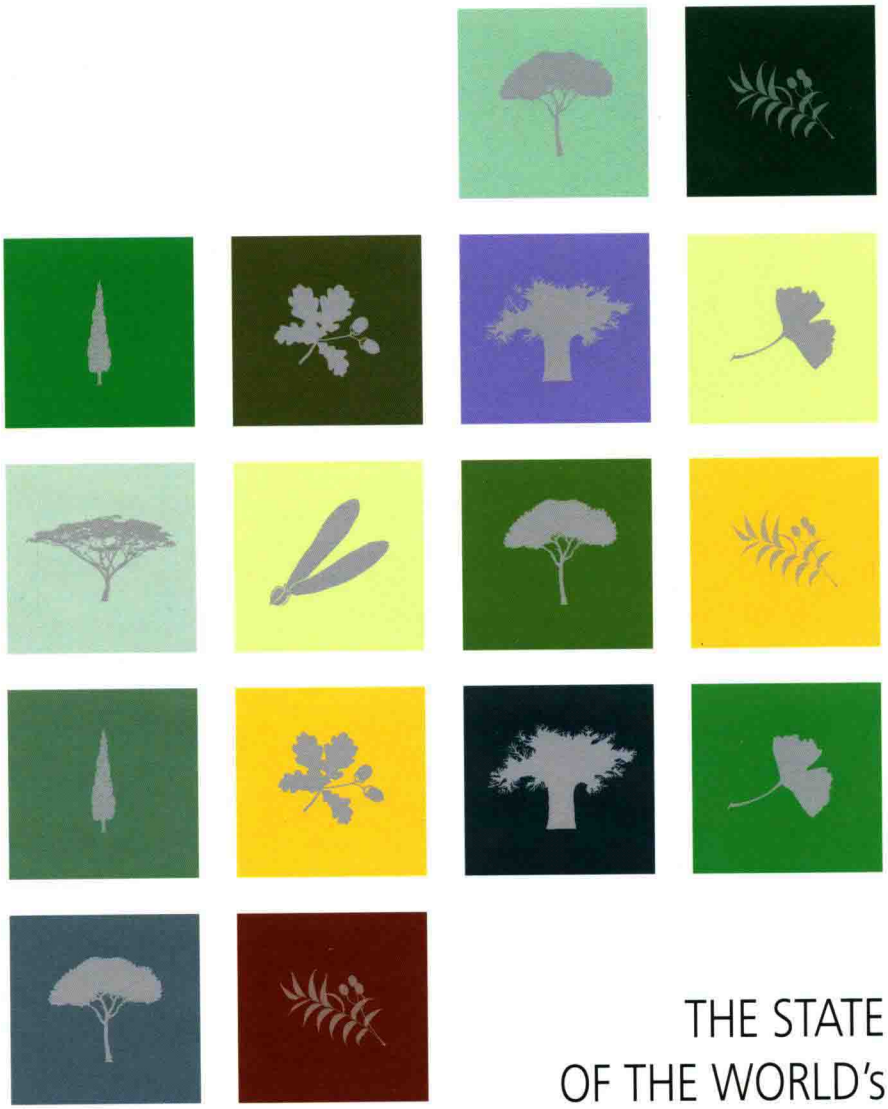


THE STATE OF THE WORLD's FOREST GENETIC RESOURCES

COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

FAO FIAT PANIS

THE STATE OF THE WORLD's **FOREST GENETIC RESOURCES**

COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2014

ISBN 978-92-5-108402-1 (print)
E-ISBN 978-92-5-108403-8 (PDF)

Foreword

Forests cover nearly one-third of the world's land area. They provide vital environmental services such as soil and water protection, regulate the climate and preserve biodiversity, produce valuable raw materials and food, and sustain the livelihoods of millions of people.

Forest genetic resources – the heritable materials maintained within and among trees and other woody plant species – are essential for the adaptation and the evolutionary processes of forests and trees as well as for improving their resilience and productivity.

The conservation of forest genetic resources is more topical than ever at a time when the world is increasingly confronted with challenges from increased human population, land-use changes and climate change. These pressures, and related increases in unsustainable use, wildfire, pests and diseases, as documented in the *Climate change 2013* report of the Intergovernmental Panel on Climate Change (IPCC), are causing losses of forest cover and of forest biodiversity, both among and within species. Lack of information limits the capacity of many countries and the international community to develop appropriate policy tools to address the issues or to integrate forest genetic resources management into relevant cross-cutting sectorial policies.

Reliable data on the status and trends of forest genetic resources are required for decision-makers and stakeholders to provide adequate support for their sustainable management. Recognizing this need for information and the urgency of addressing the conservation and sustainable use of forest genetic resources, the Commission on Genetic Resources for Food and Agriculture requested and guided the preparation of *The State of the World's Forest Genetic Resources,* and agreed, in response to its findings, on strategic priorities which the FAO Conference adopted in June 2013 as the *Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources.*

This first ever report on *The State of the World's Forest Genetic Resources* constitutes a milestone in building the information and knowledge base required for action at the national, regional and international levels. It has been developed through a country-driven process, building on 86 country reports – representing over 85 percent of global forest cover – and with the participation of representatives from national institutions and non-governmental and community-based organizations. Its recommendations are based on these reports, which indicate that about half of the forest species in reporting countries are threatened or subject to genetic erosion, and only about one-quarter are actively managed for their products and/or services. This publication provides the basis for renewed efforts to realize national and international commitments to improved conservation, sustainable use and management of forest genetic resources.

As established in its Reviewed Strategic Framework 2010-2019 and in particular through its Strategic Objective 2, FAO is striving to "increase and improve provision of goods and services from agriculture, forestry and fisheries in a sustainable manner". Measures include strengthening its technical support to countries in the area of forest genetic resources and promoting the integration of forest genetic resources into broader forest resource management programmes at the national, regional and international levels. This report is a key ingredient in this effort.

I am confident that the information in *The State of the World's Forest Genetic Resources* will be used as the basis for policy and technical decisions to strengthen national efforts in

conservation and sustainable management of forest genetic resources, efforts that will contribute to meeting the world's current and future needs for forest products and environmental services while enhancing food security.

José Graziano da Silva
FAO Director-General

Acknowledgements

This report has been made possible thanks to the contribution of time, energy and expertise of many individuals, and the collaboration and support of governments and partner institutions. FAO would like to take this opportunity to acknowledge these contributions.

The report was prepared by the FAO Forest Assessment, Management and Conservation Division. The core team was coordinated by Oudara Souvannavong and included Albert Nikiema and Judith Nantongo. The finalization was supervised by Albert Nikiema.

The country reports submitted by governments were the main source of information for *The State of the World's Forest Genetic Resources.* FAO wishes to thank the governments and all the individuals involved, in particular the National Focal Points, for their contributions on the status of forest genetic resources in their countries.

The preparation of the report would not have been possible without the generous financial support provided by the Governments of Germany, Norway, Spain and Sweden, and the in-kind contributions from the Governments of Canada and Uruguay.

During the entire report preparation process FAO benefited from the very close collaboration of the Bioversity International FGR team composed of Judy Loo, Laura Snook and Jarkko Koskela, and the World Agroforestry Centre (ICRAF) team comprising Ramni Jamnadass and Ian Dawson.

The development of the guidelines for preparation of country reports, the organization of training workshops and other international, regional and national consultations and follow-up workshops involved the following team of FAO Officers at headquarters and in decentralized offices, visiting scientists and experts from regional and international institutions and networks: Moujahed Achouri, Nuria Alba, Ricardo Alia, Simmathiri Appanah, Nabil Assaf, Daniel Baskaran, Zohra Bennadji, Nora Berrahmouni, Foday Bojang, Sairusi Bulai, Rene Czudek, Ian Dawson, Patrick Durst, Claus Eckelmann, Lay-Thong Hong, Benoit Horemans, Riina Jalonen, Ramni Jamnadass, Edward Kilawe, Judy Loo, Aru Mathias, Mario Mengarelli, Judith Nantongo, Jean-Claude Nguinguiri, Albert Nikiema, Hivy Ortiz, Cenon Padolina, José Antonio Prado, Dan Rugabira, Mohamed Saket, Aubain Saya, Heok-Choh Sim, Oudara Souvannavong, François Tapsoba, Maarten van Zonneveld, Barbara Vinceti, Norbert Winkler and Ekrem Yazici.

A series of regional consultation workshops was organized to share preliminary findings of country reports, discuss regional syntheses and adopt recommendations on needs and priorities for action. This approach greatly contributed to the preparation of the report and FAO wishes to acknowledge the participants, including representatives of 82 countries, the National Focal Points, partner institutions and other interested parties. For the organization of the regional workshops, FAO also wishes to acknowledge the generous support and the active collaboration of a number of organizations: African Union Commission; Asia Pacific Association of Forestry Research Institutions (APAFRI); Asia Pacific Forest Genetic Resources Programme (APFORGEN); Bioversity International; Central African Forests Commission (COMIFAC); Kenyan Forest Research Institute (KEFRI); Latin American Forest Genetic Resources Network (LAFORGEN); National Tree Seed Centre of Burkina Faso (CNSF); Organisation for Economic Co-operation and Development (OECD) Secretariat; Royal Botanic Gardens, Kew, United Kingdom; Secretariat of the Convention on Biological Diversity (CBD); Secretariat of the Pacific Community (SPC); State Committee for Environment Protection of the Republic of Tajikistan; Sub-Saharan African Forest Genetic

Resources Network (SAFORGEN); Wallonie-Bruxelles International; World Agroforestry Centre (ICRAF); and World Wide Fund for Nature (WWF).

Regional synthesis reports, which provided useful underpinning for the publication, were compiled by Fadi Asmar, Natalia Demidova, Jerome Duminil, Riina Jalonen, Judith Nantongo, Moussa Ouedraogo and José Antonio Prado.

Data entry and analysis of information from country reports was done by Albert Nikiema with the assistance of Judith Nantongo and Laura D'Aietti. Maps were prepared by Laura D'Aietti.

The report was written by Tannis Beardmore, Judy Loo, Steve Mathews, Katherine McGovern, Albert Nikiema, Oudara Souvannavong, Mary Taylor and Lex Thomson. Comments by members of the Commission on Genetic Resources for Food and Agriculture are gratefully acknowledged. Contributions to the text were made by Henri-Noël Bouda, Stephen Cavers, Jerome Duminil, Marius Ekue, Bruno Fady, Hugh Pritchard, Evert Thomas and Maarten van Zonneveld.

The draft report was reviewed by numerous countries and experts. It is not possible to name each of them here, but their contribution is deeply appreciated. Thanks are due to Ian Thompson for carrying out the final review of the completed report.

The final editing was achieved by Andrea Perlis and coordinated by Suzanne Lapstun. Additional editorial assistance was provided by Miriam Jones. Layout and graphic design were the work of Joanne Morgante with assistance from Roberto Cenciarelli. The final publication of the report was supervised by Douglas McGuire.

Throughout the report preparation process, continuous support and encouragement were received from the Secretariat of the Commission on Genetic Resources for Food and Agriculture as well as the Directors of the Forest Assessment, Management and Conservation Division: José Antonio Prado and Eduardo Mansur. Administrative support was provided by Mustapha Kerdi, Joy Taylor and Sugi Yoo.

Listing every person by name is not easy and carries with it the risk that someone may be overlooked. Apologies are conveyed to anyone who may have provided assistance whose name has been inadvertently omitted.

About this publication

The State of the World's Forest Genetic Resources addresses the conservation, management and sustainable use of forest tree and other woody plant genetic resources of actual and potential value for human well-being in the broad range of management systems.

This report complements two other FAO flagship publications in the field of forestry, the annual *State of the World's Forests* and the periodic Global Forest Resources Assessment (FRA). *State of the World's Forests* reports on the status of forests, recent major policy and institutional developments and key issues concerning the forest sector. FRA provides comprehensive data on forest distribution and status, including on matters influencing forest genetic resource (FGR) conservation and management, such as indicators of sustainable forest management, extent of permanent forest estate and protected areas, and regeneration methods used. However, forest cover and related data cannot be used as a surrogate for assessment of the status of FGR. This first edition of *The State of the World's Forest Genetic Resources* will help to differentiate between the state of the world's forest resources and the state of the genetic resources on which they depend for their utility, adaptability and health.

The State of the World's Forest Genetic Resources also complements two flagship publications in the field of genetic resources for food and agriculture: *The State of the World's Animal Genetic Resources for Food and Agriculture*, published in 2007, and *The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture*, published in 2010. The three reports have in common that they have been initiated by and prepared under the guidance of FAO's Commission on Genetic Resources for Food and Agriculture (the Commission) (see Box).

This is the first synthesis of its kind for FGR and constitutes a baseline against which future status assessments can be compared. Sources of information include national reports prepared by countries, regional summaries prepared following regional workshops and commissioned thematic studies (see section on the reporting and preparatory process

The Commission on Genetic Resources for Food and Agriculture

With its 177 member countries, the Commission on Genetic Resources for Food and Agriculture offers an intergovernmental forum where global consensus can be reached on policies relevant to biodiversity for food and agriculture. The main objective of the Commission is to ensure the conservation and sustainable use of genetic resources for food and agriculture and the fair and equitable sharing of benefits derived from their use, for present and future generations.

The work of the Commission focuses on developing and overseeing the implementation of policies and supporting initiatives that not only raise awareness but also seek ways to solve emerging problems. It guides the preparation of periodic global assessments of the status and trends of genetic diversity, the threats facing genetic diversity and the measures being taken to promote its conservation and sustainable use. The Commission also negotiates global action plans, codes of conduct and other instruments relevant to the conservation and sustainable use of genetic resources for food and agriculture.

below) as well as published literature. Of necessity the treatment of knowledge of FGR in this report is selective, as volumes would be required to capture all the available knowledge.

Part 1 provides an overview of basic definitions and concepts in forest genetics, the value of FGR (recognition of which is essential to ensuring their conservation), FGR conservation approaches, and the state of knowledge and information in this field.

Part 2 addresses drivers of change, including forest conversion and expansion of crop land, demand for wood energy, and unsustainable harvesting and use. Next it presents the global forest trends affecting FGR, with data on trends in forest cover, biodiversity conservation and ownership, drawn primarily from FRA 2010. The consequences of these trends for FGR are also outlined, in terms of loss of ecosystems, tree species and intraspecific diversity.

Part 3 examines the current and emerging technologies in the field of FGR, including information on indigenous and traditional knowledge and classical tree improvement, modern advances including the use of molecular markers and genetic modification, and FGR conservation-related knowledge. This part also addresses research on climate change and FGR and genetic technologies for reducing illegal forest harvesting.

Part 4 reviews the state of FGR conservation and management. This part, based on the reports submitted by countries, addresses countries' FGR strategies and programmes, their progress in characterizing their genetic diversity, and the state of *in situ* and *ex situ* conservation and management. It also reviews progress in breeding and genetic improvement of forest tree species, and the systems for producing and distributing forest genetic materials for use on farms, in natural and planted forests and in research. Finally, it presents the state of the institutional framework for FGR conservation and management, including national institutions dealing with FGR, policies and laws, education and training, research, communication and public awareness raising, and international and regional collaboration, including networks.

The concluding section, Part 5, addresses the needs and responses required to improve FGR conservation and management in the future. It provides recommendations for improving practices and technologies in FGR conservation and management; and for enhancing national polices and institutions, capacity building, knowledge and information availability, and public awareness for improved conservation and management of FGR worldwide.

The reporting and preparatory process

In considering the status of conservation and use of forest genetic resources, the Commission, at its eleventh regular session in 2007, emphasized their importance for food security, poverty alleviation and environmental sustainability and recognized that the lack of information limits international, regional and local decision-making and action on these vital resources. The Commission included the preparation of *The State of the World's Forest Genetic Resources* in its Multi-year Programme of Work and requested that FAO begin to prepare it. The Commission's request was supported by the FAO Committee on Forestry (COFO) at its nineteenth session (March 2009). At its twelfth regular session (October 2009), the Commission endorsed a proposed outline of the report and agreed on an indicative timeline and the process for country involvement. The Commission also established an Intergovernmental Technical Working Group on Forest Genetic Resources (ITWG-FGR) to

address issues relevant to the conservation and sustainable use of FGR, and to advise and make recommendations on the report preparation process.

In April 2010, following the process established by the Commission, FAO invited countries to nominate National Focal Points and to prepare and submit country reports, which have been the main source of information for the preparation of *The State of the World's Forest Genetic Resources* following a country-driven process. FAO provided guidelines for the preparation of the country reports, including a recommended structure and methodology (FAO, 2011). The guidelines suggested that the preparation of country reports represented an opportunity to conduct a national strategic exercise to assess the status of FGR in the countries and to reflect on needs and priorities for their conservation and sustainable use. A participatory approach, engaging a wide range of stakeholders, was encouraged.

At its twentieth session in October 2010, COFO welcomed the initiative to develop *The State of the World's Forest Genetic Resources* and recommended that FAO continue this important effort. It also invited the governing bodies of the member organizations of the Collaborative Partnership on Forests to consider the information and analysis provided by FRA and this report in their work.

From November 2010 to September 2011, FAO organized regional and subregional workshops to train National Focal Points and other national and regional experts on the preparation of country reports following the approach promoted in the guidelines. These workshops were organized in collaboration with international partners such as Bioversity International, the World Agroforestry Centre (ICRAF), the Secretariat of the Convention on Biological Diversity (CBD) and the World Wide Fund for Nature (WWF), as well as regional institutions such as the Central African Forests Commission (COMIFAC) and the Secretariat of the Pacific Community (SPC) and regional networks and programmes such as the Asia Pacific Association of Forestry Research Institutions (APAFRI), the Asia Pacific Forest Genetic Resources Programme (APFORGEN), the Latin American Forest Genetic Resources Network (LAFORGEN) and the Sub-Saharan African Forest Genetic Resources Network (SAFORGEN). The workshops covered 82 countries and gathered 137 experts.

A total of 86 countries submitted reports (see Figure), accounting for 76 percent of the world's land area and 85 percent of the global forest area, with good latitudinal and ecoregional representation.

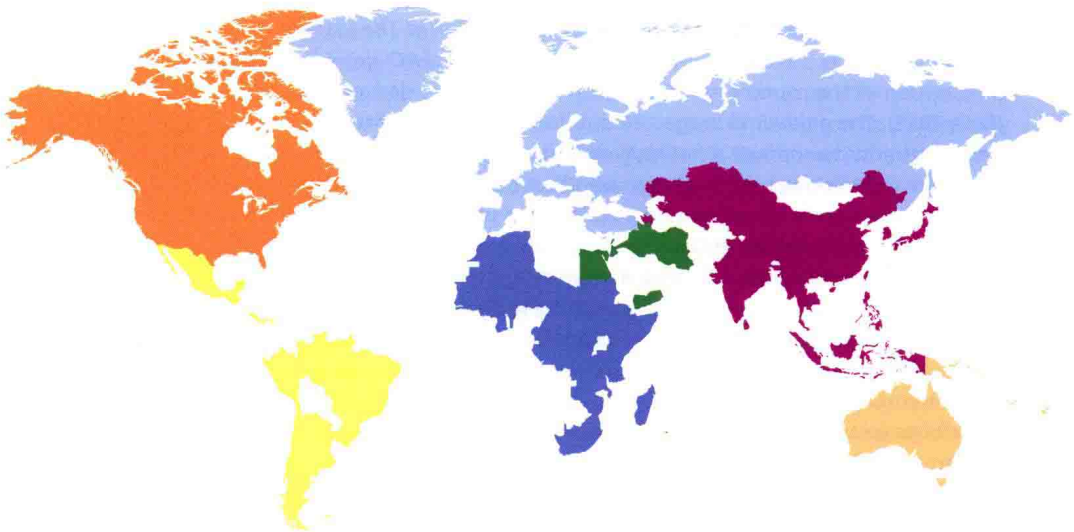
Five thematic studies were prepared on issues relevant to the conservation and sustainable use of FGR at the global level:

- Indicators of forest genetic diversity, erosion and vulnerability
- Role of FGR in adaptation to biotic and abiotic factors in a changing climate
- Trees, tree genetic resources and the livelihoods of rural communities in the tropics
- Genetic considerations in ecosystem restoration using native tree species
- Genetic effects of forest management practices

The country reports and the thematic background studies prepared for *The State of the World's Forest Genetic Resources* will be made available on a dedicated page on FAO's website.

A draft of the present report was reviewed by ITWG-FGR at its second session in January 2013 and presented to the Commission at its fourteenth regular session in April of the same year. Countries were invited to provide comments on the final draft, which were taken into consideration in the finalization of the report.

Countries reporting for *The State of the World's 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

Note: The region referred to as Oceania – for consistency with data reported in the Global Forest Resources Assessment and *State of the World's Forests* – is synonymous with the Commission's South West Pacific region.

Based on the findings of *The State of the World's Forest Genetic Resources*, ITWG-FGR and subsequently the Commission agreed on strategic priorities for forest genetic resources, adopted by the Conference of FAO at its thirty-eighth session in June 2013 as the Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources. This Global Plan of Action identifies 27 strategic priorities grouped into four areas:

- improving the availability of, and access to, information on FGR;
- conservation of FGR (*in situ* and *ex situ*);
- sustainable use, development and management of FGR;
- policies, institutions and capacity building.

Implementation of the Global Plan of Action will strengthen the sustainability of forest management while contributing towards the Millennium Development Goals, the post-2015 development agenda and the Aichi Biodiversity Targets.

Executive summary

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 change;
- 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.

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 (the Commission), at its eleventh session (2007), emphasized the importance of FGR 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, 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 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.

The draft report was reviewed by the working group, the Commission and individual experts; it was finalized by FAO incorporating 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.

Key findings

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, s, 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.

Economic value is the main factor in setting management priorities

Priority setting is fundamental to effective FGR conservation and management, given the vast number of tree and other woody 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.

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. However, some countries included threats at population level, which may account for the great variation in number of threatened species reported.

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.

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.

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.

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.

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 700 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.

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*. 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.

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.

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.