THE STATE
OF THE WORLD's

FOREST GENETIC RESOURCES
SYNTHETIC ACCOUNT

COMMISSION ON
GENETIC RESOURCES
FOR FOOD AND
AGRICULTURE

Forests and trees enhance and protect landscapes, ecosystems and production systems. They provide goods and services which are essential to the survival and well-being of all humanity. Forest genetic resources (FGR) are the heritable materials maintained within and among tree and other woody plant species that are of actual or potential economic, environmental, scientific or societal value. FGR are essential for the adaptation and evolutionary processes of forests and trees as well as for improving their productivity.

The world's current population of 7.2 billion is projected to reach 9.6 billion by 2050. Along with population growth, the demand for energy and wood products for both industrial and domestic uses is expected to increase by 40 percent in the next 20 years. The demand for other forest-related goods (food, medicine, fodder and other commodities) is also predicted to increase.

A major consequence of population pressure is land-use change. Forest conversion to crop and pasture land, together with overexploitation, selective harvesting and high tree mortality due to extreme climatic events, in combination with regeneration failure, can result in local population extinction and the loss of FGR.

Conservation and sustainable management of FGR is therefore a must to ensure that present and future generations continue to benefit from forests and trees.

The State of the World's Forest Genetic Resources

This first *The State of the World's Forest Genetic Resources* constitutes a major step in building the information and knowledge base required for action towards better conservation and sustainable management of FGR at national, regional and international levels.

The report was prepared based on information provided by 86 countries, outcomes from regional and subregional consultations and information compiled in thematic studies. It includes:

- an overview of definitions and concepts related to FGR and a review of their value;
- a description of the main drivers of changes;
- the presentation of key emerging technologies;
- an analysis of the current status of FGR conservation, use and related developments;
- recommendations addressing the challenges and needs.

This synthesis report provides key findings of *The State of the World's Forest Genetic Resources*.

Key findings of *The State of World's Forest Genetic Resources*

1. Access to information and knowledge on FGR needs to be improved

Adequate management of FGR requires the availability of accurate knowledge and information on ecosystems and species. Although a range of 80 000 to 100 000 is the most widely used estimate for the number of tree species, the range of published estimates is much wider, from 50 000 to 100 000, indicating the need for further efforts in botanic assessment to obtain more accurate figures.

The status of botanical knowledge varies from country to country. Very few countries have detailed tree species checklists that include species characteristics allowing distinction between different plant life forms, e.g. trees, shrubs, palms and bamboo. Information on the conservation status of species populations is not available in many countries.

The country reports mention 8 000 species of trees, shrubs, palms and bamboo; of these, genetic level information is available for only 500 to 600 species.

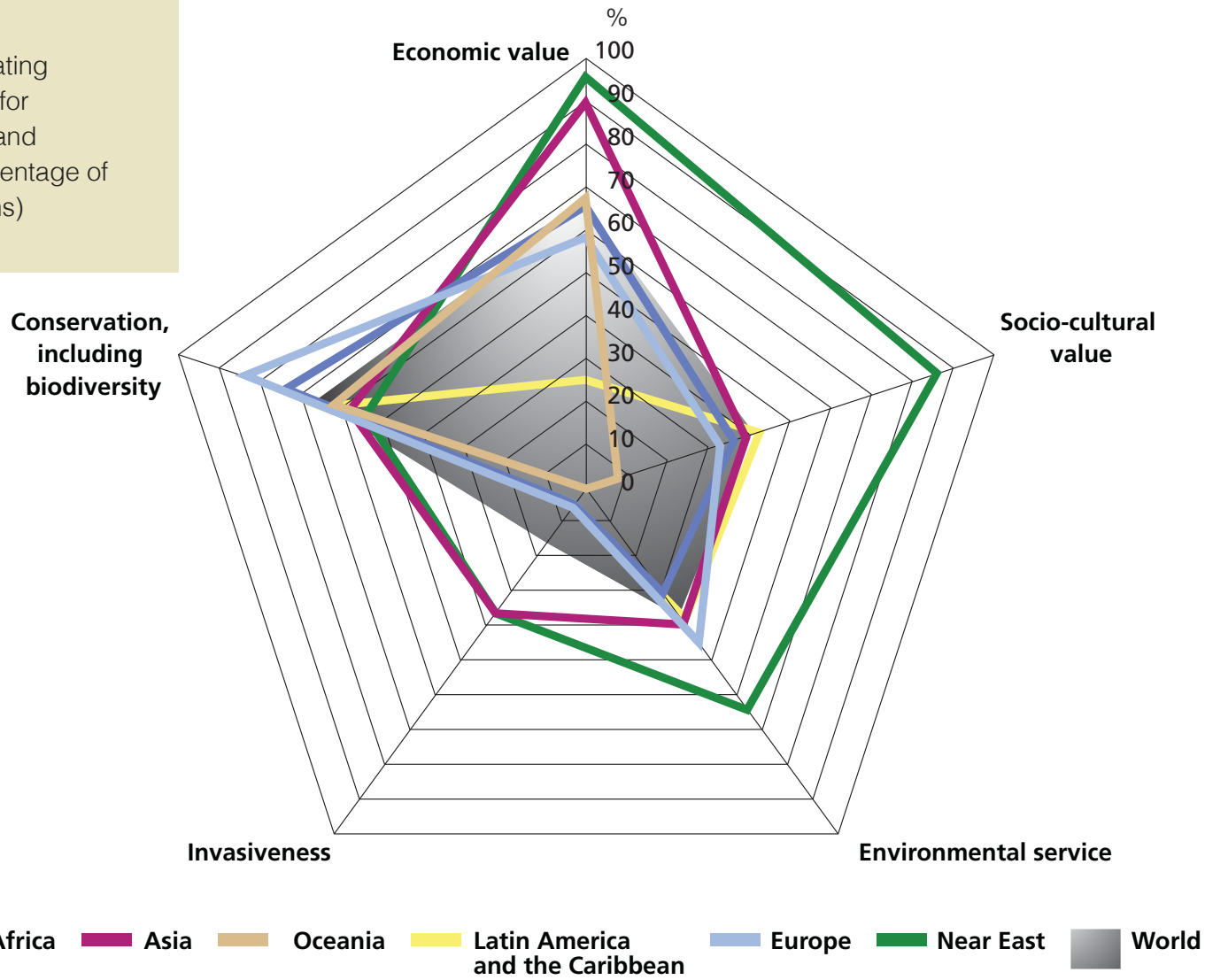
The collaborative development of an FGR database is urgently needed to enhance access to valuable information and avoid duplication efforts and waste of resources.

2. Economic value is the main factor in setting conservation priorities

Priority setting is fundamental to effective FGR conservation and management, given the vast number of tree and woody shrub species and the typically considerable intraspecific variation across their natural range. Reasons for nominating species as priorities include their economic value (timber, pulp, food, wood energy, and non-wood forest products), social and cultural value, conservation value (biodiversity, threatened species, endemic species, genetic conservation, scientific value), environmental value (e.g. soil and water protection, soil fertility and watershed management) and invasiveness.

Results from the country reports indicate economic and conservation value as the two main reasons for nominating species for priority for FGR conservation and management; each accounts for two-thirds of species nominations (Figure 1).

Figure 1: Reasons for nominating species for priority for FGR conservation and management (percentage of species nominations)



Note: North American countries did not report on reasons for prioritizing species.

3. Half of the forest species reported by countries are threatened

Loss of plant species or species genetic erosion in forest ecosystems is mostly due to conversion of forest to other land use types, overexploitation and effects of climate. The proportion of threatened species reported by the countries varies widely, from 7 percent in Oceania to 46 percent in North America (Figure 2). However, some countries included threats at population level, which may account for the great variation in number of threatened species reported.

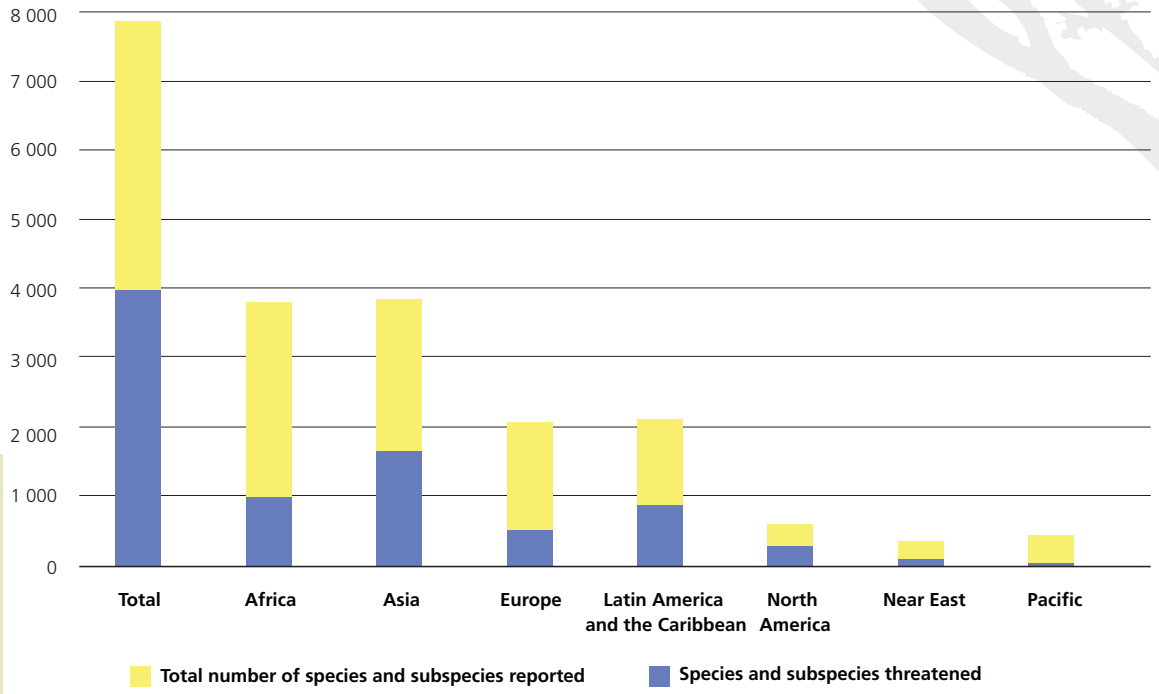


Figure 2: Number of species reported as threatened in country reports

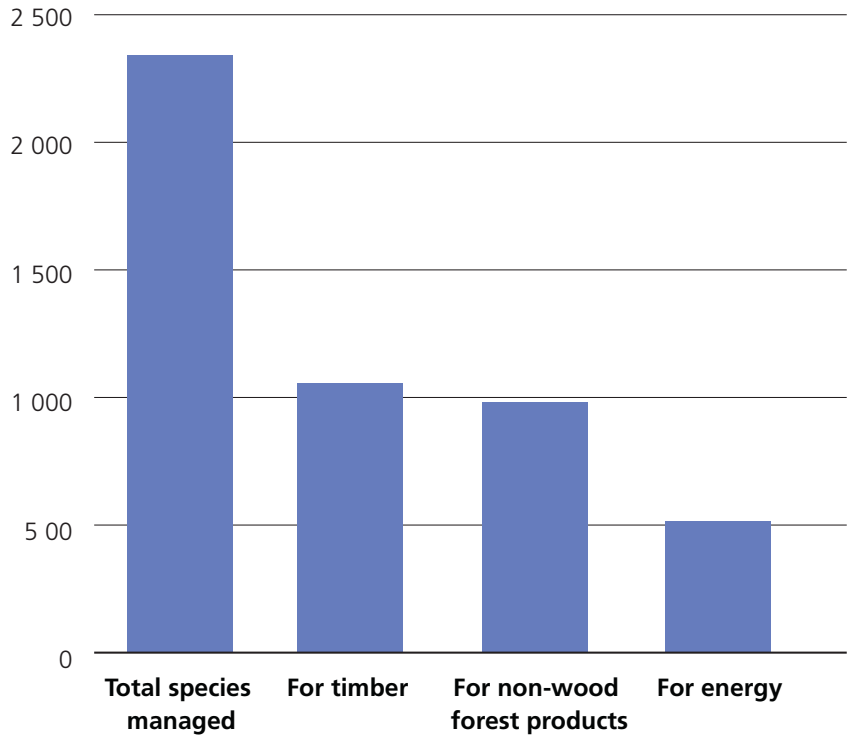
4. 8 000 forest species are used and one-third of them actively managed

Of the 8 000 species of trees, shrubs, palms and bamboo cited in country reports, around 2 400 are mentioned as actively managed, in other words managed specifically for their products and/or services (Figure 3).

The main products and functions targeted through management activities are reported by the countries as timber (42 percent), non-wood forest products (41 percent) and energy (mainly fuelwood) (19 percent).

The high number of species used and their multiplicity of products and services indicates the enormous value of FGR; it suggests their great potential to support agriculture, forestry and environmental sustainability, as well as food and nutrition security, if better evaluated and developed.

Figure 3: Number of species mentioned as actively managed in country reports, by main management objective



5. Species distribution maps are vital, but rarely available

Adequate management of FGR and monitoring of their *in situ* conservation status requires reliable baseline information. Development of species distribution maps showing locations of all populations is an essential step in conservation. However, not many countries have the resources to include the development of such maps in their conservation strategies. Mapping at the regional level can make it possible to cover a large portion if not all of a species' distribution range (Figure 4).

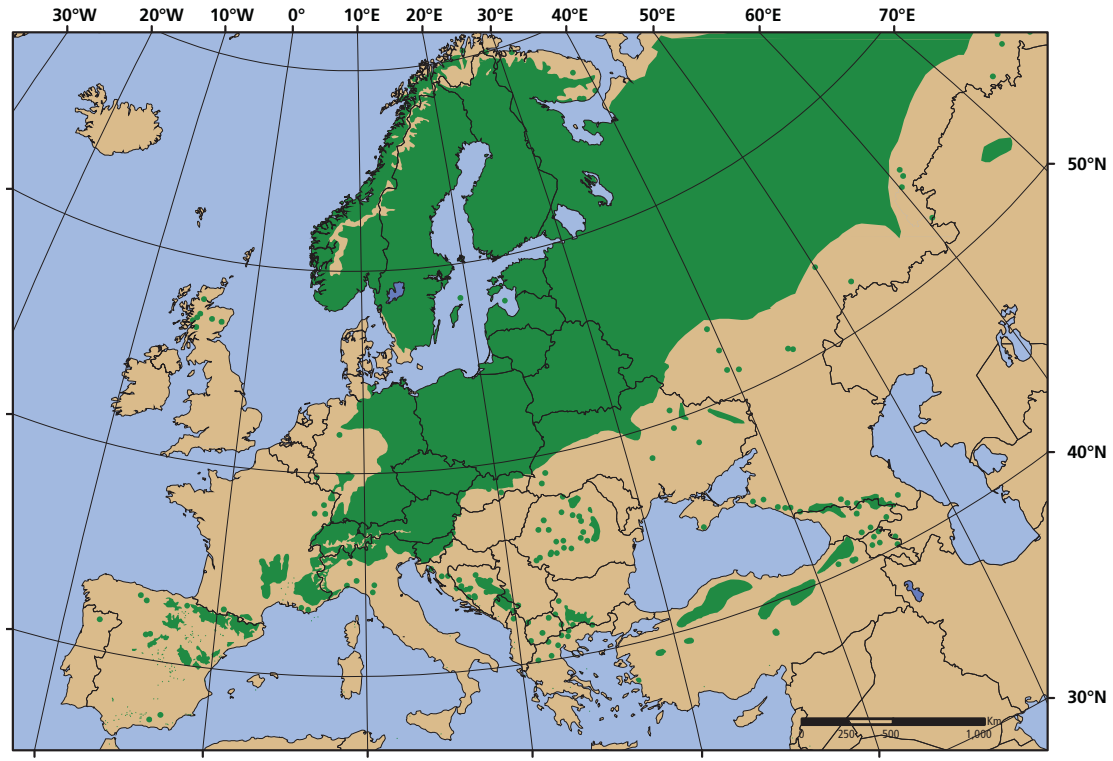


Figure 4: Example of a regional species distribution map: *Pinus sylvestris* in Europe

6. Most species are conserved *in situ*, in naturally regenerated and planted forests

FGR management actions are usually undertaken at forest ecosystem, species (interspecific) or genetic (intraspecific) levels. FGR are to a large extent preserved in wild populations and managed in naturally regenerated forest except for some commercial wood-producing genera and species undergoing intensive tree breeding (e.g. *Acacia* spp., *Eucalyptus* spp., *Populus* spp., *Pinus* spp. and *Tectona grandis*).

In many countries plant wild populations and crop wild relatives are conserved in protected areas and/or in naturally regenerated forest lands. Examples include *Malus* spp. in central Asia, *Coffea arabica* in Ethiopia and *Eucalyptus* spp. in Australia.

In addition, farmers contribute to the conservation of populations of many tree species through traditional agroforestry practices. *Vitellaria* spp. (shea) is an example from semi-arid tropical Africa.

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7. Effective *ex situ* conservation programmes are restricted to limited species and populations

Ex situ conservation programmes remain confined to some economically important species undergoing intensive breeding or under serious threat with high financial implications.

The Millennium Seed Bank Partnership, based in Kew, United Kingdom, hosts the world's largest collection of wild plant species in long-term seed storage. It covers 10 percent of the world's wild plant species – including many woody species – and aims to conserve 25 percent by 2020.

Of the 2 400 actively managed species, about 500 to 600 are managed in planted forests and approximately the same number is included in tree improvement programmes. In some countries planted forests and trials contribute to *ex situ* conservation programmes.

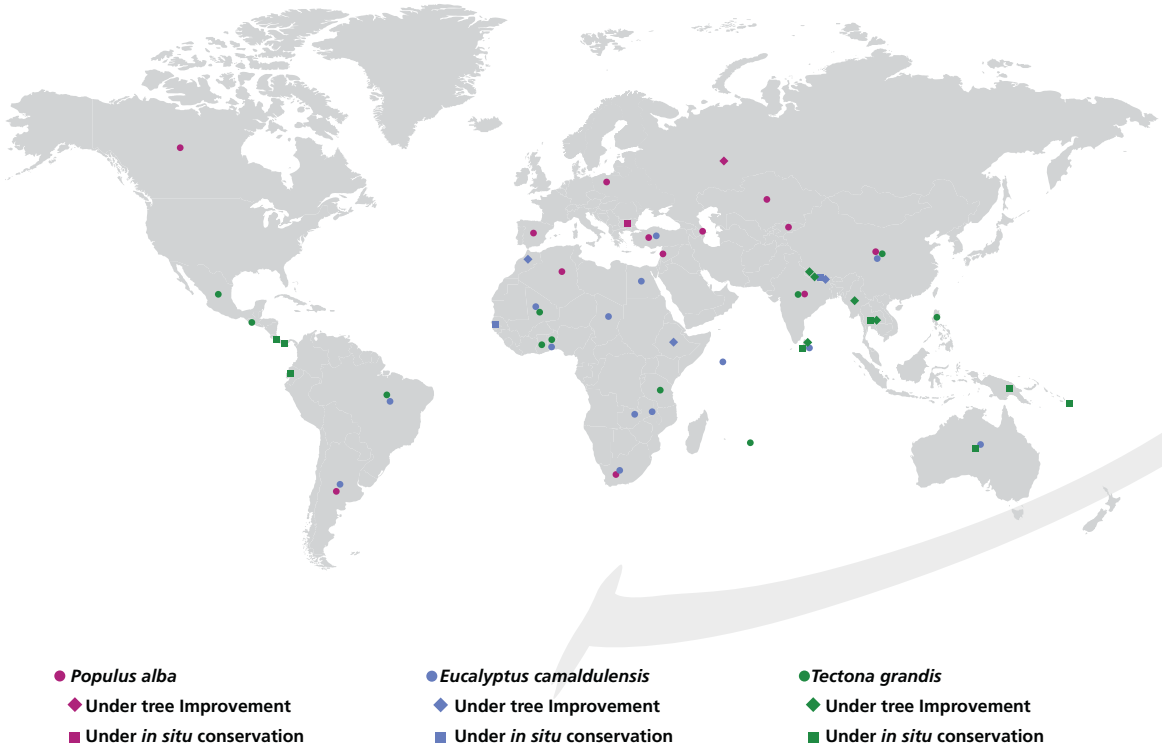
8. Tree improvement greatly enhances productivity and offers potential for adaptation to changing climate

In recent decades government agencies and the private sector have subjected a wider range of tree species to domestication and formal breeding programmes to produce timber, pulp, fuelwood and non-wood forest products and to provide forest service functions. Tree breeding programmes have the potential to improve the production of planted forests and trees in a sustainable way and are necessary to meet growing global demand for forest products and services. Through tree improvement programmes, productivity can be increased by 10 to more than 60 percent depending on the targeted products (wood, fruit, leaves, resins) and the species.

Examples of tree species in countries' intensive selection and breeding programmes include *Eucalyptus* spp., *Pinus* spp., *Populus* spp. and *Tectona grandis* (Figure 5). Hybrid breeding is used in many countries to produce trees with superior productive capabilities (through heterosis) and also to introduce genes for disease resistance. Examples include eucalypt hybrids, *Larix* and *Populus* hybrids and *Pinus* hybrids.

Tree improvement also has an important role in targeting traits suitable for adaptation to varying environmental conditions, including those associated with climate change. These efforts rely on improved understanding of the genetic structure within and between species populations.

Figure 5: Most common species in conservation and tree improvement programmes worldwide



9. Emerging technology opens new avenues in FGR management and conservation

An array of biotechnological tools are contributing to the knowledge of forest genetic resources. For natural forests, biotechnology contributes to the knowledge of genetic variation within and between species populations. In tree improvement programmes, biotechnology tools such as enhanced vegetative propagation techniques and marker-assisted tree selection are making significant contributions. Genomics is also being used in forestry as a tool to enhance conservation, for example through the development of DNA banks. Biotechnology offers innovative means of controlling illegal forest harvesting, with DNA fingerprints now used in timber tracking. Genetic modification has been explored to increase or improve wood production in a few countries. However, no commercial planting has been reported.

Of the over 700 tree species reported by countries as subject to tree improvement programmes, 241 species are included in biotechnology research. The development of large-scale clonal plantations of some economically important species (e.g. *Eucalyptus* spp., *Tectona grandis*) using biotechnology has been reported by a number of countries, including tropical countries.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10. Policies and institutional frameworks are insufficient

Because of insufficient awareness on the importance of forest genetic resources in improving forest production, enhancing ecosystems and improving adaptation of tree species to changing environmental conditions, national policies and regulatory frameworks for FGR are, in general, partial, ineffective or non-existent. Most developing countries lack the funding and the institutional and technical capacities required to address FGR issues. The institutional and policy framework therefore needs to be improved to address the constraints related to the conservation, sustainable use and development of FGR. Many countries identify integration of FGR concerns into broader forest-related policy as a priority.

What needs to be done?

Improve the availability of, and access to, information on FGR

- Establish and strengthen national FGR assessment, characterization and monitoring systems.
- Develop national and subnational systems for the assessment and management of traditional knowledge on FGR.
- Develop international technical standards and protocols for FGR inventory, characterization and monitoring of trends and risks.
- Promote the establishment and reinforcement of FGR information systems (databases) to cover available scientific and traditional knowledge on uses, distribution, habitats, biology and genetic variation of species and species populations.

Enhance *in situ* and *ex situ* conservation of FGR

- Strengthen the contribution of primary forests and protected areas to *in situ* conservation of FGR.
- Promote the establishment and development of efficient and sustainable *ex situ* conservation systems, including *in vivo* collections and gene banks.
- Support and strengthen the role of indigenous and local communities in the sustainable management and conservation of FGR.
- Identify priority species for action.
- Harmonize measures for *in situ* and *ex situ* conservation, including through regional cooperation and networking.

Improve sustainable use and management of FGR

- Develop and reinforce national seed programmes to ensure the availability of genetically appropriate tree seeds in the quantities and of the quality needed for national plantation programmes.
- Promote restoration and rehabilitation of ecosystems using genetically appropriate material.
- Support climate change adaptation and mitigation through proper management and use of FGR.
- Promote appropriate use of emerging technology to support the conservation, development and sustainable use of FGR.
- Develop and reinforce research programmes on tree breeding, domestication and bioprospecting.
- Develop and promote networking and collaboration among concerned countries to combat invasive species affecting FGR.

Strengthen policies and institutional capacities

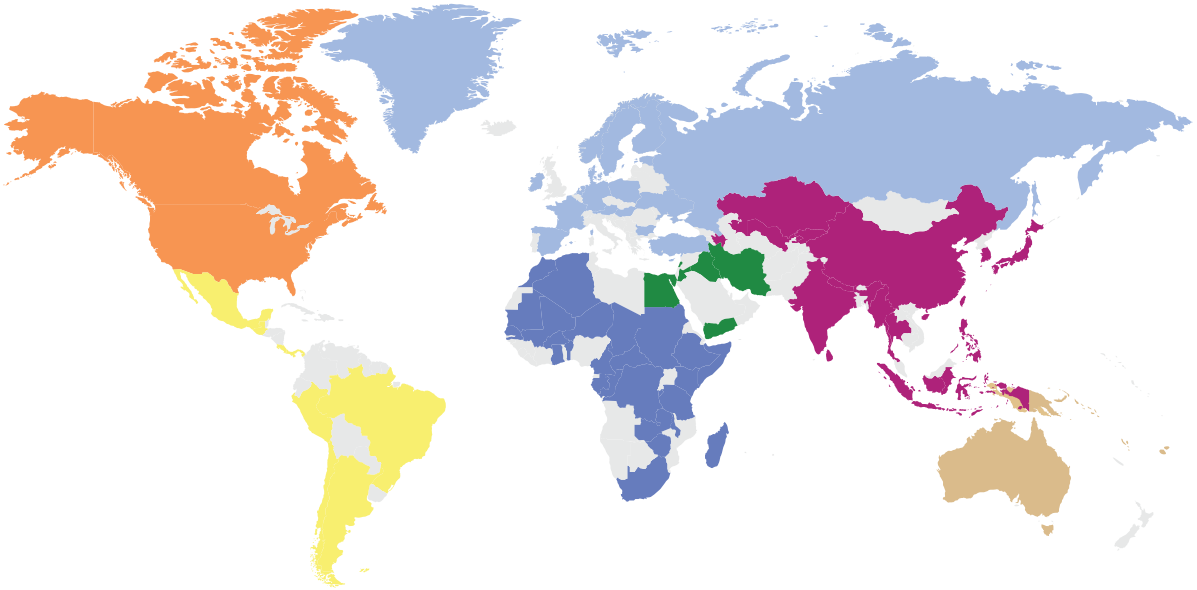
- Develop national strategies for *in situ* and *ex situ* conservation and sustainable use of FGR.
- Integrate FGR conservation and management into wider policies, programmes and frameworks of action at the national, regional and global levels.
- Develop collaboration and promote coordination of national institutions and programmes related to FGR.
- Establish and strengthen educational and research capacities on FGR.
- Promote the participation of indigenous and local communities in FGR management in the context of decentralization.
- Promote and apply mechanisms for regional germplasm exchange for research and development, in agreement with international conventions.
- Reinforce regional and international cooperation, including networking, to support education, knowledge dissemination, research, and conservation and sustainable management of FGR.
- Promote public and international awareness of the roles and value of FGR.
- Strengthen efforts to mobilize the necessary resources, including financing, for the conservation, sustainable use and development of FGR.

Preparation of the report

Recognizing that the lack of information limits the capacity of decision-makers to determine the action needed on FGR at the international, regional and local levels, the Commission on Genetic Resources for Food and Agriculture (Commission), at its eleventh session (2007), emphasized the importance of forest genetic resources for food security, poverty alleviation and environmental sustainability. The Commission stressed the urgency of addressing the conservation and sustainable use of FGR through sustainable forest management, especially those resources that are under threat at the global level, and requested FAO to prepare a report on the state of the world's FGR based on country reports.

To assist countries in their reporting, FAO carried out regional training workshops which covered 82 countries and gathered 137 experts. A total of 86 countries submitted reports (Figure 6), accounting for 76 percent of the world's land area and 85 percent of the global forest area. The Commission established an Intergovernmental Technical Working Group on Forest Genetic Resources.

The draft report was reviewed by the working group, the Commission and individual experts; it was finalized by FAO based on the comments received. Based on the findings of *The State of the World's Forest Genetic Resources*, the Commission agreed on strategic priorities at the national, regional and international levels. In 2013, the Conference of FAO adopted these priorities as the Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources.



Africa (31 countries)
Algeria, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Democratic Republic of the Congo, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Niger, Republic of the Congo, Senegal, Seychelles, Somalia, South Africa, Sudan, Swaziland, Tunisia, United Republic of Tanzania, Zambia, Zimbabwe

Asia (14 countries)
Azerbaijan, China, India, Indonesia, Japan, Kazakhstan, Kyrgyzstan, Myanmar, Nepal, Philippines, Republic of Korea, Sri Lanka, Thailand, Uzbekistan

Europe (18 countries)
Austria, Bulgaria, Cyprus, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Netherlands, Norway, Poland, Russian Federation, Spain, Sweden, Turkey, Ukraine

Latin America and the Caribbean (9 countries)
Argentina, Brazil, Chile, Costa Rica, Ecuador, Guatemala, Mexico, Panama, Peru

Near East (6 countries)
Egypt, Iran, Iraq, Jordan, Lebanon, Yemen

North America (2 countries)
Canada, United States of America

Oceania (6 countries)
Australia, Cook Islands, Fiji, Papua New Guinea, Solomon Islands, Vanuatu

Figure 6: Countries that submitted reports for *The State of the World's Forest Genetic Resources*

The state of knowledge of forest genetic resources: a summary

- Knowledge of FGR is reported to be inadequate for well-informed policy or management in most countries.
- Studies have described genetic parameters for less than 1 percent of tree species, although both the number of studies and the number of species studied have increased significantly in the past decade.
- Most studies conducted during the past two decades have been at the molecular level, either using DNA markers or genomic technologies to characterize genetic resources. Molecular information is accumulating much faster than whole-organism information, with the consequence that little of the accumulating knowledge has direct application in management, improvement or conservation.
- A few species have been well researched – through both molecular and quantitative studies – and genetically characterized; these mainly comprise temperate conifers, eucalypts, several acacias, teak and a few other broadly adapted, widely planted and rapidly growing species.
- Quantitative genetic knowledge has led to significant productivity gains in a small number of high-value planted timber species.
- Genomic knowledge of forest trees lags behind that of model herbaceous crop species, including the important agricultural crops, but for several tree species the entire genome has been or is in the process of being sequenced, and novel approaches have been developed to link markers to important traits. Genomic or marker-assisted selection is close to being realized, but phenotyping and data management are the biggest bottlenecks.
- Many of the species identified as priorities, especially for local use, have received little or no research attention, indicating a need to associate funding with priority-setting exercises.

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