration of gene pool reserves should be the responsibility of forest management and be integrated with regional management plans and objectives. Genetic evaluations within and between populations will require the assistance of research units and applied tree improvement groups, all of whom have a fundamental interest in the maintenance of genetic reserves.

COST-BENEFIT

Establishment of gene pool reserves *in situ* will follow investigations of existing inventory, utilization and regeneration records, reviews of management plans and field inspection. Most of the costs are indirect for no capital or operating cost is involved, with the possible exception of designation of private land. The information must be incorporated into working plans, operations maps and land use schemes dealing with the areas concerned. Once designated, costs would be limited to maintaining basic records and planning in advance for artificial regeneration when required. Normally special provisions for planting stock would not be needed because the sources would be available from routine nursery production. Costs of seed production and collection should not be greatly increased by designation of reserves and in many cases may be reduced by ensuring that the required quality and quantity of seed trees are available when needed.

The establishment of a system of gene pool reserves *in situ* is the most effective and economical application of genetics to silviculture that can be made immediately and the results are guaranteed. Possible losses due to disgenic effects of less controlled seed collection and distribution are avoided. The positive effects will be immediate in terms of seed quality and lasting in terms of maintaining and improving the productive potential of our forest tree species.

CONCLUSION

The philosophy to be applied to genetic conservation in forestry is well expressed in the following quotations from an address entitled Forestry and Ecology given by Hon. Jack Davis before the Council of Forest Industries of British Columbia in April, 1971:

"There are tolerances in nature and we must learn to use them. However, we rarely know what they are and, until we know how far we can go in any one direction we must tread very carefully indeed."

"Variety is the best kind of life insurance you can have. The greater the diversity the more stable the ecosystem is likely to be."

The ecosystem is the result of the interaction of environment and genetic resources. Degeneration of either component directly affects the ecosystem. Conservation of genetic resources is a basic prerequisite to maintaining a viable and productive ecosystem and is a prime responsibility of all who utilize and manage forest land.

RECOMMENDATIONS

1. That the Committee on Forest Tree Breeding in Canada urge Provincial Forest services to implement systems of gene pool reservations *in situ* for commercial tree species.
2. That gene pool reserves be used for mass seed collection and include natural areas for ecological as well as genetic study.
3. That a national working group be established consisting of active members of the C.F.T.B.C. and forestry management personnel to draft practical proposals for genetic conservation in Canada. The group would act in an advisory capacity to forest services and industries.
4. That a C.F.T.B.C. request that two active members, one from eastern Canada and one from western Canada, be appointed to the National Committee on Plant Gene Resources of Canada. (Dr. Roland Loiselle, Permanent Secretary, Research Branch, C.D.A., Ottawa).
5. That a central registry and seed bank of Canadian forest gene pool reserves be established. The Petawawa Seed Unit would be a suitable center for holding basic records and for maintaining small seed reserves.

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THE ROLE OF FOREST TREE SEED STORAGE IN GENE CONSERVATION

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INTRODUCTION

The purpose of this report is to discuss the role seed storage can play in forest gene conservation and how it can be used most effectively. Tree seed and other germ plasm storage is not the whole answer to gene conservation, and it is necessary to use it in conjunction with other gene conservation measures such as conservation of natural populations and clone banks. Seed and other germ plasm storage, however, is a valuable insurance against loss of genetic material in the field or nursery due to insects or diseases or catastrophes such as fire. Such storage has the advantage that it occupies a relatively small space, is not easily contaminated with unwanted genes, and is easy to transport. In this report the value of seed storage in gene conservation will be considered in isolation bearing in mind that it is only one part of a spectrum of gene conservation measures.

THE NEED FOR FOREST GENE CONSERVATION

On a global scale there is a growing realization by geneticists and breeders that in many areas gene resources are being drastically reduced and that protective measures are needed (Jasso 1971). This is particularly the case in densely populated countries such as those of Eastern Europe where natural forest populations are rapidly disappearing and selective fellings have often left the worst genotypes. In 1967 recommendations of the Technical Conference on Utilization and Conservation of Gene Resources sponsored by FAO and IBP suggest among other actions that national and international efforts should be directed towards the exploration, conservation and utilization of plant gene resources in agriculture and forestry in accordance with species and regional priorities, and the danger index of genetic erosion. Subsequently, a report of the FAO Panel of Experts on Forest Gene Resources meeting was published in 1969. The importance and urgency for the preservation of forest gene resources in forest research and practice was emphasized by Hagman (1971) and Jasso (1971).

Some countries such as Canada, however, still have indigenous forest populations of considerable extent that are relatively undisturbed. Even in these countries, however, felling, artificial reforestation with introduced seed, urban expansion, etc., have resulted in considerable local erosion of forest populations of value either in economic forestry or for ornamental and amenity purposes. In some cases the tree species involved are hardwoods (e.g. in Southern Ontario) for which seed storage is problematic. On a national scale Canada's gene resources are not in danger of

immediate serious depletion, but locally the preservation of forest genes is warranted and is even a matter of some urgency (Roche 1970).

Following the FAO-IBP sponsored international meeting, a work planning meeting on the plant gene resources of Canada was held under the auspices of Canada Department of Agriculture in 1968. The meeting concluded with recommendations from which a tentative national policy for the conservation and utilization of plant gene resources in Canada was formed. Forestry was included in the plant gene resources recommendations.

THE ROLE OF SEED STORAGE IN FOREST GENE CONSERVATION

Forests are composed of perennial species and the life-span of most tree crops ranges from 60 to 500 years in natural conditions, although today's foresters aim at rotations of 40 to 100 years or much less. Trees can, therefore, be preserved *in situ* by protecting natural stands or even plantations of known origin from contamination from introduced pollen, together with protection from fire, insects or diseases. Alternatively the forest genes can be preserved in clone banks or plantations established for this particular purpose which, once they are sexually mature, will produce seed for many years. Gene preservation by seed and other germ plasm storage becomes important when it is not possible to preserve forest populations *in situ*, or when establishment of clone banks or seed orchards must be delayed, or when important populations are in danger of extinction. Seed storage can be used to insure against losses of actual trees. Agricultural crops are often annual or biennial and can often only be preserved by storage of seed and other germ plasm. Many agricultural seed stocks can be easily replenished by producing seed for the stored seed stock in one or two years when the germinability of the stored seed shows signs of deterioration. Replenishing tree seed stocks is, however, much more difficult; trees take longer to reach sexual maturity and even then often do not produce good seed crops every year. It takes at least 20 years to achieve a good yield for most tree species. For this reason, seeds should be collected only in years of abundant flowering when a large proportion of genes of the designated populations will be present.

The function of tree seed storage is to provide the seed intended for use in gene pool plantations with the most favourable conditions under which respiration of the seed can be minimized and germinability maintained over a period of perhaps 30 to 40 years. Although the primary objective of tree seed storage is to preserve seed quality until it can be used for gene pool plantations, specified quantities of the stored seed can be distributed for breeding research or seed production during the storage period. The goal of such tree seed storage is to maintain the quality of the seed for a prolonged period.

THE PERIOD OF TREE SEED STORAGE

The period of time tree seed will remain germinable in storage varies greatly with the tree species and the storage conditions. Seed of

silver maple (*Acer saccharinum* L.), beeches (*Fagus* spp.), oaks (*Quercus* spp.), chestnuts (*Castanea* spp.), hickories (*Carya* spp.), walnuts (*Juglans* spp.) and willows (*Salix* spp.) are all considered short-lived (Crocker and Barton 1957) while most other hardwood and conifer seeds are relatively long-lived. Under optimum storage conditions, well pre-conditioned tree seed of the short-lived category can be stored satisfactorily for 1 to 3 years and that of the relatively long-lived category for 5 to 30 years. In the case of tree species with seed that can only be stored for short periods, the stocks are in frequent need of replenishment. This limits the value of seed storage as a gene conservation technique. This applies also to small fruit trees in horticulture.

STORAGE CONDITIONS

Storage conditions are related to seed moisture content and they effect the period for which seed can be stored. Tree species requiring high moisture content (25-79%) to maintain their germinability (e.g. seeds of chestnuts, oaks and silver maple) cannot tolerate the sub-freezing storage temperatures (Jones 1920; Holmes and Buszewicz 1958; Yamamoto 1966; Krajicek 1968) that are favourable for prolonged storage of most other hardwood and conifer seeds (Holmes and Buszewicz 1958; Barton 1961; Buszewicz 1963; Jones 1966; Barnett and McLemore 1967; Huss 1967).

The primary requirements of optimum storage conditions for tree seeds requiring low moisture content to maintain germinability are low storage temperature and low relative humidity. Most conifer and hardwood seeds can be stored successfully at -18°C for 5 to 30 years when their moisture content is properly reduced to 6 to 8%. At present comparatively little is known about the optimum storage conditions for hardwood seeds of southern Ontario. The Tree Seed Unit at Petawawa Forest Experiment Station is currently reviewing available information on the storage of hardwood seed.

PREREQUISITE OF SEED MATERIAL FOR STORAGE

Tree seed collected from designated stands or populations and for short or long term storage requires careful control of origin and preservation of quality from the time of harvesting through all stages of handling and processing to storage. The significance and effectiveness of seed storage in gene conservation cannot be realized unless such control is fulfilled.

Seed Origin

Prior to seed collection, it is absolutely essential to ascertain that designated stands from which seeds are to be collected are of known origin and that collections are made with strict supervision of lot identification and seed labelling.

Seed Quality

High initial seed quality of tree seed is always favoured for short and long term storage (Holmes and Buszewicz 1958; Allen 1957; Barton 1961).

In order to insure high quality seed for storage, it is not only important to collect the seed at maturity in good seed years but also to extract, dew and clean the seed carefully (Huss 1954; Allen 1957, 1957a; Kamra 1963).

TESTING OF QUALITY OF STORED TREE SEED

Careful storage of dead seed is futile. To insure the storage value of preserved seed and to detect any deterioration in germinability or increase in moisture content of the seed, it is essential to determine the initial moisture content and germinability by official standard methods and reliable germination criteria prior to and during the storage period. For long term storage of tree seed, an acceptable level of germinability should be established at the beginning of the storage, and seed stocks should be replenished or replaced when germinability of the seed decreases below that acceptable level.

THE FUTURE NEEDS AND PRIORITIES

1. Based on present knowledge, work on the evaluation of tree species in respect to the need for gene conservation should be started immediately and steps should be taken to preserve endangered populations or species.
2. Temporary storage space must be made available immediately for storing seed material or other germ plasm of populations of particular genetic interest that are in immediate danger of extinction.
3. The best methods of collection, extraction, processing, testing and storage of tree seed of each species should be applied to the seed destined for gene conservation.
4. Permanent storage facilities should be established for short and long term storage of tree seed in conjunction with a seed testing laboratory.
5. Research in longevity and storage conditions of tree seed and other germ plasm in general and of hardwood seed in particular should be intensified.
6. In conjunction with other gene conservation measures, standard systems should be developed for recording, storage and retrieval of information on stored seed stocks and other germ plasm.
7. Adequate criteria regarding the population, number of trees and quantities of seed or other germ plasm required for gene conservation storage must be established.

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CONSERVATION OF FOREST GENE RESOURCES WITHIN IBP FRAMEWORK

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INTERNATIONAL ORGANIZATION

In 1964, ICSU (International Council of Scientific Unions) agreed to sponsor an International Biological Programme for integrated study of the biological productivity, conservation and human adaptability.

Two phases were planned at that time; the first was Planning and Preparation (1964-67), and the second was Operation (1967-72).

In September 1970, SCIBP (Scientific Committee of the International Biological Programme) agreed to extend the program for two additional years, for phase three, Synthesis and Transfer (1972-74).

The activities of IBP were organized into seven sections, each headed by a convener and a responsible committee. The following fields were chosen:

PT Productivity of Terrestrial Communities

Convener, J.B. Cragg University of Calgary, Canada

PP Production Processes

a) PP-P Production Processes (Photosynthesis)

b) PP-N Production Processes (Nitrogen fixation)

Both PP sections convened by Dr. I. Malek, Czechoslovak Academy of Science, Prague, Czechoslovakia.

CT Conservation of Terrestrial Communities

Convener, E.M. Nicholson, London, UK.

PF Productivity Freshwater

Convener, G.G. Winberg, Academy of Science of USSR, Leningrad, USSR.

PM Productivity Marine

Convener, Dr. M. Dunbar, McGill University, Montreal, Canada.

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UM Use and Management

Convener, G.K. Davis, University of Florida, Gainesville, USA.

HA Human Adaptability

Convener, J.S. Weiner Anthropological Institute, London, UK.

Within each of these sections are more specialized subsections called "THEMES". By the end of 1970, there were 83 themes comprising more than 2,000 individual research projects. At that time, 58 countries formed national committees while 32 others participated informally.

CANADIAN PARTICIPATION

In 1965, the Canadian Committee for the International Biological Programme, sponsored by the National Research Council, was established. CCIBP formed seven sections matching each of the seven international sections as described previously.

Some of the major projects supported or recognized by CCIBP are:

- a) Matador Project, Saskatchewan, supported by CCIBP, section PT
- b) Marion Lake Project, British Columbia, supported by CCIBP and UBC, section PF
- c) Gulf of St. Lawrence Project, Quebec, supported by CCIBP, Fisheries Research Board and universities, section PM
- d) Igloolik Project, Northwest Territories, supported by CCIBP and University of Toronto, section HA

CONSERVATION OF PLANT GENE RESOURCES

Conservation of plant gene pools is a theme of section UM with Dr. O.H. Frankel of Canberra Australia as coordinator. The main concern of this theme is conservation of cultivated plant gene pools and their related wild allies, eg. wheat, potatoes, etc.....

Since forest trees cannot be manipulated and stored as cultivated plants, we (IBP-CT section) claim that this type of conservation is relevant of CT section.

IBP-CT IN CANADA

This section is organized differently than other sections of the IBP, as it is concerned with a different problem. The chairman of this section is Dr. W.A. Fuller of the Department of Zoology, University of Alberta.

For the IBP-CT program, Canada is divided in 10 regions, each Regional organization has two co-chairmen assisted by a regional panel. One of the chairmen is a zoologist and the other a botanist.

Regions are as follows:

- Region 1: British Columbia
Chaired by V.J. Krajina and Peter Larkin
- Region 2: Alberta
Chaired by G.H. La Roi and W.A. Fuller
- Region 3: Saskatchewan
Chaired by J.S. Rowe, D.H. Sheppard and U.T. Hammer
- Region 4: Manitoba
Chaired by J.M. Walker-Shay and R.W. Nero
- Region 5: Ontario
Chaired by J.B. Falls and G.A. Hills
- Region 6: Quebec
Chaired by M. Maldague and G. Lemieux
- Region 7: Maritimes (New Brunswick, Nova Scotia, Prince Edward Island)
Chaired by P.M. Taschereau and I.G. McQuarrie
- Region 8: Newfoundland - Labrador
Chaired by D.H. Steel and O.A. Olsen
- Region 9: Tundra Northwest Territories
Chaired by G.W. Scotter and V. Geist

All these panels have been active since 1968.

Check-Sheeting Procedures

The co-chairmen and panel members of each region have met several times to take inventory of their regional requirements. The most endangered areas, areas of special botanical or zoological features and samples of most ecosystems to be protected for conservation and research purposes have been selected.

Each candidate area is visited by field parties and described in a standard way on a check-sheet designed for world-wide use. When a check-sheet has been completed, a copy is deposited at the National Library in Ottawa and the original is deposited at Monks Wood, U.K., for international registration.

In January 1971, candidate areas and check-sheeted areas were as follows:

	Candidates	Check-sheeted
1-	British Columbia..... 63.....	43
2-	Alberta.....127.....	38
3-	Saskatchewan..... 82.....	21
4-	Manitoba..... 45.....	11
5-	Ontario.....280.....	96
6-	Quebec..... 78.....	9
7-	Maritimes.....153.....	2
8-	Newfoundland - Labrador..... 34.....	0
9-	Tundra (NWT)..... 54.....	2
10-	Boreal Forest (NWT).....no data.....	11
	TOTAL.....916.....	233

A majority of the 916 candidate areas are forested and all Canadian tree species are represented.

Legal Protection

It is commonly said that we shall protect our environment, but it is very difficult to do so. The only way to protect a given natural area is to provide legal protection for both crown and private lands.

This is the concern of a working group headed by Dr. A. Thompson from the University of British Columbia. They have undertaken a study of North American legislation concerning protection of natural areas to provide model legislation suitable for all Canadian governments.

Relations between IBP-CT and Governments

In most regions close liaison has been established between IBP-CT panels and provincial or federal governments. Most regions have presented briefs asking for new legislation on ecological reserves or amendments to the existing acts. The response of the different governments has been quite unequal and ranges from new legislation to the formation of advisory committees. The following is a listing of the action taken by some of the governments concerned.

British Columbia

In May 1971, the Legislative Assembly introduced the "Ecological Reserve Act".

Alberta

In early 1971, the Legislative Assembly of this province introduced the "Wilderness Area Act".

Saskatchewan

The Deputy Minister of Natural Resources has decided to set up a committee to consider requests for natural areas.

Ontario

In 1969, an Advisory Committee on Nature Reserves was established to advise the minister of the Ministry of Natural Resources.

Quebec

In 1971, a brief was submitted to the government for an Advisory Committee and an amendment to the "Land Act".

Newfoundland

In May 1971, a formal proposal was made to the government asking for protection for natural areas.

Northwest Territories

Last May a request for protection of tundra was made to minister Jean Chretien for the Northwest Territories.

The preceding represents the work done by IBP in the last four years. With the help of other scientific organizations, such as yours, it will be soon possible to provide protection for all our endangered plants and animals.

THE CANADIAN INSTITUTE OF FORESTRY PROGRAM ON NATURAL AREAS

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ABSTRACT

It is proposed that the Canadian Institute of Forestry establish a national system of standards for the selection, registration and management of forested natural areas in Canada. The Society of American Foresters has been operating such a system in the U.S. for a number of years.

A policy statement was prepared based on the SAF policy, policy standards of the U.S. Federal Government, and the comment of a number of correspondents in Canada. It is hoped that CIF sponsorship of such a system will enable other organizations interested in natural areas (International Biological Program (IBP), Provincial Governments, etc.), to use the services and good offices of professional foresters to select and set-aside forested natural areas. Simultaneously it is hoped that the registration will ensure that a minimum standard size of natural area is established in representative portions of all of Canada's major forested cover types. Such natural areas would represent reserves of gene pools.

The policy was adopted by the CIF at the Annual Meeting in October 1971. Cooperation with all other interested agencies is proposed through a permanent national committee. This committee will also examine proposals for registration and set-up a registration system.

The policy statement "Canadian Institute of Forestry Policy for Selection, Protection and Management of Natural Areas" has been published (For. Chron. 48:1-3).

The purpose of this paper is to outline recent developments on a proposed national registration system for forested natural areas in Canada. Although the registration system is still in the planning stages, I hope that this outline will enable you to judge how such a system might serve the need for the conservation of forest gene resources and other purposes.

HISTORY OF THE NATURAL AREA CONCEPT

In 1969, R. Buckman of the U.S. Forest Service gave a talk to the Society of American Foresters in Boston outlining the development of the SAF program for scientific natural areas. The following is a quote from his paper.

¹Chairman, CIF Natural Areas Committee.

"The beginning of concern about natural areas for scientific purposes is uncertain, but it appears that Victor E. Shelford, working through the Ecological Society of America in 1917, was the first in the U.S. to recognize the need. W.W. Ashe of the Forest Service made a plea for the importance of natural areas in the Journal of Forestry in 1922. In the late 1920's, E.N. Munns, also of the Forest Service, began to push for natural areas. The first areas were actually set aside in the National Forests about 1930.

In 1947, the SAF established a Natural Areas Committee. John Shanklin, Chairman of the Committee from 1947 to 1960, recently described the history of the Committee in the Journal of Forestry. You may also have noticed another recent article in the Journal by Jerry Franklin and Jim Trappe, giving a contemporary view of the importance of forested natural areas. The SAF recognized perhaps 50 natural areas in 1947; it recognizes about 200 today. The Society's Committee on Natural Areas hopes within a year or so to prepare a completely revised list of areas, last brought up to date in 1960.

In 1963, the American Association for the Advancement of Science prepared what is the most complete study of natural areas yet undertaken in the U.S. Among other recommendations the AAAS report called for enlarged and better co-ordinated natural areas programs in the U.S. In the mid-1960's the federal land managing agencies formed an Interagency Committee to review natural area programs on federal land. The Interagency Committee in 1968 published a Directory of Research Natural Areas, describing 336 examples of natural communities, set aside on the National Forests, National Parks, National Wildlife Refuges and the Public Domain (land under jurisdiction of the Bureau of Land Management)."

You will note that foresters took the lead in the United States. Listening to this talk made me wonder whether or not such a system was required in Canada. Thus the need for such a system in Canada was presented in the February 1970 issue of the Forestry Chronicle (Weetman 1970) together with a report by J.H. Cayford (1970) on a recent meeting of the SAF Committee. He reported as follows:

"The SAF has defined a natural area as a 'tract set aside to exemplify typical or unique forest vegetation, and its associated biotic, edaphic, geologic, and aquatic features in as near-natural conditions as possible, primarily for purposes of science and education'. The classification system for the SAF natural area vegetation types is the publication 'Forest cover types of North America', published by the Society. However, it is recognized that extensive and variable forest types such as eastern hardwoods and ponderosa pine require recognition of sub-types and diverse habitats when establishing natural areas."

Among the activities of the SAF Committee are (Cayford 1970):-

1. To develop and maintain standards of conditions and quality governing the selection of natural areas and to set forth principles for their protection and management.
2. To sponsor liaison officers in SAF Sections to promote natural area selection and establishment and to make recommendations to the Committee.
3. To encourage natural area establishment and preservation by all landowners, public and private, where SAF standards can be met.
4. To approve the registration of natural areas by the Society of American Foresters on the basis of their qualifications, the needs of the national program, and the protection assurance from the landowner.
5. To promote research and educational uses of natural areas by the scientific and educational community through publicizing negotiations between landowners and users.

Since the inception of the program some 200 natural areas have been recognized (U.S. Fed. Comm. on Res. Nat. Areas 1968). The last complete list was issued in 1960; it lists 128 natural areas located within 34 states and Puerto Rico. One of the current aims of the natural areas committee is to prepare a new revised up-to-date list as soon as possible. Prior to publication, each area listed in 1960 will be reviewed to determine its current status; it is expected that a few areas will have to be discarded for various reasons.

Continual progress is being made in locating and approving natural areas. In 1969, twenty-six additional areas were added to the list; these include natural areas in such diverse types as bur oak, red pine, black spruce-tamarack, pinyon-juniper, water tupelo and Douglas-fir and are located in 13 different states extending from Maine to California.

CIF NATURAL AREAS COMMITTEE

A CIF natural areas committee was formed and an organizing and discussion meeting was held in Winnipeg in October 1970. The appropriate Provincial and Federal Government departments were asked to be represented at the meeting. The meeting was well attended and the consensus was that a policy and registration system should be developed.

G.F. Weetman visited R. Buckman of the U.S. Forest Service in Washington, D.C., to learn more about the operation of the SAF system of liaison officers and about other professional and governmental and private organizations involved in establishing natural areas.

J.H. Cayford, Canadian Forestry Service, on behalf of the CIF attended a meeting of the U.S. Federal Committee on Research Natural Areas in Portland, Oregon, in May 1971. From these meetings and contacts, plus

correspondence in Canada with provincial parks people (Ont. Adv. Comm. on Nat. Res. 1969-70) and the IBP-CT Program - "CT" members in several provinces (Fuller 1971; Maldague & Lemieux 1971) and also people concerned with the recent B.C. Ecological Reserves Act (Franson 1971), a large amount of reference material and advice on policy matters was obtained.

From this material, a draft CIF Natural Areas Policy was assembled, largely based on the SAF (Soc. Amer. For. 1971) policy and papers given at the Portland meeting, (N.W. Sci. Assoc. 1970). The policy was adopted by the Canadian Institute of Forestry at the 1971 Annual Meeting, (Canadian Institute of Forestry 1972).

CIF POLICY STATEMENT

The main points of the policy statement are as follows:

1. Natural areas of suitable size and representative of the major forest sections in Canada should be established.
2. The natural areas shall be protected and if necessary 'managed' in order to maintain them.
3. The policy only mentions forested or 'forest related' natural areas. At the moment other natural areas (tundra, marine, prairie, etc.) are considered to be outside the CIF's jurisdiction, although recognition and registration of such areas is considered desirable.
4. Unique natural areas are recognized.
5. Standards are proposed for recognition.
6. None of the policy statement is really original, it is nearly all taken directly or developed from various sources, mainly from the United States (see reference list).

How Would Such a Registration System Work?

The details of the registration system have not been worked out. Obviously there will be coordination problems with a system of CIF liaison officers, one in each of the CIF Sections. You will note that cooperation with other organizations and interested persons is stressed. Files would be kept in the CIF head office at MacDonald College near Montreal.

It is my impression that no other organization wants to take on this job, that foresters should be involved and that the CIF is the logical agency to get it started.

Reactions to the Policy Statement

Reactions to the statement have generally been favourable, but several commentators have brought up the need for registration of natural areas, other than forested ones and suggested that one central agency such as the Department of the Environment, the Biological Council of Canada, or the National Research Council should do it.

Also concern has been expressed over definition, size, the need for 'management', and the ability of the CIF to operate such a program. Generally favourable or sympathetic comments have been received from individual provincial government commentators in British Columbia, Saskatchewan, Manitoba, Ontario and Nova Scotia and, also, from the Canada Department of Indian Affairs and Northern Development. No comment has been received from Alberta, Quebec, New Brunswick, Newfoundland or Prince Edward Island. Further comments will be requested at the October 1971 national meeting of the CIF in Victoria, B.C. Commentary from the Canadian Committee on Forest Tree Breeding would also be appreciated.

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CONSERVATION OF FOREST TREE GENE RESOURCES IN CANADA: AN ECOLOGICAL PERSPECTIVE

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ABSTRACT

Forests cover about 48% of the 3.56 million square miles of Canada's land surface, and include about 130 native tree species. Since the settlement of Canada by Europeans, the conversion of about 2% of forest land to agricultural uses, together with extensive utilization of the remaining forest land for consumptive forestry, has probably adversely affected forest gene resources locally. On a national scale, however, the erosion of forest gene pools has been relatively small. None of the Canadian tree species is in immediate danger of either extinction or serious genetic erosion, except in the case of local populations of a few tree species in southern Canada near urban and industrial centres. New taxa are still being evolved as tree populations migrate, and man's activities have contributed to this evolution.

Post-glacial history of the forest vegetation, vegetation dynamics, spatial and temporal relationships between species and habitat, climatic fluctuations, role of disturbances, compatibility of gene pool preservation with other aspects of conservation, reproductive behaviour and future utilization of species are all factors that should be considered in relation to the preservation *in situ* of the gene pool of a species in all its diversity. Gene pool preservation *in situ* requires management of the designated areas with well defined objectives. Such effort is expensive and considerable planning is necessary before committing a tract of forest land primarily for the purpose of gene pool conservation. Canadian efforts in this area should be coordinated with those in the U.S.A.

INTRODUCTION

Increasing world-wide utilization of forest landscapes by man and the paucity of ancestral types for the genetic improvement of agricultural and horticultural species has led to some interest in the conservation of gene pools of forest tree species (Food and Agriculture Organization 1969; Frankel and Bennett 1970). This report examines the status of gene resources of forest trees in Canada from an ecological viewpoint and describes some ecological aspects of conserving these resources *in situ*. The views presented here essentially represent an analysis of the general situation across Canada; however, the existence of localized exceptions to the generalized statements is recognized.

THE CANADIAN FOREST

Post-glacial History

Most of Canada was covered by ice during the pleistocene. Following the retreat of the glaciers, the land was colonized by species which survived south of the glaciers and others which survived in refugia located in central Alaska and in the Yukon. Many species from the south and east migrated rapidly to deglaciated land. In recent times, these migrating species have come in contact with the western populations in the southwestern MacKenzie, southern Yukon and northern British Columbia. High population variation occurs in these areas, where renewed contacts between closely related species is resulting in hybridization. One example is the *Picea glauca* complex (Wright 1955). A somewhat similar situation exists in the case of *Populus* in the same area and in southern Alberta (Brayshaw 1965 a,b).

The Present Forests

Forests extend about 4,500 miles from the east to west in Canada and cover 48% of Canada's 3.56 million square miles of land surface. About 55% of this forest land is productive, i.e., capable of producing merchantable wood (Anonymous 1970). It should be pointed out that so far only 65% of Canadian forests have been inventoried (R. Grinnel, personal communication).

The present Canadian tree populations are characterized by their relative youth; in many parts of the boreal forests the land has been under a tree cover for possibly less than 10 tree generations. Species ranges are oscillating at different rates (Maini 1960, 1966) and the rate of species movement is determined by opportunity, migration potential (including reproductive capacity), and ability to acclimatize rapidly to changing ecological conditions (Rowe 1966). Broad distribution range and wide ecological amplitude of many Canadian tree species would suggest that these species are genetically very heterogenous.

About 130 native tree (above 13 feet tall) species constitute Canada's forests. Two centres of "species richness" have been recognized by Rowe, one in southern Ontario and the other in southern British Columbia. From these centres, the number of tree species decreases towards the centre of the country, as well as from south to north. For example, there are approximately 30 tree species in British Columbia, 20 in Alberta (including the Rockies) and 10 in Saskatchewan. There are perhaps 75 native tree species in southern Ontario, 50 at the latitude of Ottawa and Montreal, half this number (25) in the Clay Belt, and again half as many (12) near James Bay (Rowe 1966).

IMPACT OF MAN

Prior to European settlement, the activities of indigenous man apparently had very little impact on Canada's forests, particularly from the viewpoint of gene resources. However, almost all of the agricultural

land in eastern Canada and a considerable portion in British Columbia has resulted from clearing of forests following settlement. This activity, affecting possibly 2% of the total forest land, and selective cutting of certain southern hardwoods for the furniture industry, has undoubtedly resulted in some depauperation of gene resources of local populations. However, according to Rousseau (1966) not even a single tree species has become extinct in eastern Canada since European settlement; this observation is likely equally applicable to the rest of Canada.

While some of the non-productive and abandoned agricultural land in eastern Canada is naturally reverting to forest by extension of the surrounding forests, plantation forests are being established in other areas. On the other hand, some of the most productive agricultural land in the east (formerly occupied by forests) is being utilized for urban and industrial development. Major post-settlement impact on forests, however, is attributed to the activities related to consumptive forestry.

From the viewpoint of gene resource conservation, it is significant to note that at present, about 2.25 million acres of productive forest are harvested annually (clear cut 87%; selection cut 12%; other 1%); of the total forest area cut annually, 69% regenerates naturally (i.e., adequately stocked for consumptive forestry), 14% is planted, seeded or silviculturally treated for seedbed preparation (for natural seeding), and another 17% of the land requiring silvicultural treatment is left untreated (R. Waldron, personal communication). Up to 1965, a total of 1.85 million acres of man-made forests were artificially regenerated by planting or seeding. This, however, represents only 0.3% of Canada's productive forest land. By 1985, man-made forests may amount to more than 10 million acres, representing less than 2% of productive forest land (Cayford and Bickerstaff 1968). The current rates of planting and seeding would suggest that by the year 2000 man-made forests would constitute about 4% or, at the most, 5% of the productive forest land.

These data have a number of implications in the conservation of gene resources:

- 1) Local gene resources are perpetuated on nearly 70% of the cut-over which regenerated naturally.
- 2) The above data concerning adequate natural regeneration, are viewed strictly from the consumptive forestry viewpoint; while about 25 trees per acre is, perhaps, quite adequate to replenish the local gene pool, this number is inadequate for consumptive forestry. Therefore, while examining data on the adequacy of natural regeneration, distinction must be made between the desirable levels of stocking for consumptive forestry and for gene resource conservation. Therefore, some of the above statistics used to justify the need for the conservation of tree gene resources in Canada (Roche 1971) should be employed with caution.
- 3) Species regenerating naturally on a cut-over may be the same as those harvested or other commercially valuable species.

The above data concerning adequate stocking do not discriminate any shift in species composition.

- 4) Field observations show that almost all of the cut-over forest land is colonized by some tree species; cut-overs devoid of tree cover for an extended period are uncommon. Generally such areas are colonized by intolerant pioneer species. There is, however, nothing "unnatural" about this situation because, to my knowledge, permanent occupancy of a given piece of forest land by a particular species (or a particular assemblage of species) is not a "normal" or characteristic feature of Canadian forests.

In some cases, the habitat created by cut-overs contributes to the perpetuation of new and diverse gene pools. For example, in New Brunswick hybrids between *Picea mariana* and *Picea rubens* do not become established in habitats occupied by either parents but are successful in disturbed areas and cut-over forests (Morgenstern and Farrar 1964).

CONSERVATION OBJECTIVES

Forest conservation in its broadest sense includes resource conservation by wise management so that the resource may be used in perpetuity for consumptive purposes, as well as for recreation, education and science.

Conservation of tree gene resources may have one or more objectives. Conservation of tree gene pools for scientific purposes is already either being considered or is already in action (e.g., by the International Biological Program CT Committee (IBP-CT) and the Canadian Institute of Forestry (CIF) Natural Areas Committee). Conservation of tree gene resources for use in consumptive and non-consumptive amenity forestry has long been practised in Canada. The Food and Agriculture Organization (FAO) is concerned with the consumptive forestry aspects of gene pool conservation on an international scale, and Canada's National Parks include large tracts of natural tree populations for amenity and recreation. Often tree gene pools are preserved incidentally due to the reservation of forest land for some other purpose such as recreation. This particularly applies to national and provincial parks.

One objective of tree gene conservation which has so far received little attention is that of recognizing and conserving tree species critical in maintaining ecosystem stability. Canada's northern and central forests contain fewer tree species than those in "areas of species richness" in southern Ontario and southern British Columbia. The latter forests could perhaps tolerate the loss of a few species, but the northern and central forests could be more sensitive to such a loss.

GENE RESOURCE CONSERVATION METHODS

Methods proposed for the conservation of tree gene resources include (a) arboreta, (b) clone banks, (c) pollen banks, (d) seed banks, (e) tissue culture and (f) forests *in situ*, in conjunction with other objectives (Frankel and Bennett 1970).

All of the above methods have certain limitations and the objectives of a particular conservation program will determine the method or combination of methods employed.

The following discussion is confined to *in situ* conservation of tree gene resources.

About 26,500 square miles of forest land in Canada are reserved for National Parks and other non-consumptive uses. This does not necessarily imply that tree gene resources are being conserved by this reserved forest land. From an ecological viewpoint, consideration should be given to the following facets of conservation of gene resources *in situ*:

- 1) Static or Dynamic Conservation? Is the intention to arrest the present evolutionary state (static conservation) or to allow natural forces to act, select and alter the present gene pool?
- 2) Vegetation is not Static. A number of agencies (e.g., IBP, National Parks) do not include disturbance in their conservation scheme. Under undisturbed conditions, intolerant species are at a distinct disadvantage.
- 3) Pollen Pollution. It is virtually impossible to maintain *in situ* the present genetic make-up of a population indefinitely. Spring progresses rapidly in northern latitudes and pollen is transported long distances (Lichti-Federovich and Ritchie 1965).
- 4) Climatic Considerations. In view of increasing air pollution and its effects on vegetation, consideration should be given to the locations of major pollution sources, topographic barriers to air mass movement, and occurrence of any semipermanent inversions in relation to the location of the stand proposed for *in situ* conservation of gene resources.
- 5) Habitat Diversity. In order to conserve gene resources in all their diversity, it is important to provide diverse habitats. A forest-reserved for gene resource conservation may consist of a central core of undisturbed land with perhaps three concentric zones of increasing disturbance. Otherwise, undisturbed (stable) conditions, would become a selective force and over the long-term period, tend to narrow the genetic base of the population.
- 6) Species Occupancy (long-term). As indicated earlier, a change in species composition over a given piece of forest land is not only natural in Canadian forests, but may be in some cases quite desirable. According to some, continued occupancy by conifer crops may ultimately result in site degradation, particularly on poor soils (Page 1968). In eastern Canada, it has been suggested that long-term occupation by black spruce degrades some sites.

SOME GENERAL CONSIDERATIONS

The conservation of tree gene resources involves problems peculiar to forestry, and agricultural experience does not apply equally to forest trees. Some form of conscious or unconscious selection has been taking place in agricultural plants since 7000 B.C. The selection of these annual plants has been intensive and concentration on essentially one characteristic (i.e., higher yields) has resulted in a narrow gene base. In contrast, Canadian forests are essentially in a wild state and only recently has a relatively small component been "humanized". Forest trees are long-lived, and have many consumptive and non-consumptive uses. According to Stern (1970), genetically important features of trees include occurrence of wind pollination, allogamy, effective gene flow, high recombination index and generally broad genetic variation in local populations.

From the Canadian viewpoint, the recommendations by FAO (1969) also require careful analysis. This report does not describe the basis on which "work" (exploration, utilization and conservation) priorities were developed. While utilization involves technology and a demand, the priorities set by FAO are certainly not the same as those which apply to Canada.

CONCLUSIONS

As pointed out by Cronquist (1971), "One can neither restore the entire past, nor preserve the entire present for future generations." Compromises have to be made, and social, economic, industrial, technological factors should be considered in defining the objective of a conservation program. For example, according to MacNeil (1971), the Canadian population, which in 1965 was about 20 million, is expected to increase to 34 million by the year 2000 and to 46 million by 2020. Current trends suggest the concentration of the population in urban areas. In view of these forecasts, one would not expect any consumptive forestry in southern Ontario in the future and the situation there could be somewhat similar to that described by Richardson (1970) for Britain. Should we, then, embark on a major program to conserve impoverished gene resources of southern hardwoods in all their diversity?

Canadian forest vegetation is young, adaptable, genetically variable and essentially in a wild state. This, together with the post-glacial history and the fact that instability is an important feature of Canadian forests, would suggest that these tree species have considerable "genetic resilience". Cut-over areas are at present generally being adequately restocked by natural regeneration. The latter regeneration method will be even more favoured if aesthetic logging systems are introduced in response to demands for environment quality. Economics of forestry operations in Canada also favour natural regeneration.

General observations by Callaham (1970) that foresters are not faced with imminent loss of their wild species and that the preservation of forest gene pools is not a pressing problem, are particularly applicable to Canada.

A few researchers within the CFS have made preliminary analyses of local problems that require attention (D.P. Fowler, personal communication; B.S.P. Wang, C.W. Yeatman and E.K. Morgenstern, personal communication); these analyses are provided (Appendix II and III) in the hope of stimulating further discussion and necessary action. For the purposes of broad national strategy consideration should be given to fractionating Canadian tree-species according to their distribution range (narrow- or widely-distributed) and further subdividing into tolerant and intolerant species.

Conservation of gene resources *in situ* involves more than filling out IBP-CT check sheets or passing legislation. It requires the development and execution of well considered management plans for the designated areas. The effort will be time consuming and expensive. It is, therefore, necessary to have clearly defined objectives.

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LEGAL AND REGULATORY ASPECTS OF GENE POOL
MAINTENANCE IN ECOLOGICAL RESERVES

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INTRODUCTION

The development of legal and administrative methods by which ecological reserves may be established and maintained is dependent upon an understanding of the diversity of sites to be considered for inclusion in the system and upon the activities that will be carried out on such areas. Several years of intensive work in the Conservation Section of the International Biological Programme (IBP-CT) have not resulted in any major new suggestions for the kinds of sites desired for the system of ecological reserves. The original IBP guidelines (Nicholson 1968) recommended that:

- (a) the areas should, taken together, contain adequate and manageable samples of the entire range of major ecological formations or ecosystems in the world and illustrate the degree of variation within each;
- (b) the series should include sites which, although they do not qualify for inclusion under the first criterion, support species of plants and animals of outstanding interest or great rarity;
- (c) the series should include sites which are of scientific interest because of the human management to which they have been subjected, even if this has in some cases led to more or less far-reaching modification of the biota;
- (d) the series should include sites which are important because they have been the scene of detailed and well-documented research;
- (e) the series should include sites which contain for example, deposits of peat, lignite or sediment from which information may be obtained about past vegetational and climatic changes, and also sites which are of special palaeontological importance;
- (f) the series should include sites which are of special physiographic or geomorphological interest and which represent unusual habitats.

*Footnotes are listed at the end of this paper.

In selecting this series the following general considerations will also be borne in mind:

- (a) areas should be included whether or not they appear to be under immediate threat. Experience has shown that no reliance can be placed on the survival by good fortune even of very remote areas, and a comprehensive series of the sites which are required for science and education must be selected and preserved if further irreplaceable material is not to be lost;
- (b) other things being equal, preference should be given to sites that can conveniently be worked by existing or proposed research institutions; to sites that can be supervised and managed effectively; and to sites least likely to be affected by adverse neighbouring development and by air and water pollution;
- (c) areas must be of adequate size to support viable populations of the species which characterize them and for which they are established;
- (d) research areas must also be large enough to allow for the increasing amount of land demanded by modern field experimental research, especially since disturbance or damage arising from such research often modifies these areas and hence requires resting or replacement of such sites from time to time;
- (e) while consideration of amenities and attractiveness to tourists should not determine the selection of an area for protection for scientific purposes, there are sometimes advantages in locating scientific reserves near to or within larger areas of high landscape value, since it then becomes justifiable to protect a larger and more viable unit.

Although there will continue to be debate on the details of these original guidelines, there now appears to be consensus as to five broad purposes of ecological reserves. One way of stating these purposes is as follows⁴:

- (a) to preserve representative examples of significant natural ecosystems for comparison with those managed by man;
- (b) to provide educational and research areas for the scientific study of successional trends, evolution of species, inter- and intra- species relationships, and the balancing forces in relatively undisturbed ecosystems;
- (c) to provide educational and research areas for the scientific study of other aspects of the natural environment such as meteorological, geomorphological and pedological processes;

- (d) to provide educational and research areas for the scientific study of recovery processes in ecosystems that have been modified by man;
- (e) to serve as a natural gene pool for the preservation of species of plants and animals and their habitats.

This is the setting by which this symposium may view the question of a national policy for the conservation of forest gene resources. It is assumed in this paper that the concept of forest gene resources is a wide one that includes natural forests, artificial plantations of both indigenous and exotic species, seed stands, arboreta, provenance collections and clone archives (Richardson 1970). At least two of the broad purposes of ecological reserves are directly relevant to studies of genetics and genealogy in forests; namely, the maintenance of large, heterogeneous, natural gene pools, and the provision of outdoor laboratories of natural vegetation for a variety of research objectives⁵. The unifying objective is to have an experimental framework by which either information or genotypes from baseline areas are compared with information or genotypes from other ecosystems, especially those managed by man. The central legal and administrative questions with respect to this objective are:

- (a) How are selected areas to be given long-term tenure and legally enforceable protection against encroachments from external and incompatible land-uses?
- (b) How is on-site use of an ecological reserve, after its establishment, to be regulated to ensure perpetuation of those features for which the reserve was selected?

To provide answers to these questions, Canada Council provided funds for the establishment of a legal committee within the Faculty of Law at the University of British Columbia. From the beginning it was contemplated that one of the functions of the committee would be to provide advice to the IBP regional panels and, if called upon to do so, write briefs for presentation to governmental officials. In this paper we will describe the work of the committee and present some of its conclusions concerning the legal and administrative problems relating to the maintenance of gene pools in ecological reserves.

LEGAL AND ADMINISTRATIVE REQUIREMENTS FOR GENE POOL MAINTENANCE

Legislation Needed

Part of the work of our committee was to determine what legislation was necessary for the creation of an ideal ecological reserves programme in Canada. Because the IBP envisaged a national system of ecological reserves and because much could be gained by having a single system that would avoid duplication of administration, we investigated the possibility of placing the responsibility for an ecological reserves programme with the federal government. However, in our federal system of government the land and

resources are administered by the provincial governments. Consequently, in order to establish a federal system of reserves it would be necessary for each province to give title to ecological reserve sites to the federal government much as is done to create national parks. However, provinces jealously guard the land which they administer and it seems, therefore, that any scheme for ecological reserves would have to recognize that provincial lands would remain under the control of the provinces.

This does not bar federal participation however. The lands of the northern territories are under federal ownership and legislative jurisdiction and contain a large number of valuable ecological reserve sites, as do the national parks⁶. The role of the federal government in protecting these sites should be the same as the role of the provincial governments in protecting sites within their boundaries. In addition, the federal government could provide much needed financial support for the provincial programmes.

At the time of our survey, we concluded that legislation would be needed in all jurisdictions to establish an ecological reserves programme, and that such legislation should provide for:

- (a) acquisition of land;
- (b) designation of reserves;
- (c) restrictions on disposition of reserved lands;
- (d) the appointment of an administrator and an advisory committee;
- (e) the power to make regulations for the management of the programme.

Since that time British Columbia has enacted an Ecological Reserves Act⁷ containing some, but not all, of the features we feel are necessary.

In most cases, new legislation would not be necessary to allow the provinces to acquire and designate land as an ecological reserve. Expropriation acts are generally broad enough to allow purchase of ecological reserves and crown lands acts generally contain provisions allowing the designation of certain crown lands for public purposes. However, existing legislation would provide little protection for such reserves once designated, would not provide for management of the reserves, and would offer no guidance to administrators considering sites proposed for inclusion in the reserves system.

Moreover, although ecological reserves may often be created from crown lands, where unique areas are sought or where there is very little crown land available, such as in southern Ontario and the Maritime provinces, privately held land will be required. Therefore a model act should contain provisions for exchange, purchase and expropriation of lands as well as an authorization to accept gifts. In some cases private owners will not wish to give over clear title to the government department administering reserves

and therefore a partial donation of the land in some form that would leave the formal title unimpaired or only partially impaired such as a determinable fee simple or an easement should be acceptable within a reserves system⁸. Vacant land held in a natural condition will increase in value with continued population and urban growth. Tax incentives are one method of encouraging private holders to preserve their land and groups such as the Nature Conservancy actively lobby for special tax status of designated lands. Provision for tax relief, in the form of a clause in a reserves act or an amendment to taxation acts, might gain provincial approval if there is a responsibly run, permanent programme.

In addition, much existing crown land is already encumbered. Grazing permits, mineral leases, timber licences, and petroleum exploration licences are all examples of legally binding contracts which must be recognized. It is not part of our legal history to confiscate such interests without compensation and in some cases compensation would be prohibitively expensive. For those encumbrances that will expire at a fixed date if no work is done or discovery made, ecological reserves legislation might provide that leases of lands within an ecological reserve not be renewed when they expire.

Perhaps the most important requirement of ecological reserves legislation is that it should protect the reserves against the many conflicting land uses that exist. Partial protection can be provided by giving the agency administering the reserves the power to make regulations restricting or prohibiting all uses. We felt that such measures were inadequate because a government might be persuaded to allow commercial development which offered attractive economic prospects for the province. We also feared that areas might be removed from the reserve system altogether in response to economic demands.

One way of meeting these threats is to include in the legislation a declaration that the lands are to be held in trust for ecological reserve purposes. Because this technique is relatively unused in Canada it is difficult to predict its effect. However, it may enable members of the public to intervene if the reserves were not managed in an appropriate manner. Certainly it would serve to draw to the attention of those charged with administration of the reserves the importance of their duties⁹.

Another means of protecting the reserves from the pressures that might be exerted by those favoring other uses of the land is to force decisions involving modification of the boundaries of a reserve to as high a political body as possible and provide a means for assuring that the arguments in favor of continued reserve status will be effectively made before that body. Accordingly, we suggest that the Lieutenant-Governor-in-Council, that is the Cabinet, be required to make the order withdrawing lands from the programme after an Advisory Committee has presented its position, preferably with the aid of public hearings.

The Advisory Committee should be comprised of a majority of non-civil servants who would be experienced in administration, industry, education and the various branches of science that will use the reserves.

This is the body that would formulate policy for the programme and act as its defender. It also would be the body responsible for evaluating and regulating the conflicting demands for preservation and use of the areas.

Ecological reserves legislation must also include provisions protecting the reserves from dispositions that might be made under other acts. For example, provincial forestry officials often have the power to grant cutting privileges and grazing permits on unoccupied crown lands. Protection from these threats can be afforded by specifically excluding the application of all other acts to ecological reserve lands¹⁰.

In most cases hunting and fishing can be controlled by the regulatory powers granted under the ecological reserves act and the fish and wildlife acts of the province or territory.

As yet, an unsettled difficulty for both the territories and the provinces will be native hunting rights. Such rights of course may be bargained for and the native peoples themselves hopefully will see the value of protecting segments of their landscape from the ravages of technological society.

Ecological reserves can also be adversely affected by activities taking place on adjoining lands. For example, the discharge of effluent or stream diversion upstream from an ecological reserve could affect the characteristics for which it was set aside and designated. Therefore, some provision should be made so that the administrators of the reserve are consulted through departmental channels in advance of the issuance of permits under water or pollution control acts. This requirement may involve an amendment to such statutes.

Management of Reserves

Management of ecological reserves in our model statute was left to a management authority staffed from the government department responsible for the programme. This body would be responsible to the Minister who would establish policies in consultation with his Advisory Committee. Of course, the management authority would be limited to the powers delegated to it by the Minister and the Act.

Specific regulatory powers should be included in the act so as to lay the foundation for the exercise of authority required to manage the programme while at the same time avoiding too broad and unspecified powers which could lead to a deviation from the purposes of ecological reserves¹¹.

The management authority, with the advice of the Advisory Committee, should be empowered to make classifications of reserves, to apply the classifications to particular reserves for management purposes and to prepare and publish management plans for the reserves.

There should be a general restriction against using an ecological reserve in any manner inconsistent with the purposes for which it has been designated or inconsistent with any use classification or management plan

established for it. A provision that would prohibit hunting and fishing or other casual use of the land could not be enacted until ecological reserves are posted, fenced or otherwise provided with apparent boundaries which would give fair warning to the public. Such regulatory power should be available for use at a later stage when those ecological reserves requiring this very strict protection are designated and protected with boundary fences or markers.

In order to provide for the management of ecological reserves many questions need to be answered about the use that will be made of these reserves. One such question is whether manipulative techniques will be used to manage vegetation. If reserves are to be managed to preserve the features for which they were designated the effect of other statutes will have to be excluded¹². For example, if fire is considered an essential element then some provinces' fire control statutes will have to be amended or excluded from operation; the same would apply to noxious weed control. These may seem like minor points but it is essential to meet them before difficulties develop. After a fire is started or 2-4 D has been sprayed it is too late to make amendments to existing legislation.

A more difficult question is whether the research needs of plant breeders, geneticists and genecologists are compatible with the management criteria that would need to be developed to ensure long-term protection of important features in ecological reserves. For example, does the IBP objective of maintaining large, heterogeneous gene pools within ecological reserves allow the introduction, by planting or grafting, of any genotypes from outside the designated reserve area? Might it be necessary to have a separate system of "experimental forests" into which diverse genotypes may be introduced for testing purposes? What kind of zoning criteria should be recommended to those who will formulate and enforce regulations? These questions cannot be resolved by the authors of this paper. However, it is important that these problems be introduced for discussion because the development of legal and administrative methods by which ecological reserves will be managed is dependent upon an understanding of the activities that are likely to be proposed for such areas and upon agreement as to which proposed activities are compatible with maintenance of the features for which a particular reserve was established.

Another question that deserves further consideration is the case of peripheral or disjunct populations of species that elsewhere may have apparently secure populations (Cain 1968). What biological or genetic criteria can one put forth to assist the administrator or politician who has been urged to provide protection for a population of some particular species that may be rare in his political jurisdiction but which occurs massively elsewhere? Is there justifiable provincialism in such cases? Are there special biological phenomena, such as the species tolerance limits with respect to some environmental variable, that can best be studied at the geographic limits of a species distribution? The rigidity of protective measures will, in many cases, depend upon the answers to questions such as these. In the case of forest genetics, this question may be international in character because frequently the countries in which certain seed trees

are located, and which are therefore responsible for their conservation, are not always the countries that are most directly interested in such genetic materials (Bouvarel 1970). Do forest geneticists have an obligation to preserve, either within ecological reserves or perhaps by other systems of conserving genetic materials, the habitats that support provenances of special significance to plant breeders or plantation managers here and in other countries? For example, should British Columbia provenances of Sitka spruce, Douglas-fir or lodgepole pine that are of proven superior value for plantations in Britain or continental Europe be considered during site selection for ecological reserves in this Province? If so, then organizations such as the Committee on Forest Tree Breeding in Canada, or perhaps the interested working groups of the International Union of Forest Research Organizations, would appear to have a responsibility to provide both criteria that would guide site selection and criteria by which such reserves should be regulated to protect the genetic material of particular interest.

Recognition that there may be a number of different types of ecological reserves would appear to be the most practical way of approaching the problems outlined above. For this purpose it is useful to draw upon the experience gained in Britain's series of Nature Reserves. Although Britain does have certain Reserves that are examples of relatively undisturbed habitats and are set aside entirely to preserve the fauna and flora, there are others that are deliberately managed as Nature Reserves under some kind of intervention; still others are thought of and managed primarily as public open spaces but are also important refuges for fauna and flora that survive there despite the disturbance (Nicholson 1957). In a world of increasing disturbance to the land surface, ecotypes adapted to such disturbance may themselves take on great value as important gene pools of the future (Bradshaw 1970). Therefore we envisage that ecological reserves will be zoned and classified according to type by the management authority.

PROSPECTS FOR PROVINCIAL ECOLOGICAL RESERVES SYSTEMS IN CANADA

Political reality may reveal that the model we propose is impractical or unrealistic in a particular province. Alternative methods of preserving those segments of the environment that must be preserved are available. The history of the British Columbia Ecological Reserves Act illustrates this.

Starting in 1965, discussions were held between the members of the IBP-CT Committee and officials of the Department of Lands and Forests. A joint committee composed of government officials and university scientists was established to select various areas that had been check-sheeted. Those areas approved by the committee and the Department were set aside under a temporary "map reserve"¹³. Under the Land Act, there was no authority for this procedure, but in 1970 a new Land Act was passed, which expressly empowered the Minister to temporarily withdraw crown land from disposition if he considered it to be in the public interest¹⁴. The Lieutenant-Governor-in-Council was given the power to create and cancel permanent withdrawals for public purposes¹⁵. Such power would have been sufficient to set aside crown lands for an ecological reserves programme and indeed little more than that is being sought in some provinces today¹⁶. However, the British

Columbia government felt that one specific piece of legislation would be required to protect and effectively manage a comprehensive reserves programme. Our legal committee was asked by Mr. D. Borthwick, the Deputy Minister of Lands, to submit a brief in which we set out what we considered to be a philosophy of ecological reserves and the major provisions we thought should be included in the previously discussed model statute. Although not all our recommendations were enacted into the British Columbia Ecological Reserves Act, the Act does provide the basic structure from which other statutes might grow.

From this history we draw two lessons. First, governments may favor moving cautiously with a programme of the sort envisaged by the IBP-CT. The British Columbia Government was clearly receptive to creating reserves and to enacting a statute to provide a basis for the programme. However, it exhibited a strong preference for a simple statute. Its argument was that too little is known at the current time about the needs of the programme and consequently it is better to provide for the programme in a simple fashion and make any necessary elaborations later through the regulatory powers incorporated in the Act.

The second lesson that may be learned from the experience in British Columbia is that the programme may best be initiated by government officials designating sites under any powers or procedures currently available to them. Then, as these officials become more and more involved, they will see the need for more detailed legislation. This seems to have been the progression of events in British Columbia, Ontario, and the United States, all of which now have active on-going programmes.

The first step in getting a programme started is to find some desirable ecological reserve sites on crown land that are not needed for other purposes and then convince the government that these sites should be reserved. Crown lands can usually be withdrawn from disposition for public purposes (of which ecological reserves should be one)¹⁷. The power to make temporary withdrawals is given to the minister in charge of provincial lands in British Columbia whereas permanent withdrawals in most provinces require Cabinet approval¹⁸. Other provinces are also likely to have informal withdrawal procedures. No province's land legislation expressly mentions ecological reserve sites nor does it provide adequate regulatory authority to manage a functioning programme. Minor amendments to existing legislation, although useful in getting endangered areas protected in the short run, will be inadequate to deal with management problems. Some sort of overseeing body will be required to coordinate reserves. Barring the model provisions mentioned earlier, a system based on a mixture of private and public lands such as exist in some of the state programmes may be required¹⁹. University research areas, agriculture stations, selected park areas, experimental forests, nature conservancies and private tracts could be dedicated to ecological reserve principles with minimum funding being provided by a provincial government grant²⁰. Even in this most basic scheme some form of legislative framework will be required to attract lands and ensure their preservation.

Another alternative is to use existing provincial park legislation, which often contains references to natural areas or areas of scientific interest²¹. Such acts almost invariably contain provisions for acquiring lands by purchase and expropriation. Administration is clearly laid out and regulatory powers are extensive. In most cases the basic act would require a few minor amendments to specify that ecological reserves are to receive special treatment, that the public may be excluded and that use is to be by permit only. In some cases the dedication to public use and enjoyment for recreation in the preamble of parks acts would raise serious legal problems if the public is to be barred from entry²². However, the major difficulty with including areas of scientific interest within parks is the confusion that the public and administrators will experience in trying to distinguish between the goals for which these areas are to be used and the goals of parks as we know them.

CONCLUSIONS

The legal techniques required to establish and protect ecological reserves are readily available. However, many government officials appear to remain unconvinced about the need for such reserves. Even in those provinces that are establishing reserves, officials are not convinced that the kind of legislative protection we describe here is needed. The problem is that there is no clear public or governmental support for the creation of a system of reserves for the more or less exclusive use of scientists. Greater effort seems needed from interested scientists to convince the public and governments of the value of an ecological reserves programme.

There are a number of difficult barriers to overcome. In the first place, the long-term maintenance of gene pools for possible future use is going to present difficult administrative problems because such a management goal comes into conflict with the prevalent ethic of those who think that no piece of land should simply be allowed to sit. It is not only developers and politicians but also wildlife or forest managers - and often scientists themselves - who urge that one must do something with the land (Norris 1970).

A second problem is that many questions remain unanswered concerning ecological reserves making it more difficult to sell the programme to governmental officials. They would like to know how much the programme will cost; yet uncertainty about the appropriateness of classification schemes makes it impossible to give realistic estimates of the number of plant communities that must be protected and consequently of the total land area that will be required²³. Other questions involve the use that is to be made of the sites. For example, how often is it realistic to assume that educational use can be made of the sites by our secondary schools? Or, as we have asked above, are the research needs of plant breeders compatible with the management criteria to be established for ecological reserves, or will additional land be necessary for them? The sooner firm answers can be provided to these questions and others like them, the sooner we will be able to convince public officials that the ecological reserves programme is well thought out and worth establishing.

It is hoped that IBP and related programmes will provide a direct way to preserve habitats and gene resources of important vegetation types, but the legislation that will lead to direct protection of samples of such habitats will come about only if groups such as the participants in this symposium can demonstrate to the public and to the law-makers why it is vital to future plant-breeding programmes that we protect currently unexploited genetic material. This is not a simple concept to convey to non-geneticists but it must somehow be done.

FOOTNOTES

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⁴This statement is based on letters from each of the regional chairmen of IBP-CT. We had sent them a draft statement of objectives that was very much like the statement in the text. Their responses indicated general agreement although minor differences of opinion remained concerning wording.

⁵The value of long-term protection can be seen from the now classic demonstration of genotypic response of plants to local habitats by Clausen and his co-workers. Their Harvey Monroe Hall Natural Area in the Tioga Pass of the Sierra Nevada totals about seven square miles and since 1932 has served for long-term testing by reciprocal transplanting of ecotypes and their artificial hybrid progeny. J. Clausen, 1969, The Harvey Monroe Hall Natural Area, Publication No. 459, Carnegie Inst., Washington, D.C. See also A.R. Kruckeberg, 1970, "Natural Areas - scientific value and the conservation ethic". Natural Areas - needs and opportunities, p. 11, Continuing Education Books, Corvallis, Oregon.

⁶While national parks are guaranteed protection in perpetuity under the National Parks Act, R.S.C. 1971, c. N-13, additional measures will be needed to protect ecological sites within the parks from recreational users. Territorial land may be set aside for public purposes under the Territorial Lands Act, R.S.C. 1971, c. T-6, and the Land Use Regulations under that act provide for permit system for various land use practices. The land can be zoned to provide for varying degrees of protection and it is most probable that ecological reserves will receive the highest protective designation. The Land Use Regulations have recently been gazetted (July 5, 1971) but unfortunately have been severely limited in application. In conjunction, regulations can be issued under the game ordinances of the territories to protect all or some of the fauna of a reserve. While these measures provide some degree of protection to ecological reserve sites, they do not provide for the long range management of the reserves.

⁷Ecological Reserves Act, S.B.C. 1971, c. 16.

⁸A determinable fee simple is merely a conditional grant of title which reverts to the original owner if the reserve is no longer used and maintained as such. Under an easement a right of use for specified purposes would be granted to the reserve administrators. Title remains with the original owner but both he and the administrators are prevented from doing anything inconsistent with the terms of the easement.

⁹One rare occasion on which a trust dedication has been used is the establishment of the Creston Valley Wildlife Management Area under the Act of the same name - S.B.C. 1968, c. 14, s. 3(1):

3.(1) The Creston Valley Wildlife Management Area is hereby reserved, set apart, and established for the purposes of wildlife conservation, management, and development, and shall be held by the Crown in right of the province in trust for those purposes.

Whether the courts would allow an individual to enforce such a trust dedication without the consent of the Attorney-General is another disputed question.

¹⁰An example of how this might be done is found in the B.C. Ecological Reserves Act, S.B.C. 1971, c. 16, s. 5:

5. On the coming into force of this Act, any area thereafter established as an ecological reserve under this Act shall be immediately withdrawn and reserved from any further disposition that might otherwise be granted under the provisions of any Act or law in force in the Province, including, without limiting the generality of the foregoing, dispositions under the Land Act, Forest Act, Grazing Act, Water Act, Mineral Act, Placermining Act, Coal Act, Petroleum and Natural Gas Act, 1965, Water Resources Act, or Mines Rights-of-Way Act.

¹¹In our study of the United States Research Natural Areas programme we noted that such detailed regulatory power helps the reserve managers to maintain reserves for the purposes for which they were dedicated.

¹²An example of the type of conflict envisaged here is the absolute duty imposed upon the Crown and private land holders to eradicate weeds in Manitoba under the Noxious Weeds Act, R.S.M. 1970, c. N-110 or in B.C. the Forest Act, R.S.B.C. 1960, c. 53, s. 127(1), which provides for cutting of diseased timber on both private and crown lands.

¹³The map reserve designation was created by a letter from the Minister of Lands to other government departments stating that the land was temporarily set aside for a specific purpose such as a gravel pit, ecological reserve or proposed highway route. These map reserve letters were merely filed and the reserver continued until lifted by the Minister.

¹⁴Land Act, S.B.C. 1970, c. 17, s. 12, replacing R.S.B.C. 1960, c. 206.

¹⁵*Id.*, s. 11.

¹⁶Concurrent with the map reserves there had been "Nature Conservancy" designations under the Park Act, S.B.C. 1965, c. 31 which contained areas of scientific interest but were open to the public and had not supported any research function.

¹⁷For example:

Public Lands Act, R.S.A. 1970, c. 297, s. 10(e):

The Lieutenant Governor in Council may

(e) set aside public lands

(i) for use as provincial parks, historical sites, natural areas, wilderness areas, game preserves, bird sanctuaries, public shooting grounds or public resorts or for the development of any natural resource.

Crown Lands Act, R.S.M. 1970, c. C-340, s. 7(1):

7(1) The Lieutenant Governor in Council may

(d) set aside Crown Lands for use as provincial parks, forest reserves, game reserves, bird sanctuaries, public shooting grounds or public resorts or for any other similar public purpose.

Lands Act, S.B.C. 1970, c. 17, s. 11:

11(1) The Lieutenant Governor in Council may, for any purpose that he considers advisable in the public interest, by notice signed by the minister and published in the Gazette, reserve Crown land from disposition under the provisions of this Act.

(2) The Lieutenant Governor in Council may, by notice signed by the minister and published in the Gazette, amend or cancel in whole or in part any reserve of Crown land established under this Act or any former Act.

¹⁸Land Act. S.B.C. 1970, c. 17, s. 12:

12. The minister may, for any purpose that he considers advisable in the public interest, temporarily withdraw Crown land from disposition under this Act, and he may amend or cancel such withdrawal.

¹⁹For example:

Indiana see:

A.A. Lindsey, D.V. Schmelz, S.A. Nichols, 1970, Natural Areas in Indiana and their Preservation, pp. 7-8, University of Notre Dame.

A nature preserve is a natural area which has been dedicated or committed as such, in what is intended to be permanent status, by a governmental, corporate or private owner.....

The history of losses of Indiana natural areas which an individual owner or family had intended to protect in

perpetuity is such a sad one that no area should be termed a "nature preserve" without formal and legally binding commitment as such. Dedication of a privately owned area takes place when the owner, while retaining ownership and appropriate use of his natural area, makes it an official "nature preserve" by signing away his (and his heirs) right to "louse it up".

The Citizens Committee for Nature Conservation (Illinois) recommended the following definition of "nature preserve" for legislative purposes.

An area of land or water in public or private ownership which is formally dedicated to being maintained as nearly as possible in its natural condition; which area either retains to some degree its primeval character (though it need not be completely natural and undisturbed at the time of dedication) or has unusual flora, fauna, geological or archeological features of scientific or educational value and which area is used in a manner and under limitations consistent with its continued preservation, without impairment, disturbance, or artificial development, for the public purposes of scientific research, education, esthetic enjoyment and providing habitat for plant and animal species and communities and other natural objects.

Vermont see:

H.W. Vogelmann, 1969; Vermont Natural Areas, Central Planning Office and Interagency Committee on Natural Resources, Montpelier.

New Hampshire see:

Natural Areas of New Hampshire suitable for ecological research, 1971, Publication #4, Department of Biological Sciences, Dartmouth College, Hanover.

²⁰While such indirect means of conserving gene resources lack the long-term safeguards that we would desire, these various forms of land alienation should not be overlooked as bases for long-term agreements or understanding with respect to protection. Federal grants may also be a source for obtaining funds for land acquisition as evidenced by the creation of the Second Century Fund for B.C. Although little is known about this fund at the time of writing it seems to be a federal government centennial grant of \$4.7 million to be administered by a federal appointee. The monies will be used to purchase tracts of land for ecological and nature education. See, "Second Century Fund to preserve B.C. Land", The Vancouver Sun, July 2, 1971, p. 2, col. 4.

²¹Park legislation from which natural area designations might be obtained are:

National Parks Act, R.S.C., 1971, c. N-13;
Park Act, S.B.C., 1965, c. 31, s. 6(1);
Provincial Parks Act, R.S.A. 1970, c. 288, s. 8;

Provincial Parks, Protected Areas, Recreation Sites and Antiquities Act, R.S.S., 1965, c. 54, ss. 3-4;
Provincial Parks Act, R.S.M., 1970, c. P-20, s. 3(1);
Provincial Parks Act, R.S.O. 1960, c. 314, s. 3(6);
Parks Act, S.N.B., 1961, c. 14, s. 1(d);
Provincial Parks Act, R.S.N.S., 1967, c. 244, ss. 6-7;
Provincial Parks Act, S.P.E.I., 1956, c. 25, ss. 5-9;
Provincial Parks Act, R.S.Nfld., 1952, c. 49, s. 9.

Quebec Legislation does not contain such a provision.

There are also other forms of land alienation such as municipal watersheds, Defence Department lands, lands held by other public agencies or Crown corporations and also by private persons, all of whom may manage their land in a way that makes them, for practical purposes, reservoirs of important genetic material even though such areas may never be officially designated as ecological reserves.

²²Some provincial parks legislation contain preambles dedicating the lands of parks to the use and enjoyment of the public. An ecological reserve might require exclusion of the public and only limited access to scientists which would obviously not be a recreational use. Most dedication provisions include "education" and therefore the problem is avoided, but even where it is not, the courts might hold that a member of the general public has no legal standing to enforce the dedication and that only the Attorney-General may represent the people. American courts have tended to recognize the individual's right to maintain this type of action and Canadian courts might follow in the future.

²³One practical problem in an ecological reserves programme is that of knowing where to locate reserves that will be representative of habitats in the political jurisdiction that is establishing them. Not surprisingly, this problem is forcing re-appraisal of past philosophies and priorities in the various approaches to ecological study of landscapes. For example, in the United States where classification down to a plant community or ecosystem level has rarely been stressed in ecological studies, there is now realization that a high priority for the Section C.T. programme must be to establish criteria by which ecosystems can be classified; E.M. Nicholson, 1968, Handbook to the Conservation Section of the International Biological Programme, I.B.P. Handbook, No. 5, p. 36, Blackwell Scientific Publications, Oxford. At a 1971 meeting on natural areas held in Portland, Oregon, much emphasis was placed on the inadequacy of current classification schemes and the problem of reaching agreement on a classification scheme that would be a suitable guide for site selection of ecological reserves. In contrast, where there has been greater use of the European approach to ecological studies of vegetation, with its emphasis on plant community description and classification, it is now possible to proceed directly to the task of actual site selection for reserves. British Columbia, with its well-documented division into eleven biogeoclimatic zones, is a good example of the latter; V.J. Krajina, 1969, "Ecology of Forest Trees in British Columbia", Ecology of Western North America, Vol. 2, pp. 1-126. There is, in addition, in British Columbia a fairly accurate

knowledge that there are about 130 basic plant communities (plant associations) in the forested parts of the Province's eleven zones, about 60 in grassland and alpine terrestrial habitats, and 80 in aquatic (marine, lacustrine and swampy) habitats. The knowledge that there are about 270 different habitats repeatedly occurring in British Columbia provides an excellent basis on which to plan site selection for ecological reserves. One suggestion by V.J. Krajina, 1971, "Techniques for selecting and allocating land for nature conservation in British Columbia", p. 6 of Mimeo paper to be presented at Twelfth Pacific Science Congress, Canberra, is that each of these 270 general habitats be reserved in triplicate to increase the likelihood of preservation of each one and that in only one of the three examples of a particular habitat would scientific experimentation be allowed. This suggestion does not mean that there need to be 810, or even 270, ecological reserves in British Columbia because any one reserve will usually contain five to ten different habitats represented by different plant communities. Furthermore, many of the plant communities will be replicated simply by assuring that reserves are established in each of the eleven biogeoclimatic zones.

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THE FINNISH STANDARD STANDS FOR FORESTRY RESEARCH

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INTRODUCTION

Anyone who has worked for some time in the field of forest genetics and forest tree breeding is familiar with the question: "Could you, please, send me some samples from four to six localities in your country together with a description of the stand from which the seed was collected?" And everybody knows the many different ways in which such requests have been met in the past.

The tree breeder himself is frequently faced with the problem of obtaining seed lots of certain origin for his experiments, for provenance experiments with autochthonous and foreign provenances and to determine how far one can move seed within his own country. Another field where seed lots of known origin are required is for comparative tests of the performance of seed from plus stands, seed orchards, crosses for progeny testing, etc.

The variation in seed lots from different localities and even from different stands is very great. If valid comparisons are to be made in the future it will be necessary to have at hand, seed of the same origin used in the past. We all know how difficult it has been to follow up the old international provenance experiments, e.g. with Norway Spruce, because it is almost impossible to go back to the stands the seed originally came from and because the descriptions of the stands are in many cases insufficient.

Besides these problems, there is a rapidly expanding one, in that more and more forest cultivations are taking place with seed that might not in all cases be of the local race. Even in a country such as Finland, we will at some time in the future, be faced with the problem of losing most of the original "landrace". How are we then going to compare the products of breeding with what we had before and how are we going to conserve the original gene pool?

It is clear, that some of the original forest will always be left in inaccessible places and in National Parks set aside for the conservation of nature, but in many cases these forests do not represent the forests of the management area and in addition, the collection of seeds and the carrying out of measurements, etc. in protected stands might in some cases be restricted.

It was with this in mind that in the middle of the 1950's I suggested to the Finnish Forest Research Institute the setting up of a

certain system of Standard Stands for the needs mentioned above. Although the system is not yet complete, some information is already available that I believe might be of value when considerations are made concerning the preservation of gene resources in other areas.

THE STANDARD STANDS

The original idea was to select a set of stands of the most important species in such a way that we would have a representative sample from each part of the country.

Since the purpose is to have a standard for comparison purposes, the stands chosen should be representative of the area in question. The stands themselves should be neither "plus" or "minus" stands, but rather average stands. If the stand chosen happens to come from an area where the race is generally good the standard will also be above the mean, and if the local area is represented by inferior trees the standard will also demonstrate this.

A selection of representative stands will always be a question of personal opinion and in many cases also a compromise between what we would like to choose and what is possible to obtain and save for the future, especially in a country like Finland where there are so many kinds of forestry ownership.

Since there has to be a reasonable guarantee that the stands will be preserved, the stands were chosen from state owned forests belonging to the Forest Service or the Forest Research Institute. It is with great pleasure I acknowledge the interest and efforts shown by the State Forest Service in the selection and setting aside of the standard stands.

The standard stands were always chosen from forests of natural origin, which fortunately still dominate forests in our country. As far as possible the stands are representative of middle aged stands in natural condition or ones in which only good management had been carried out. Stands thinned from above and stands showing signs of dimension cutting were not registered.

It was known from earlier experiments, that the Norway spruce, *Picea abies* L. Karst., could be moved over longer distances than Scots pine, *Pinus sylvestris* L., so the spruce stands were selected at longer distances from each other than the pine stands, the latter being selected approximately 100 to 150 km apart, so that the most continental as well as the most maritime parts of the country were represented. It was also considered important to include in the standard stands representative of the full limit of distribution of the species in the far north, especially since, for international purposes, seed from high latitudes is difficult to obtain.

A map showing the location of the standard stands is presented as Figure 1. Figures 2, 3, 4 are representative of standard stands. It is

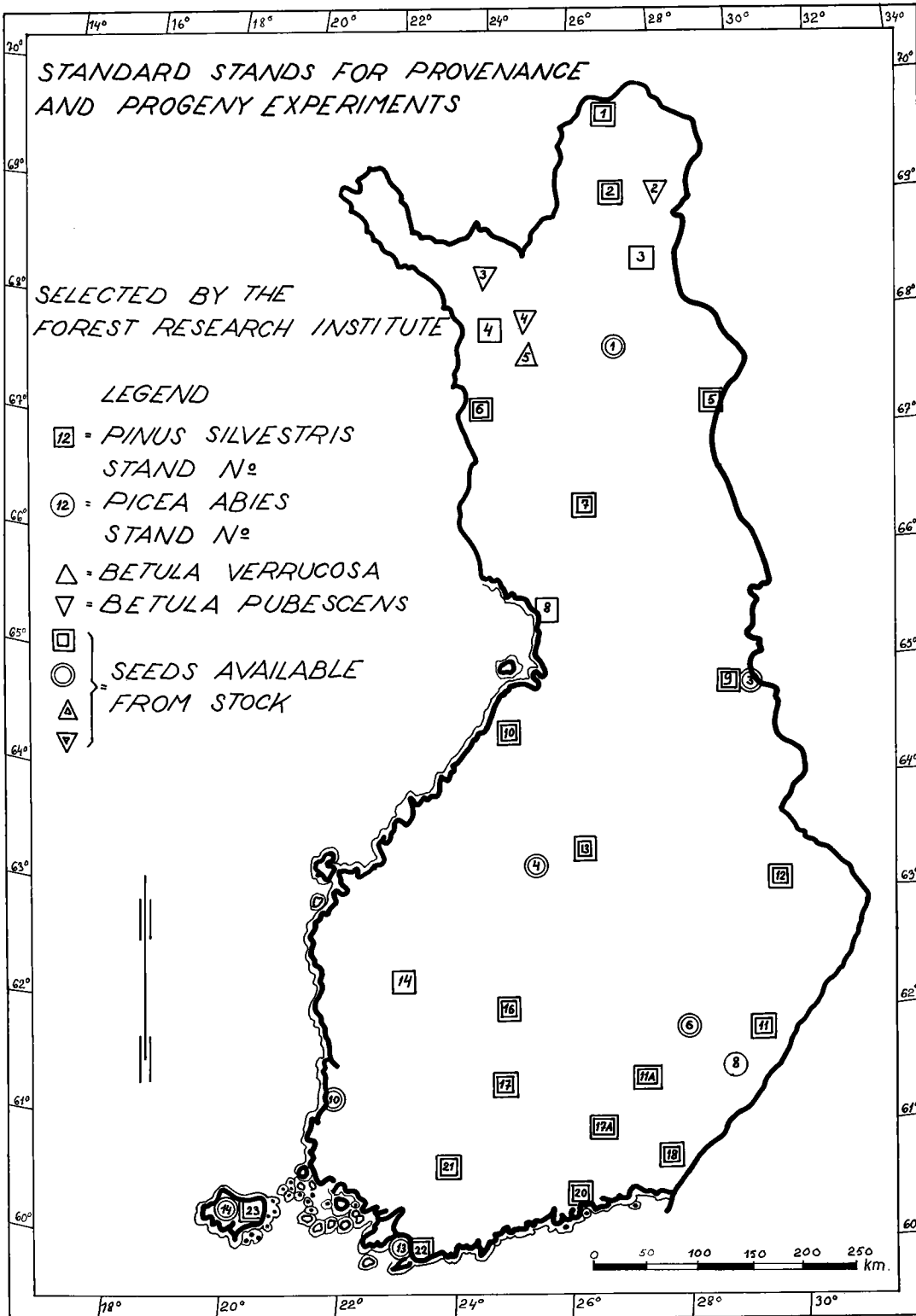


Figure 1.