CONSERVATION AND MANAGEMENT OF FOREST GENETIC RESOURCES

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Received June 1998

PALMBERG-LERCHE, C. 1999. Conservation and management of forest genetic resources. The paper reviews available strategies for the conservation, management, enhancement and sustainable utilisation of forest genetic resources, and the linkages of genetic conservation with the management of forests, tree improvement and breeding. International co-operation, co-ordination of efforts and possible future strategies of action are briefly mentioned. The paper concludes that efforts to conserve and enhance forest genetic resources for present-day and future uses must be based on the "tripod" of management of protected areas, the management of productive forests, and the management of breeding populations. It stresses that the key to success will lie in the development of programmes which harmonise conservation and sustainable utilisation of forest genetic resources within a mosaic of land use options, including a strong element of active gene management.

Key words: Forest biological diversity - forest genetic resources - conservation of forest genetic resources - tree improvement - forest seed procurement - sustainable forest management

PALMBERG-LERCHE, C. 1999. Pemuliharaan dan pengurusan sumber-sumber genetik hutan. Artikel ini mengulas mengenai strategi yang ada bagi pemuliharaan, pengurusan, peningkatan dan penggunaan secara berkekalan sumber-sumber genetik hutan, serta kaitan pemuliharaan genetik dengan pengurusan hutan, pembaikan pokok dan pembiakbaikan pokok. Kerjasama antarabangsa, penyelarasan usaha dan strategi tindakan pada masa hadapan juga dinyatakan secara ringkas. Artikel ini juga membuat kesimpulan bahawa usaha-usaha untuk memulihara dan meningkatkan sumber-sumber genetik hutan untuk kegunaan masa kini dan akan datang mestilah berdasarkan kepada pengurusan "tripod" iaitu kawasan perlindungan, pengurusan hutan yang produktif, dan pengurusan pembiakbaikan populasi pokok. Ia menekankan bahawa kunci kejayaan adalah bergantung kepada perkembangan program yang menyesuaikan penggunaan pemuliharaan dan pengekalan sumber-sumber genetik hutan dalam pengalihan kegunaan tanah, termasuk unsur-unsur yang kuat dalam pengurusan baka yang aktif.

Introduction

Most organisms in nature are, inherently, variable. Conservation of biological diversity and genetic resources, in essence, means ensuring that variation will be kept available and allowed to develop and evolve through both natural processes and the direct or indirect intervention or influence by man.

It is acknowledged, at technical and scientific levels, that the values derived from biological diversity are associated with the different levels of organisation of diversity in plants and animals. These levels include the main components of ecosystems, species, populations, individuals and genes. It is also acknowledged that varying and complex interactions exist between these levels.

As managers, technicians and scientists we know that, in considering action in any field, the first step is always to clearly specify objectives aimed at. In the case of genetic conservation, the levels of diversity targeted for conservation must be clearly specified from the outset. This is of utmost importance, as it is possible to conserve an ecosystem and still lose specific species; and as it is possible to conserve a species and lose genetically distinct populations, or genes which may be of value for the adaptation and future survival of a species, or genes which will facilitate the genetic improvement of the species in breeding programmes benefitting mankind. Conservation must be accompanied by regular monitoring to ensure that progress is being achieved in reaching stated objectives either through active management or through non-intervention. In regard to monitoring, it should be noted that there may be no single objective measure of biological diversity, only complementary measures appropriate for specified and, by necessity, restricted purposes (Williams *et al.* 1994).

Debate on conservation at both policy and popular levels has been greatly intensified over recent years in the light of actual and perceived losses of diversity. In the current discussions, it is often incorrectly assumed that diversity in plant and animal communities, by definition, confers resilience (Holdgate 1996); that strong functional relationships exist among all organisms and among all levels of diversity; and that there are relatively few ultimate causes of threat to diversity. It is also frequently assumed that any intervention by man will, without fail, cause unwelcome influences and destructive, or at least highly disruptive and negative, effects. If this were true, then managers and policy makers would not need to know much about the structure and dynamics of diversity, since single actions would have largely predictable effects. With the perception of a broad, common threat with largely foreseeable overall consequences, there is a natural hope and belief that simple solutions, such as withdrawing all human intervention, or segregating land uses into strict, separable compartments, will solve the problem (Namkoong 1996).

Unfortunately, the fact is that a simple, uniform answer and a single strategy for genetic conservation is not available.

Especially when the popular term, "biodiversity", is used in calls for action, it is frequently not specified which level of diversity is discussed, nor what the ultimate aim or aims of conservation of dynamically changing natural systems will be. This will make it difficult, if not impossible, to respond in a scientifically and technically sound manner.

It can be concluded that, *from a technical and scientific point of view,* there is an urgent need to gain more information on ecosystem dynamics, on genetic variation available in species, and on the way diversity is spatially and temporally organised within and among populations. Such information should form the basis for decisions on how to conserve, manage, sustainably utilise and enhance existing diversity. *More generally*, there is an urgent need to inform politicians, decision-makers and the public at large of the strategies and methodologies available to respond to the challenge, and of the steps needed to carry out well-targeted and efficient conservation programmes. The message must be clear, convincing, informative and technically sound. Its aim must be to help dispel the misinformation prevailing in much of the public debate of today, which is a source of pressures and hasty policy decisions which are not always based on facts, and which may be damaging rather than constructive. Among the myths to be dispelled soonest are those related to the belief that nature is static and that lack of human intervention or management will ensure a *status quo* in ecosystems; that the present state of diversity is the ideal one; and that human action can only diminish, never help maintain, or enhance, genetic diversity (Eriksson *et al.* 1993, Palmberg-Lerche 1993b).

The present paper reviews available strategies for the conservation, management, enhancement and sustainable use of forest genetic resources, and the linkages of genetic conservation with the management of forests on the one hand, and with tree improvement and breeding, on the other. It is focused on the conservation of genetic resources of trees and shrubs found in forest ecosystems. Such ecosystems also house a range of other plant and animal species, and great numbers of insects, microbes and other organisms. This complexity adds to their overall value and importance, which need to be maintained and enhanced for the benefit of present-day and future generations. International co-operation, co-ordination of efforts and possible future strategies for concerted action are briefly touched upon in concluding the overall review.

In the present paper, the concept of *genetic resources* refers to the environmental, social, economic and scientific values of the heritable materials contained within and among species. *Conservation* is defined as the actions and policies that assure the continued availability and existence of these resources (FAO 1989).

Basic considerations in the conservation of forest genetic resources

Forest trees are long-lived, outbreeding and generally highly heterozygous organisms, which have developed a number of natural mechanisms to maintain intra-specific variation. These mechanisms, combined with the often variable environment (in time and space) in which forest trees occur, have contributed to the fact that, with a few exceptions, forest trees are among the most genetically variable of all living organisms studied to date (Libby 1987).

A large number of genera and species can provide the goods and services generally sought from forests and trees, such as timber, wood, food, fodder, shade, shelter, environmental stabilisation, and amenity, cultural and spiritual values. Although it is true that less than 500 tree species have been systematically tested for their present-day utility for man, and less than 40 are being actively bred (FAO 1990, Anonymous 1991), it is also true to say that a range of different species are used in different countries and regions to provide the same goods and services, even in the case of programmes focused on intensive forestry production. In contrast to crop breeders (see e.g. Frankel 1976, Holden & Williams 1984), foresters do not generally attempt to change the environment to suit a specific species or variety. Foresters generally aim at identifying species and provenances which can provide some levels of the goods and services required also without major selection and improvement, and which, intrinsically, are buffered against variations in soil, aspect and microclimate at the site on which they are used (Palmberg-Lerche 1993a, Ouedraogo 1997). This gives some assurances of the conscious, or at times even unconscious, maintenance of a range of highly diverse species and provenances in local, national and regional plantation programmes.

However, such assurances alone are not enough. The conservation of forest genetic resources is today rightly a subject of greatest concern, mainly due to habitat destruction and alteration, and to undocumented and uncontrolled movement of germplasm, oblivious of problems of potential loss of genetic identity of diversified, local populations (Palmberg-Lerche 1987, 1994a, 1997).

Strategies for the conservation of forest genetic resources

While some losses in present-day biological diversity over time are inevitable due both to natural and man-made causes, diversity can be conserved and managed through a wide range of human activity, from the establishment of nature reserves and managed resource areas, to the inclusion of conservation considerations into improvement and breeding strategies of species under intensive, human use (see e.g. Namkoong *et al.* 1980, Namkoong 1986, Wilcox 1990, 1995, Kemp 1992, Palmberg-Lerche 1993b, Kemp & Palmberg-Lerche 1994a, Varela & Eriksson 1995).

The strategy of conservation and exact methodologies applied will depend on the nature of the material, the time-scale of concern, and the specific objectives and scope of the programme; the latter, in turn, are dependent on institutional and economic realities. The two main strategies for the conservation of genetic resources, are conservation *in situ* and conservation *ex situ.* These two strategies are complementary, and should be used in parallel, whenever possible.

In situ conservation implies 'the continuing maintenance of a population within the community of which it forms a part, in the environment to which it is adapted' (Frankel 1976). It is most frequently applied to wild populations regenerated naturally in protected areas or managed forests, but can include artificial regeneration whenever planting or sowing is carried out, without conscious selection, in the same area in which the seed of a native species and provenance was collected (FAO 1989). *Ex situ* conservation includes conservation in seed banks; in live collections such as arboreta and clone banks; in specially established *ex situ* conservation stands; and as pollen or tissue. The two strategies of *in situ* and *ex situ* conservation, methodologies in their implementation, and their comparative advantages and complementarity, have been amply covered in recent literature (see e.g. FAO 1975, 1989, 1990, 1993 a,b, Holden & Williams 1984, Ledig 1986, Palmberg 1987, Palmberg-Lerche 1993b, Ouedraogo 1997).

Definition of the amounts and proportions of extant genetic variation which needs to be retained, in the long term, to ensure that species and populations are able to adapt to future changes in environmental conditions (including changes in climate, and occurrence and pathogenity of pests and diseases), is central to the question of conservation. A similar question in tree improvement relates to concerns to meet shifting needs and demands of users over time, in addition to ensuring adequate buffering of breeding and production populations to environmental change.

In relation to *in situ* conservation in protected (nature) reserves and in gene management areas, the concept of "adequate size" has caused over the years a lot of confusion, having been used frequently in an unspecified manner to relate to ecosystems, species, intra-specific variation and/or genes, at times even to landscapes. When the focus is on the conservation of genetic resources, consideration must be given to the number of unrelated, inter-breeding individuals needed to constitute a viable genepool of species targeted for conservation, rather than to the physical size of the area in which they are contained. The minimum number of individuals, in turn, is in the case of forest trees related to basic issues such as flowering phenology, breeding system, and pollen and seed dispersal mechanisms.

Further to size, correlated with the number of inter-breeding individuals in the gene pool targeted for conservation, the number and siting of conservation areas (or of populations which will be used in sampling for *ex situ* conservation), is of crucial importance. In addition to the fact that individual species possess varying, total levels of genetic variation and that the intra-specific distribution of such variation differs between them, differing variation patterns seem to exist even within any one species: morphological characteristics tend to be more evident at the provenance, and less at the individual stand levels; isozymes tend to concentrate more than 90% of their variability in the within-stand component; while variation in components of growth, survival and susceptibility to various physical and biotic events is important in all of these categories (Libby 1987, 1995).

In this kind of situation, it is clear that conservation of diversity can only be achieved to any degree of satisfaction through systematically including conservation considerations in overall land use plans, and through managing genetic variability of target species within a mosaic of economically and socially acceptable land use options, ranging from protected areas to managed forests, agro-ecosystems and forest plantations (Wilcox 1990, 1995, Kemp & Palmberg-Lerche 1994).

Most forestry agencies deal with a great number of species, and conservation and gene management programmes for these species will necessarily differ in form and intensity. In presently little-used forest tree species, a network of *in situ* conservation areas and protected reserves, which are placed under varying intensities of management, should be demarcated or established. Such genetic conservation areas, which must be kept large enough to avoid negative effects of inbreeding and genetic drift, should cover central as well as outlying populations of the species targeted for conservation.

Conservation of genetic resources through protection and management must be coupled with action to meet immediate needs for reproductive materials for tree planting and plantation forestry. Procurement of reproductive materials needs to adequately cater for the needs of longer-term breeding programmes (Danell 1991); these programmes, in turn, can help support conservation efforts as an integral part of the overall conservation strategy.

For species and provenances under intensive domestication and use, managed conservation areas should be complemented by *ex situ* conservation stands and by close integration of conservation and breeding (Namkoong 1986, 1989, Palmberg-Lerche 1989). Especially in the case of economically important species in which breeding programmes are in place or under development, conservation cannot remain separate from breeding and will, in fact, rely on breeding as one important component of the overall conservation strategy. On the other hand, unless deliberately planned, conservation will not be effective in aiding breeding programmes in the long term.

One possible solution aimed at realising the complementary values of conservation and breeding lies in maintaining a hierarchy of different populations managed for, respectively, long- and short-term objectives (e.g. conservation; breeding; provision of planting materials; production of specific goods and services). However, if the conservation populations do not improve at roughly the same rate as the more highly selected breeding populations, use of the former for re-introduction of added genetic variation into the breeding populations and, subsequently, into the production populations to meet new environmental needs or user requirements, will cause substantial decline in earlier improved desirable characteristics such as e.g. productivity.

An alternative solution, applied today in a number of developed and developing countries, lies in establishing and managing an array of multiple populations of target species, separately selected and bred for a range of environmental conditions and for varying objectives and end uses. The greater the uncertainty for future environmental changes or human needs, the greater is the benefit of separate and diverse, actively managed sub-populations of each species, since some of them will have greater probability of being close to a future optimum than one single population would; and since, from a conservation point of view, intra-specific variation can be maintained and even enhanced, and the probabilities of maintaining rare or low-frequency alleles will be increased in multiple populations. When dealing with species included in intensively managed breeding programmes, there are indications that, in the long term, it will also be cost-effective from an economic point of view to improve yield or other traits through the management of an array of multiple populations adapted to a range of specific environments and focused on specified characteristics. Overall variation can subsequently be increased by mixing or combining materials derived from divergent populations in the production populations (plantations) to obtain e.g. broadly based insect and disease resistance, while at the same time continuing to maintain multiple sets of separate breeding populations. The multiple population breeding strategy will greatly benefit in technical and economic terms from collaboration between a number of institutions with a common interest in genetic management of given priority species. (For additional information on alternative breeding strategies and their complementarity and relative advantages, see e.g. Namkoong *et al.* 1980, Burdon & Namkoong 1983, Namkoong 1984, 1986, 1989, Varela & Eriksson 1995.)

Conservation of forest genetic resources and forest management

Especially in the case of forest trees, it is evident that large-scale and lasting conservation can only be achieved if the resources —in this case the trees, forests and woodlands targeted for conservation—have a value in the present time. This implies the application of forest management methods which will allow the resources to be sustainably utilised for the development of nations, as well as for the direct benefit of human communities living in or close to the forests. Fortunately, genetic resources and the forests which provide these resources are renewable, if adequately managed: they can be used without ever being used up (Ledig 1986).

Over the past years FAO, as well as a number of other organisations and agencies, in line with the above, have stressed that management for the production of goods and environmental services from the forest is generally compatible with the conservation of genetic resources of the species being utilised, provided that some basic, genetic and silvicultural principles are applied (see e.g. FAO 1989, 1993a, Kemp 1992, Kemp & Palmberg-Lerche 1994, Wilcox 1995). In practice, this means that prevailing forest management prescriptions must be examined in the light of guidelines available for the conservation of genetic resources of the species being utilised; and that management interventions are adjusted so that both forest management and genetic conservation aspects are considered in a balanced manner. Needless to say, monitoring and control of forest management operations must be in place to ensure that recommended practices are followed. Similarly, monitoring of effects of implementing given forest management prescriptions will be necessary to ensure that observed changes in species composition and genetic variation in component species are within acceptable limits from a conservation point of view.

Conservation of forest genetic resources and tree breeding

As already stressed, the definition of priorities and strategies for the *conservation and management* of forest genetic resources requires an understanding of the degree and patterns of genetic diversity among and between species and specific populations (provenances). Within *improvement and breeding* programmes, the search for populations and individuals useful as sources of desired characteristics and genes, is, similarly, based on locating genetic variation and understanding variation patterns in the species and populations concerned. In either case, provenance and progeny testing, at times complemented by the use of genetic markers, are the scientific methods and practical working tools used to distinguish levels of variation (Anonymous 1991). As basic information needs are the same whether the focus of action is on conservation or on breeding, it is clear that pooling of resources and joining efforts in programmes aimed at genetic conservation and those aimed at tree improvement will make best use of resources and will more quickly help fill the considerable gaps in information prevailing in the forestry field.

A common, early approach will also help ensure that the continued flow of genetic materials from conserved status into breeding populations, and vice versa, is feasible and practicable, and that it forms an integral part of the dynamic development of both conservation and breeding strategies over time.

As stressed in the section on conservation strategies above, if sustainability in acievement is to be ensured breeding cannot remain separate from conservation. In a breeding programme with no base populations other than the commercial one, additive gene effects for, for example, enhancement of average growth, in one kind of environment, are identified, utilised and conserved. Selection and intensive breeding for such additive traits only, carried out without due concern to conservation of others, will over time lead to allelic losses and, as a consequence, to loss of the ability of populations to respond to future shifts in environmental conditions and selection objectives. On the other hand, a sound breeding strategy can help create and maintain greater genetic diversity among populations and can, furthermore, enhance present-day utility of available genetic resources (Namkoong *et al.* 1980, Namkoong 1986). From the point of view of continued improvement and breeding to enhance utilitarian values of forest genetic resources, integration of genetic conservation concerns into tree improvement and breeding strategies is thus an absolute and obligate must.

Conservation of forest genetic resources and seed procurement

With growing attention being paid to tree planting and the development of forest plantations to meet present-day needs for goods and services available from the forest, national and international movement of forest reproductive materials has greatly increased over the years. Movement of germplasm must be carried out using only well-documented seedlots, and must at all times be based on conscious decisions taken with a full understanding of actual or potential genetic consequences of such action.

In view of the basic need to be informed of the genetic characteristics and value of the reproductive materials used, it is evident that any seedlot moving within or outside of national borders without documentation on origin, provenance and genetic quality (including information on number of mother trees from which the seed or scions have been collected), must be disqualified from use and discarded. This basic principle is not negotiable, ever.

In addition to general risks implied by the use of unknown, possibly sub-standard genetic materials in tree planting and, at times, even as a starting point for selection and improvement programmes, a more subtle, but no less real, danger in the movement of forest germplasm relates to the risks of pollution of local genepools by pollen from introduced populations of hybridising species or provenances. Decades of provenance research have shown that most forest tree species exhibit considerable population divergence in genetically based traits. This inter-population differentiation (provenance variation) means that certain alleles, or combinations of alleles, are more common in some populations than in others. Losing local populations, or losing their genetic identity through pollen contamination, will influence evolution based on specific alleles or allelic combinations, and is likely to diminish the possibilities of adaptation of populations to continuing environmental changes. It will also decisively increase the amount of effort needed to breed for enhancement of such alleles for their immediate use.

In view of the above, the introduction of genetic materials from elsewhere must always be based on a conscious and well-informed choice. Reproductive materials must not be introduced on a large scale until they have proven to be of more value, in all aspects tested, than local species and provenances.

At times species or provenance hybrids have proven highly productive in the F-1 generation, especially when planted on special and difficult sites, or when occupying a niche which is not suitable for either parent. Should species or provenance hybrids prove their worth in locally established field trials, such hybrids could and indeed should be used and profit drawn from the possible heterosis or the special combination of characteristics manifested in them. It should, however, be acknowledged that what is true for the F-1 hybrid generation will likely not hold true for subsequent generations, in which traits will segregate. Plantations established using species or provenance hybrids cannot therefore be used for the collection of seed.

Should introductions prove desirable to meet present-day needs for purposes of production in plantations or tree planting schemes, the genetic identity of local species and—especially, as changes are more subtle although no less drastic—local provenances must be, in all instances, safeguarded through parallel, active conservation measures. Such measures may, at times, imply the establishment of *ex situ* conservation stands outside of the range of polluting foreign pollen sources.

In acknowledgement of the lack of understanding of the risks and potential losses related to the contamination of local genepools by pollen from introduced genetic materials, stress on the use of *"native species"*, without due attention to the conservation of genetically divergent provenances, has been rightly called, "*A Disneyland Fantasy*" (Millar & Libby 1989).

In relation to movement and exchange of "genetically improved" germplasm, it is important to remember that "improvement" means, in essence, that the genetic base of the material thus named has been artificially and purposely narrowed to meet specific end use requirements, when used in given environmental conditions and under specified management regimes. "Improved" reproductive materials brought in from different conditions within the country, or from another country, will therefore seldom, if ever, provide a suitable starting point for local improvement and breeding. Such material can, however, at times, be used to enrich a locally generated breeding population of the same species and provenance, provided that it has proved its value in local field trials, and provided that its genetic base, selection criteria, selection intensity and other parameters related to its development, are known, recorded and considered acceptable by the receiver.

Movement of clonal material can, at times, be of scientific interest for experimental purposes. Introduction of clones has, in some limited cases, also been used to underpin tree planting programmes on an operational scale (e.g. in the case of poplars, which are usually grown in intensively managed plantations on better-than-average sites, on relatively short rotations thus reducing the calculated risks associated with the employment of genetically uniform materials). Importation of foreign clones must, as in the case of import of other, genetically narrowed-down materials, be supplemented by locally made selections from wider genepools and the conservation of such local genepools. It is important to note that such selection work, related to seed, seedling as well as clonal material, is never a one-time effort, but a continuing one, which must be carried out within the framework of a sound, local breeding programme.

The frequently expressed opinion, "*any seed is better than no seed at all*", could not be more misguided, outright wrong, and potentially of great and irreversible harm to our genetic patrimony.

At the present time, the development of prescriptions and rules governing the movement and use of genetically engineered plants is receiving considerable policy level attention, world-wide. In fact, also the movement of non-engineered, but non-native, reproductive materials could with advantage be included within the framework of emerging national legislation on "*biosafety*" in forestry, as this issue relates directly to frequent, manifested offences against sound, genetic principles, and poses obvious and known dangers in this regard.

Future co-ordinated action

As evidenced above, international discussion on the conservation of plant genetic resources has been pursued at national, regional and international levels for more than thirty years (see e.g. Anonymous 1991, Palmberg-Lerche 1994b). The FAO Panel of Experts on Forest Gene Resources, established in 1968, provides advice to FAO and, indirectly, to the international community, on programmes and priorities in the field of forest genetic resources based on information derived from all countries and regions of the world (FAO 1997). The FAO Commission on Genetic Resources for Food and Agriculture and the International Undertaking it oversees, at the present time explicitly includes consideration of forest genetic resources in its mandate[1]. Within the Convention on Biological Diversity, with which FAO has entered into a formal agreement of collaboration, forest biological diversity is included in discussions on "Terrestrial Ecosystems". A number of regional and species-specific networks have been established over the past years, such as the European Forest Genetic Resources Network, EUFORGEN, co-ordinated by IPGRI[2] in collaboration with FAO; and the Dry-Zone *Acacia* and *Prosopis* Network,

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[1] The International Undertaking is presently being re-negotiated, and it seems unlikely that it will, in the future, continue to cover forest genetic resources.

[2] List of Acronyms is given at the end of the paper.

the International Neem Network and the incipient Mahogany Network, co-ordinated by FAO, in collaboration with a range of national and international partners[3].

The Fourth International Technical Conference on Plant Genetic Resources, held in Leipzig, Germany in June 1996, adopted a *Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture* which stated that forest genetic resources would not be included in the plan, but that the need for action in this field should be reviewed in the light of the outcome of the work of the Inter-Governmental Panel on Forests (IPF)[4]. The IPF, which held its fourth and final session in February 1997, did not address the issue of forest genetic resources.

In view of the urgency of the matter and the risk of stagnation in global action in forest genetic resources, FAO raised this for substantial discussion at the Thirteenth Session of the Committee of Forestry (COFO) held in Rome in March 1997. In line with the recommendations of COFO, subsequently supported and further elaborated upon by the Tenth Session of the FAO Panel of Experts on Forest Gene Resources, FAO has initiated action to help plan and co-ordinate a series of regional and sub-regional forest genetic resources workshops, to be carried out in close consultation and collaboration with national and international partners.

The overall goal of the planned regional and sub-regional workshops on the conservation, management, sustainable utilisation and enhancement of forest genetic resources is the development of dynamic, country-driven and action-oriented regional and sub-regional plans. It is hoped that these plans will be put into action and that they will help ensure that forest genetic resources are conserved and sustainably utilised by countries concerned as a basis for local and national development, as well as for overall regional and global benefit. The action plans should, without fail, be compatible with national and regional strategies in other sectors, contributing together with these to dynamic, multi-disciplinary action aimed at overall sustainable development, poverty alleviation, food security, environmental conservation, economic and social advancement, and the maintenance of cultural and spiritual values (Palmberg-Lerche 1997).

Decisions about priorities in the conservation of genetic resources will depend on value judgements. They are to a large extent determined by the primary beneficiary of the conservation effort. In addition to determining the technical and scientific management options that are available, the values placed on genetic resources by a range of interested parties must also be considered. This leads to a series of questions that should be addressed such as: Who benefits? Who invests in

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[3]Information on the these and other FAO coordinated programmes in the field of forest genetic resources can be requested from the author of this paper; or can be extracted from the FAO Forest Genetic Resources Homepage: http://www.fao.org/waicent/faoinfo/forestry/fogenres/homepage/content.htm

[4]The IPF was established by the Economic and Social Council of the United Nations (ECOSOC) in June 1995, following a recommendation of the Third Session of the UN Commission on Sustainable Development. The successor arrangement to the IPF, the Inter-Governmental Forum on Forests (IFF), was established in 1997.

programmes affecting the resources? How can short-, medium- and long-term support to genetic management programmes be secured? How can we assure that investments generated are based on some sense of justice, taking into consideration the needs of all concerned, in the long as well as in the short term? (Namkoong 1986). To ensure a holistic view, it is clear that dialogue and involvement of all stakeholders are of utmost importance; such a dialogue should include Government and national academic and research institutions, private owners, industry and national non-governmental organisations. Mechanisms must also be in place to ensure that needs and aspirations of local communities are duly considered.

National forest genetic conservation programmes will constitute the building blocks of regional and sub-regional action plans. In this regard, it is acknowledged that national plans and programmes will vary according to local biological, social and economic environments and according to national needs and priorities. The purpose of the planned workshops is to help streamline concerted action at regional level; the aim is not the development of one, single model for conservation, but rather the elaboration of a framework for co-ordinated action, valid at sub-regional and regional levels.

While national plans are at the bases of regional and sub-regional action plans, these latter ones can, in turn, provide a point of reference for national activities in the exploration, collection, evaluation, conservation *in* and *ex situ* and improvement and breeding of forest genetic resources. Common agreement on principles and mechanisms for the determination of priorities for species and specific, conservation-related activities, and on optional strategies for action, will help justify such work and will help strengthen the impact of national activities also at regional level.

Co-ordination of action at regional level will, furthermore, help make best use of scarce resources by avoiding duplication and overlap of effort, and by facilitating the sharing of technologies, information, know-how and genetic materials, on mutually agreed terms.

The sub-regional and regional action plans on forest genetic resources which will be developed in the planned workshops and which will serve as dynamic tools underpinning action by countries concerned could later, if countries so wish, be placed within a larger context, contributing to a comprehensive, international framework. A coherent global framework for action on forest genetic resources could decisively help promote overall co-ordination of action and help further co-operation between and among geographical regions and, above all, between and among countries in ecological regions of the world in which environmental conditions and social and economic aims and aspirations are similar, and in which such collaboration could therefore bring tangible benefits to all concerned.

In line with priorities expressed by countries in international fora in which the issue has been discussed, IPGRI, ICRAF and FAO have joined forces and plan to help organise, in September 1[illegible]8, a *Workshop on the Conservation, Management, Sustainable Utilization and Enhancement of Forest Genetic Resources in Sub-Saharan Dry-Zone Africa.* This country-driven workshop and its follow-up will be carried out in close collaboration with the Secretariat of CILSS, and with the support of other concerned international and bilateral organisations with an interest and know-how in the subject.

Experience and information from the Sub-Sahelian workshop will help facilitate planning of a similar workshop in Eastern and Southern Africa, in collaboration with the SADC Secretariat and, pending identification of necessary resources for this purpose, further workshops in countries and regions which have requested support in this regard (initially, tentatively, the Pacific, Central America).

While the main responsibility of follow-up to the regional and sub-regional forest genetic resources workshops will lie with national Governments, funding will also be sought from outside donors to support action and to help enhance national capacities both in the public and the private sectors. Especially in the case of conservation and management of economically important species or species with proven potential, national Governments will be supported, as applicable, in on-going or incipient efforts to draw upon the dynamism, organisational capacity, know-how and investment capital available in the private sector, for mutual benefit. In this regard, there is a need to help provide a conducive legal and institutional environment for private sector involvement, to ensure that investments are sustainable from financial, environmental and genetic perspectives, and to guard against potential conflict-of-interest situations arising among the various stakeholder groups at national level. The final challenge for countries will be to develop open and sincere collaboration between the Government, the private sector and other stakeholders.

Concluding remarks

Genetic erosion is today occurring at an increasing pace, mainly due to changes in land use leading to habitat loss and degradation, and to selection and breeding carried out without including in the breeding strategies necessary elements of genetic conservation. Large-scale, uncontrolled movement of germplasm and consequent genetic contamination and potential loss of local genepools aggravate this problem in the forestry field.

Active and vigorous measures are needed to reverse this trend. These must be based on improved technical and scientific understanding of ecosystem functions, and of the extent, distribution and dynamics of biological diversity and genetic resources directly and indirectly used by man. Strong and continuing policy level support and genuine collaboration between all stakeholders are needed to successfully carry out related activities. In this regard, there is an urgent need to better inform decision makers and the public at large of facts and available alternatives for action.

Neither natural ecosystems nor breeding programmes are static. Genetic conservation must not be aimed at freezing a given state, which would imply an arbitrary fixation, or a haphazard snapshot in time, of dynamically evolving, living systems. Similarly, it should be recognised that since economic, social and environmental requirements continually shift, objectives and aims of breeding for utilitarian purposes will change in time and space, leading to the need to ensure the long-term maintenance and enhancement of genetic diversity to meet future requirements.

Efforts to conserve and enhance forest genetic resources for present-day and future uses will involve action related to the management of protected areas, the management of productive forests, and the management of breeding populations. This "tripod" of action offers the only lasting solution to the challenge of conservation. The key to success will thus lie in the development of programmes which harmonise conservation and sustainable utilisation of forest genetic resources within a mosaic of land use options; and which include a strong element of active gene management. Sustainability of action over time will be based on genuine efforts to meet the needs and aspirations of all interested parties, and will require close and continuing collaboration, dialogue and involvement of stakeholders in the planning and execution of related programmes.

As stressed by a number of countries at the Thirteenth Session of COFO and other international fora, including the XI World Forestry Congress held in Turkey in October 1977, action to safeguard and sustainably utilise forest genetic resources is an urgent priority. Delays in the conservation of forest ecosystems, species and genetic resources of trees and shrubs will be costly, implying environmental, economic and social risks, needs for expensive and at times difficult remedial action, and foregone opportunities in management and sustainable resource utilisation in support of overall national development.

The regional and sub-regional, country-driven and action-oriented workshops on the conservation, management, sustainable utilisation and enhancement of forest genetic resources which FAO plans to help co-ordinate in collaboration with countries concerned, relevant CGIAR Centres, IUFRO and other international players are a first step towards concerted action in response to these urgent needs.

Manifestation of the above needs by countries concerned, and requests for support received in this regard are a clear indication of a growing acknowledgement of the fact that conservation is not a limiting factor for development, but a precondition for lasting well-being.

Acknowledgements

The author acknowledges the useful guidance from an anonymous reviewer, and constructive and helpful comments during preparation and revision of the document by colleagues in FAO's Forestry Department and those received through correspondence with B. Ditlevsen (Denmark), G. Eriksson (Sweden) and P.Y. Kageyama (Brazil).

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Appendix

Acronyms

CGIAR	Consultative Group on International Agricultural Research (Washington D.C., USA)
CIFOR	Centre for International Forestry Research of the CGIAR (Jakarta, Indonesia)
CILSS	Permanent Interstate Committee for Drought Control in the Sahel (Ouagadougou, Bukina Faso)
FAO	Food and Agriculture Organization of the UN (Rome, Italy)
ICRAF	International Centre for Research in Agroforestry of the CGIAR (Nairobi, Kenya)
IPGRI	International Plant Genetic Resources Institute of the CGIAR (Rome, Italy)
IUFRO	International Union of Forestry Research Organizations (Vienna, Austria)
SADC	Southern African Development Community (Gaborone, Botswana)
UNEP	United Nations Environment Programme (Nairobi, Kenya)