PRESENT STATUS OF FOREST PLANTATIONS IN LATIN AMERICA AND THE CARIBBEAN AND REVIEW OF RELATED ACTIVITIES IN TREE IMPROVEMENT[1]

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SUMMARY

The paper reviews present status of forest plantations in countries in Latin America and the Caribbean in the light of information being collected within the framework of the Global Forest Resources Assessment Programme (FRA) and the on-going FRA2000 study. It discusses the type and reliability of available information and analyses trends in the tropical and temperate zone countries in the region. The place and role of traditional and advanced technologies of tree improvement and breeding are examined in the light of the need to improve quality and increase production of a range of goods and environmental services which can be derived from forest plantations and tree planting activities, while at the same time ensuring the conservation of the genetic variation necessary in the light of constantly changing environmental conditions and new and often unforeseen demands of society. The paper underlines that forest plantation and tree improvement strategies must form an integral part of sound forest management. To be successful, activities must be supported by adequate policies which consider the needs of a range of stakeholders, underpinned by a solid institutional framework and based on scientifically and technically sound practices which consider short and medium-term benefits as well as
long-term stability of action.

El ESTADO ACTUAL DE LAS PLANTACIONES FORESTALES EN AMERICA LATINA Y EL CARIBE Y EXAMEN DE LAS ACTIVIDADES RELACIONADAS CON EL MEJORAMIENTO GENETICO

RESUMEN

Esta ponencia hace un examen del estado actual de las plantaciones forestales en países de América Latina y del Caribe, basado en información que actualmente se obtiene por medio del Programa de Evaluación Mundial de los Recursos Forestales (FRA) y del estudio sobre la Evaluación de los Recursos Forestales Año 2000. También analiza el tipo y la confiabilidad de la información disponible y las tendencias en los países tropicales y templados de la Región. Además, esta ponencia examina el papel de las tecnologías tradicionales y de las avanzadas en mejoramiento genético de árboles, dentro del marco de la necesidad de mejorar la calidad y aumentar la producción de una serie de bienes y servicios ambientales que se pueden obtener mediante actividades relacionadas con el establecimiento y manejo de plantaciones forestales, asegurándose al mismo tiempo la conservación de la variación genética necesaria, en vista del cambio constante de las condiciones ambientales y de las nuevas y frecuentemente imprevistas demandas de la sociedad. El documento recalca que las estrategias de plantaciones forestales y mejoramiento genético deben formar parte integral de todo proceso de ordenación forestal bien concebido. Para obtener buenos resultados, las actividades correspondientes deben estar apoyadas por políticas adecuadas que tengan en cuenta las necesidades de una serie de usuarios, y que estén respaldadas por un marco institucional bien establecido, además de estar basadas

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en prácticas científicas y técnicas reconocidas, que consideren los beneficios de corto y mediano plazo, así como la estabilidad del programa en el largo plazo.

1. FOREST PLANTATIONS

1.1 The forest plantation resource - estimates and reliability

The planting of trees is of growing importance to satisfy the demands for wood and wood products of increasing populations and higher standards of living, while at the same time off-setting decreased availability of wood and other forest products from natural forests. Plantations are also needed in cases where areas deprived of woody vegetation, for example salt-affected wastelands, are to be rehabilitated; and where rapid regeneration of the vegetative cover is needed, for example in the case of watershed protection, the protection of dams and canals, or the stabilization of hillsides or shifting sands.

The global forest plantation resource has thus continued to increase in recent years, following the trend of the last two decades. There is no precise global figure for plantation areas, for the reasons given below, but by 1995 there were probably over 110 million ha of forest plantations in the world, a total that is continuing to increase as planners and policy-makers react to the increasing shortages of wood supply from natural forests.

Estimates of the world's forest plantation areas are imprecise for several reasons. The first is that forests of native species in several developed countries in the temperate and boreal regions are largely regenerated naturally and it is not possible to distinguish those areas where supplementary, artificial planting has been done. An approximate estimate of the areas of plantations in developed countries was 60 million ha, of which an area of about 15 million ha in European countries (1997) could be clearly identified as artificially-created "intensively managed stands of introduced or domestic species, usually with a primary goal of maximum wood production" (Anon. 1998a). There were significant areas of forest plantations in New Zealand (1.54 million ha in 1996, 91% of which was *Pinus radiata*) (Anon. 1996a), and Australia (1.04 million ha in 1994, 85% of which was softwood species, mainly *P. radiata*, and the hardwood species are almost all eucalypts) (Anon. 1997a). Forest plantations are thus an integral part of forest management in those and many other countries.

The distinction between natural forest and forest plantations is more clear cut in countries outside the industrialized countries, in which the composition of natural and planted forests usually differ decisively**.** Table 1 below shows the regional totals derived from a recent FAO review of published information for individual countries (FAO 1998a).

The second reason for the lack of precision in plantation area figures is referred to in note 2 of the table below. The plantation area figures that are reported by countries often fail to take account of losses after planting, or from fire or pests, or include the replanting of areas that have been recorded once before - or even two or more times previously. This only becomes apparent when - and if - countries carry out periodic survey or inventories of their plantations, and correct the figures. But in the assessment of tropical forest plantations carried out in 1990 (FAO 1995b), for example, only eighteen countries had in the recent past carried out forest plantation inventories covering a mere 22% of the total reported plantation area at that time. The situation was rather better in Latin America and the Caribbean in that five countries had carried out inventories, covering about 42% of the plantation areas reported in the region. The information given in Table 1 is based on the best sources available at the time of writing, but sometimes data on, for example, private sector or small-scale plantations established by "outgrowers" lies outside the knowledge of the reporting agency (usually the national Forest Service), and is inadvertently omitted.

Table 1. Reported Forest Plantation Areas in Developing Countries, 1995 (1,000 ha)[2]

Region	Reported Areas			Estimated Net Areas	Reported Yearly Rate
	Industrial	Non-industrial	Total		
Africa	3 787	3 025	6 812	5 861	288
Asia-Pacific	31 781	2 1216	5 2997	40 471	2 330
Latin America	7 826	2 134	9 960	8 898	401
Total	43 394	26 375	69 769	55 230	3 019

In considering ownership of the forest plantation resource in Latin America and the Caribbean it should be noted that in many countries of the region with large areas of forest plantations, ownership of plantation resources is with the private rather than with the public sector. The market for plantation wood and for the growth of the industrial plantation programme in these countries has thus been less influenced by the government's presence as plantation manager, but may nonetheless have been highly affected by the incentives offered by governments. Several countries have been offering incentives for the establishment of forest plantations. The incentives include direct subsidies, tax deductions and subsidised loans, while the countries include among others Argentina, Brazil, Chile and Uruguay. These incentives, while sometimes poorly targeted and monitored, have resulted in a large expansion of the forest plantation area in countries concerned and have stimulated interest in tree breeding.

1.2 Species composition[3]

It was calculated from reported figures that 57% of the area of forest plantations in developing countries consisted of non-conifer species and 63% was established for industrial purposes (the corresponding figures for Latin America and the Caribbean were 56% and 79% respectively). Nearly three-quarters of these plantations were in the Asia-Pacific region, where China (21 million ha) and India (20 million ha) dominate, while about 15% were in Latin America and 10% were in Africa. The reported annual afforestation rate for industrial roundwood and fuelwood in developing counties in 1995 was about 3 million ha/an..

It was not always possible to separate from the reports the areas established for industrial roundwood or for fuelwood - the eucalypts for example are established for pulpwood and to a lesser extent for sawtimber in several countries such as Brazil, Chile and Uruguay, while large areas are established for industrial fuelwood in Brazil and for domestic fuelwood in many countries.

Eucalypts comprise the largest global area of hardwood plantations planted for industrial use (30% of the hardwood area, or nearly 10 million ha), followed by acacias (3.9 million ha or about 12% of the hardwood area) and teak (about 7%).

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[2] Notes to *Table 1:*

(i) The figures refer to forest plantations established for wood supply (industrial roundwood and non-industrial wood, largely fuelwood). "Non-forestry"species such as rubber are not included, but their contribution to wood supplies is discussed below.

(ii) The 1995 figures incorporate new and more reliable inventories of forest plantations done in some countries such as Brazil and Indonesia, which have reduced the 1990 estimates.

(iii) "Reported Areas" refer to gross areas derived from various published sources.The "Estimated Net Areas" are derived from the "Reported Areas" through the application of reduction coefficients to allow for poor survival or other losses, based on inventory results where available and on expert opinion where not.

[3] The source of figures quoted in this section, unless otherwise stated, is FAO (1998a).

The composition of the main genera and species grown in forest plantations in Latin America was estimated to be as follows in 1995:

Species	Area (1 000 ha)
Eucalypts	3 981
Fast-growing pines	3 745
Other broadleaves	754
Other conifers	214
Gmelina arborea	145
Terminalia spp.	27
Teak	26*
Mahogany	6
Total	8 898

* Subsequent plantings and revision of the area figures have increased this - see below.

Eucalypts (nearly 4 million ha reported) and pines (3.7 million ha of fast-growing pines reported) were the two main genera established in Latin America up to 1995. There are no reliable estimates of how much of this area was allocated to different uses, such as sawtimber, pulpwood or (in the case of the eucalypts) firewood. The species of both these genera have, not surprisingly, been the subject of selection and breeding programmes for sawtimber and pulpwood, for example in Argentina, Brazil, Colombia, Chile, Uruguay and Venezuela.

Short rotation plantations of non-conifer species have been grown for many years for a number of objectives such as pulpwood and fuelwood by the private sector, but there has previously been little interest in the establishment of plantations of teak, mahogany or other valuable hardwood species because of their long rotations and hence delayed returns, aggravated in the case of mahogany by pest problems (see *e.g.* FAO 1997a). But the prospect of reduced supplies of high quality hardwood logs from natural forests, combined with growing purchasing power and expected higher prices, is leading to increasing interest being shown in investment in valuable hardwood species, especially teak, in a number of countries in Asia such as India, Malaysia, as well as in Latin America (especially Costa Rica, Panama and Trinidad, but also Brazil) and in Africa (especially Ghana). Recent figures for Central America (de Camino and Alfaro 1998) quoted 43 000 ha by 1997 for the sub-region, 60% of which lay in Costa Rica and 30% in Panama. Teak, of the valuable hardwoods, will attract increasing interest from investors especially where supported by incentive schemes targeted on national and international investors, as in Costa Rica. Teak will be the subject of tree breeding programmes especially to improve form and stem circularity (reduction of buttressing).

The potential of two other genera for industrial use, namely the poplars and willows, is attracting interest. There is a long tradition of cultivation of poplars and willows in Argentina, where it was reported that there were 70 000 ha of poplars and 51 000 ha of willows in 1995, which contributed annually 526 000 m^3 and 193 000 m^3 respectively of industrial wood. Eighty to ninety per cent of the annual volume production of willows was used for pulp production (Arreghini and Cerillo 1996). Chile has an area of 10 000 ha of poplars, with a further 8 000 ha of windbreaks. Chile is planning to expand the area of poplars to 100 000 ha over 20 years as part of its “Programme for Forest Diversification”, which aims to reduce the proportion of plantations established as single species. Brazil and Uruguay have potential for poplar cultivation in their temperate and sub-tropical regions and Uruguay, while it only has a small area of poplar at present (4 500 ha) is promoting the establishment of poplars and willows through legislation[4]. Poplars and willows are and will continue to be subject in certain countries *e.g.* Argentina and Chile, to intensive tree breeding to improve yield.

[4] Cerillo, T. (1998). *Pers. comm.*

Fast-growing pines, such as *Pinus radiata*, *P. patula*, *P. caribaea* comprise about 25% of the area of softwoods grown for industrial purposes in the world, while slower-growing pines (*e.g. P. kesiya*, *P. massoniana*, *P. merkusii*, *P. roxburghii*, *P. halepensis*, *P. pinaster* and *P. wallichiana)* make up about 36%.

The trend over the past five years towards the utilisation of wood and fibre from species such as rubber, coconut and oil palm which are not traditionally considered "forest crops" has continued. It was estimated that in 1997 in South America there were 238 000 ha of rubber (*Hevea*) plantations, 269 000 ha of coconut, and 265 000 ha of oil palm. Not all of this area is available for the production of wood or fibre; but all three species provide raw material for industrial products in a more environmentally friendly manner than the former practice of disposing of them by burning; rubberwood and coconut stems are derived from the conversion of old plantations while the residue of the oil palm fruit is used for medium density fibre board. Rubberwood is reported to be used for the manufacture of about 80% of the furniture made in Malaysia, and coconut and oil palm and the branches of rubberwood are used for various forms of reconstituted wood (see *e.g.* Anon.1990, FAO 1993c). Rubberwood has in fact become so valuable that now the Rubber Research Institute of Malaysia is breeding dual purpose latex/timber clones, which have recently been released for commercial planting (Ahmad and Ghani 1997).

1.3 The potential contributions of sustainably managed forest plantations to wood supply

There has been a continuing increase in the area of forest plantations which have been established for industrial wood supply to meet the reduction of out-turn foreseen from natural forests arising from deforestation (largely in the tropics and sub-tropics) or from natural forest being taken out of production and devoted to service functions such as biological or nature conservation (largely in the temperate countries).

Over 25 000 ha of high-yielding hybrid poplar plantations have been established in the north-west USA between 1992 and 1997 for example, in response both to increased demand for poplar wood for oriented-strand board (OSB) and to decreased supply from public forests (Anon.1996b).

No global estimate of current output of timber from forest plantations is available, but FAO's Global Fibre Supply Study (GFSS) estimated that the potential annual growth of industrial forest plantations in developing countries constituted about 5% of the increment of natural forests in 1995 (FAO 1998b). In some countries, plantation production already constitutes a significant proportion of the industrial wood supply. For example, 99% of the industrial roundwood in New Zealand in 1997 was grown in plantations; the corresponding figure was 96% in Zimbabwe, 84% in Chile, 52% in Brazil, and 50% in Zambia.

Estimating the future contribution of forest plantations to wood supply is imprecise and is based on many more or less reliable assumptions, particularly concerning the rate at which afforestation will continue. By the year 2010 the GFSS (*op. cit*). estimated that the potential increment from forest plantations would be about 40% of that from natural forests in Asia, Oceania and Latin America and about 15% in Africa, under rates of deforestation and afforestation largely the same as today.

But the establishment of forest plantations and woodlots, whether mixed or pure, whether of local or introduced species, must be based on careful prior planning. Such planning should be carried out within the framework of overall national and provincial land use planning, and must also at the local level pay maximum attention to land tenure as well as the aspirations and requirements of various user groups for land and for products (see *e.g.* Kanowski 1996, Marien 1996).

Whether primarily targeted to meet industrial, protective or environmental needs, or multiple needs of local populations, plantations require sound and continuing management, security of land tenure, and long-term commitment to funding. Sustainable plantation forestry, in more general terms, also implies ready availability of users and/or markets, and the ability to fulfil manifested needs or to produce specified goods at competitive prices or conditions, at local, national and, at times, international levels.

2. TREE IMPROVEMENT

2.1 General Considerations

Tree planting offers a valuable opportunity to carefully consider the choice of species and provenances to be used. In addition to matching of species and provenances to environmental conditions and end use requirements, it furthermore offers increased possibilities to gradually improve the genetic quality of the tree populations established. Through careful consideration and choice of breeding strategies genetic resources can be conserved and enhanced, increasing chances to meet changing future needs and environmental requirements (Namkoong 1986, 1996; Palmberg 1987, Palmberg-Lerche 1993a, 1998; Koshy and Namkoong 1996).

Need to maximise returns on investment in plantations has over recent years been further underscored by shortages of suitable land for the planting of trees in many countries and, consequently, rising land prices. Basic costs of plantation establishment will be much the same regardless of the quality of the seedlings or scions used. The use of select planting materials of high physiological and genetic quality coupled with careful management will, on the other hand, ensure high survival, facilitate later tending, silvicultural and harvesting operations, and can greatly increase production. Such gains in adaptation to site, yield and, where applicable, uniformity of material produced, can be compounded by further selection and breeding.

Investment in soundly-based tree improvement programmes has over the past 30 years proved to be one of the most cost-effective activities in tree planting in temperate countries, with internal rates of return of between 6 and 20%, in situations in which 8% was considered satisfactory (Palmberg 1993b; see also *e.g.:* Li *et al.* 1998, Teissier du Cros 1998). Based on evidence to date, investments in tree improvement programmes in the tropics and sub-tropics exceed these estimates, as rapid growth rates and relatively short rotations will help realise gains more quickly (see *e.g.* Walker and Haines 1997). Such gains, if based on sound genetic programmes, are of a lasting nature.

Success of both plantation and tree improvement programmes are dependent on long-term commitment of funding and staff resources. In many cases, plantation programmes of individual institutions and agencies are not large enough to justify the expenses involved. The basic minimum costs need to be spread over an adequate area of highly productive plantations if they are to prove profitable. For example, a tree improvement unit costing $US 100 000 per annum and producing improved seed capable of yielding an increase in discounted product value of $US 100 per ha/an, would more than pay for itself on a 10 000 ha/an planting programme, but could not be justified for a 100 ha/an programme (Willan 1973, Ditlevsen 1980). Industrial scale plantations and tree improvement programmes are therefore generally best suited for governments and large corporations to undertake; however, this does not mean that smaller organizations, institutes and even individual owners cannot share in the benefits. Small-holders can join forces in tree planting, and smaller entities with similar goals and ecological conditions can collaborate and, possibly, establish more formal cooperative tree improvement programmes.

With increasing supply of industrial roundwood coming from "outgrowers"[5], the emphasis must be on the supply of planting material well-adapted to the growing conditions, the intensity of management and the end use. Cooperative programmes between industry and private growers can

[5] "Outgrowers" are the owners of small landholdings who provide wood for large processing companies: they may receive support from the processing company in the form of loans (repayable against the collateral of the tree crop), improved planting stock and advice, and a guaranteed price for the tree crop.

help ensure success in this regard.

A number of tree improvement cooperatives operate in Tropical America (*e.g.* CAMCORE in North/Central/South America, and collaborative activities by countries in Central America, coordinated by CATIE, Costa Rica). Such cooperatives have also been established in the temperate zones of Latin America, notably Brazil and Chile. Many have originally received inspiration and a "model" from North American cooperatives, such as the one operating in South Eastern USA and based at the North Carolina State University in Raleigh. In addition to sharing of costs in investment and sharing of benefits of improved genetic materials, commitment, the sense of responsibility and enthusiasm can be greatly enhanced through such cooperation, which has proved successful in most cases where it has been initiated with the seriousness required (Palmberg 1993b). Experiences gained in this respect in Tropical America can potentially serve as a model for other tropical regions in the world.

The dynamism, organisational capacity, know-how and investment capital available in the private sector has played an important role in many countries especially in the case of utilization and improvement of economically important species. To capitalise on opportunities offered by private-sector involvement, governments will need to 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 local and national level. The final challenge for countries will be to develop open and sincere collaboration between Government, the private sector and other stakeholders (Palmberg-Lerche 1998).

Various types of technical and information networks can be of great value for information exchange and the exchange of experiences and know-how. Examples of this kind of networks include the *Agroforestry Network for Latin America and the Caribbean*, and *the Latin American/Caribbean Network for Technical Cooperation in National Parks, Other Protected Areas and Wildlife*, both coordinated by the FAO Regional Office for Latin America and the Caribbean (RLC). The *Technical Cooperation Network on Plant Biotechnology in Latin America and the Caribbean, REDBIO*, also based at RLC, was established in November 1990 at the request of FAO Member Nations in the region. *REDBIO* aims at assisting collaborating countries in the formulation of national and regional policies on biotechnology, and helps promote the exchange of information, research results and biotechnological materials. The network Secretariat also helps organise regional training activities, and maintains a computerized database on plant biotechnology laboratories in the region.

A number of information and research networks are based at and coordinated by institutes such as CATIE, Costa Rica, and the Instituto Forestal Latinoamericano based at the Universidad de los Andes, Mérida (Venezuela). These are supplemented by a great number of species and subject specific collaborative groups under the overall umbrella of IUFRO, in which many institutes and researchers in the region actively participate.

2.2 New Technologies

Over the past decade there has been a greatly increased global interest in plant genetic resources, including forest genetic resources. This interest is due to the general realisation that these valuable resources, which are necessary for adaptation of plant populations to changing environmental conditions and the basis for plant breeding to meet changing human needs, are being lost at accelerating rates. Increased reliance on forest plantations has also tangibly demonstrated the need to have access to high-quality genetic materials for tree planting and further breeding. The development of new biotechnologies, prospects of directly manipulating and transferring traits over generic barriers, and emerging or already existing national legislation and international agreements on plant breeders rights and the patenting of new varieties or even of genes, have expanded this traditionally technical level interest also to policy-making levels.

Exciting biotechnological advances have been made especially in the field of medicine but also in agriculture. In the latter field, advances include the development of new methods of vegetative propagation, including *in vitro* systems; cryopreservation; increased regulation of flowering; and molecular tools for locating and applying DNA markers and for carrying out genetic transformation. Given the constraints traditionally imposed by the long life cycles and physical size of trees, and the limited cross-fertility between many related species, the use of biotechnology for genetic improvement in forestry looks attractive. New and improved systems of vegetative propagation could, and in some cases do, help allow, *inter alia*, more rapid delivery of genetic gain by mass propagation of improved material. Increased control of flowering and the maturation state of trees are also challenges which biotechnologies could potentially help meet. Development of satisfactory systems of genetic fingerprinting would be a much welcome aid to both breeding and conservation of forest trees (Burdon 1994).

It is clear that new technologies will open up new possibilities and are likely to facilitate the work of the tree breeder in the future. Findings in biotechnology can, however, only be capitalised if basic, biological information and knowledge are available, and if sound tree improvement programmes are in place. Conditions that are needed for biotechnological tools to be used advantageously and safely are reviewed *i.a.* by Burdon (1994), Haines and Martin (1997), Carson *et al.* (1996), Griffin (1996) and FAO (1993a, 1994).

In the early 1990s, FAO sponsored an André Mayer Research Fellowship to review the present state and future potential of new biotechnologies in forest tree improvement. The study noted that the use of new biotechnologies will necessitate intimate knowledge of the species under use.. However, existing knowledge of the biology, breeding systems, variation and variation patterns of both industrial and non-industrial forest tree species, especially in regard to the latter ones, is presently limited. The study concluded that although new technologies can support and facilitate work, major emphasis in the genetic improvement of most forest tree species is likely to remain, over the coming years, on taxonomic studies of variation, species and provenance testing, the field assessment of characteristics under use, and the development of tree improvement strategies which combine breeding and genetic conservation (FAO 1994).

The above conclusions were confirmed in a subsequent study on the potential role of biotechnology in future wood production commissioned by the ITTO (ITTO 1995, Haines and Martin 1997). The study concluded that, while commercial applications in crop breeding are rapidly escalating and while the employment of biotechnology in research, in support of forest tree breeding, is of great interest, there are no major examples of operations in forestry where biotechnology currently is being applied in plantation establishment or management to major commercial advantage (see also Carson *et al.* 1996). Noting that much research work has a generic basis and is best conducted with model species in well equipped and staffed laboratories, the study recommended that available resources should generally be spent on advancing tree planting, forest management and breeding programs in individual countries and in priority species used in planting programmes to a stage where they can benefit from the application of biotechnological advances made with model species. The ITTO study stressed the need for a collaborative approach, including networking and twinning of research organizations in developed and developing countries.

In summary, all recent authoritative studies on the role of biotechnologies in forest tree breeding reviewed underline the potential of the new powerful tools that these technologies provide. All of them, however, stress that funding and efforts channelled towards such work must not be at the expense of the development and maintenance of sound and continuing classical tree improvement programmes. This general principle, and a plea to decision makers to recognize this, has been made repeatedly over the years by a number of authorities in tree breeding (see above studies by FAO 1994, Haines and Martin 1997, and *e.g.* Namkoong 1986, Burdon 1994, Burdon and Carson 1998, Teissier du Cros 1998), by the FAO Panel of Experts on Forest Gene Resources (see *e.g.* FAO 1997b), and in recommendations and deliberations of major important fora, such as the 10th World Forestry Congress (Anon.1997b) and the recently held IUFRO Division 2 Conference on Forest Tree Breeding held in

Beijing in August 1998 (Anon.1998b).

Burdon (1994) concluded: "*Appropriate allocation of resources to classical tree breeding and biotechnology will not of itself ensure that good results are obtained, but it is a crucial prerequisite for it. The clear message is that, at least in the short to medium term, the adoption of new biotechnology must be part of a substantially increased commitment to the genetic improvement of forest trees, rather than a switch of effort away from classical breeding measures*."

Burdon further stresses that tree planting and improvement using traditional and new technologies must be based on increased and improved silvicultural inputs. This latter point is also forcefully stressed by *e.g.* Davidson (1996) and Wadsworth (1997).

3. CONCLUSIONS

In the preceding sections, the present situation and trends of forest plantations and tree improvement have been discussed in the light of general, global developments. There is an urgent need to increase the area under plantations in Latin America and the Caribbean to contribute to meeting growing productive, protective and environmental needs at the local, national, regional and global levels. Above all, there is a need to ensure that plantations are established with specified, stated objectives in mind, using documented, high-quality reproductive materials; and that they are tended, protected, managed, regularly inventoried and duly regenerated at the end of the rotation, to reverse the rather dismal situation documented in recent global and regional studies (FAO 1995a, 1995b).

If based on "*good forestry practice*" (FAO 1993b), plantations established using well-adapted species and provenances can multiply yields of the natural forest in wood and non-wood products and secure high-quality environmental services. In relation to wood production, in addition to direct benefits, increased yields, in practice, mean that rotations can be shortened and that more wood can be grown per unit area of land, releasing "excess" areas for other uses, including food production. Well-managed forest plantations can also complement protective and environmental values derived from natural forests, and contribute to the conservation and enhancement of genetic resources of priority species.

Tree improvement can greatly increase the benefits derived from forest plantations, and if sound strategies are followed, which pay due attention to both improvement and conservation aspects, achieved gains are of a lasting nature and can be further increased in subsequent generations.

Both plantation forestry and tree improvement are economic activities, which necessitate substantial investment in land and in human and financial resources. Commitment at both political and technical level, leading to continuity of action over time, is essential for lasting success.

To ensure a holistic view and lasting benefits, dialogue and involvement of all stakeholders potentially interested in plantation establishment, or directly affected by such action, is of utmost importance. Such a dialogue should include government and national academic and research institutions, private owners, traditional users, industry and national non-governmental organizations. Mechanisms must also be in place to ensure that the rights, needs and aspirations of local communities are duly considered.

When viewed in the light of projected future needs, and considering potential returns from tree planting, forest plantations and tree improvement, the investments urgently needed are, in relative terms, minor. Investments, if rightly made, will in time pay back manifold in productive, protective and environmental terms and will improve human well-being in the present and in future generations.

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