

NATIONAL FOREST INVENTORIES AND GLOBAL RESOURCE ASSESSMENTS

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Summary

Forest resources are essential for humankind. They provide food, fuel, shelter, soil and water protection, and filter the air that is breathed. With increasing human populations, there is demand for increasing forests and the goods and services they produce. Concerns for the environment and the need for economic development led to the Earth Summit or United Nations Convention on Environment and Development (UNCED) in 1992. This, in turn, led to the various international conventions and agreements calling for global information on the world's forest resources. National inventories and global resource assessments provide basic data for the developing sustainable management plans. Global forest data are derived from forest resource assessments conducted by the United Nations and assessments of forest cover, generally produced by national and international space agencies. These two assessments compliment each other. The former is best suited for providing data on forestland use and production. The latter provides data on the extent and changes of forest cover. Neither, however, provides all the data identified as being necessary at the Earth Summit. To meet these needs, integrated resource inventories and assessments may be required.

1. Introduction: Global Importance of Forests

Forests are an essential part of Earth's life support systems. They help to manufacture the air that is breathed, filter the water that is drunk, and stabilize soils for crop production. Information on the amount, extent, and condition of the world's forestland is important economically, environmentally, ecologically, socially, and politically. The services of ecological systems, including forests, and the natural capital stocks that produce them, are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the economic value of the planet. For the entire biosphere, the value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations, is estimated to be an average of US \$33 trillion per year.

World trade demand for timber and other forest goods and services is increasing with increasing human populations. International trade in wood products is estimated to be over \$100 billion per year. This makes it the third most valuable commodity traded internationally after oil and gas, and the first most valuable renewable resource traded internationally.

Almost half of the world's original forest cover has been lost since the last great ice age, with most of this loss occurring since the 1960s. At the beginning of the twenty-first century, forests cover an estimated 3 454 million hectares of the Earth. The United Nations Food and Agriculture Organization (FAO) showed that forests were being lost at a rate of about 14.6 million hectares per year in the 1990s, largely in the tropics,

primarily due to conversion of land to agriculture, but including some loss from forest management practices. Subsequent assessments by the United Nations and others confirm that the scale and pace of forest loss continues to grow, and is estimated at the beginning of the twenty-first century to be around 15 million hectares per year.

The historical loss of forest cover is in sharp contrast to the growing global demand for wood fiber. According to FAO, since 1960 the production of sawnwood has doubled, fuelwood production has increased 2.5 times, and paper production has more than tripled. During this same period, the world's population almost doubled, and the world economy expanded by a factor of 3.5. Looking ahead, most experts agree that global fiber supplies will be adequate, assuming the ability to manage some forests intensively, and with perhaps some notable regional gaps, even though the world population is expected to double yet again and economic activity to quadruple by 2020. The ability of countries to meet increasing demand has made wood fiber one of the world's truly global commodities. Increasingly, the condition and management of forests in any major producing nation has far-reaching impacts on market conditions, affecting producers worldwide.

Region	Fuelwood and charcoal	Industrial roundwood	Sawnwood	Wood-based panels	Pulp for paper	Paper and paperboard
Africa	519.9	67.9	9.1	1.8	2.1	2.7
Asia	905.2	280.2	98.2	45.3	42.9	81.9
Europe	82.4	369.7	110.3	44.2	38.0	80.9
North and Central America	155.	600.4	176.9	49.9	83.4	106.8
Oceania	8.8	41.5	6.8	2.2	2.3	2.7
South America	193.0	129.9	28.3	6.0	9.7	9.3
World	1 864.7	1 489.5	429.6	149.4	178.5	284.4

Table 1. Production of forest products (1996) in millions m³

Nearly 1563 million ha of natural forestland are considered to be available for wood supply under current legal and market conditions. Table 1 shows the production of forest products in 1996.

There are two main global trends in timber production: harvest levels from the world's important forest regions are declining as a result of environmental pressures, and wood demand is rising with population growth. There was a net decline of 47 million m³ (3%) in log harvests for 1990–1995. The United Nations projects that timber demand will increase by 22% (400 million m³) between 1990 and 2000, i.e., an increase of 2% per annum. Globally, forested lands are on a decline.

Statistics on the Earth's forest resources come from national forest inventories aggregated into global assessments. This article describes global forest resource assessments and assessments of forest cover. It addresses the strengths and limitations of each type of assessment, and lays out some recommendations for the future.

2. National Forest Inventories

National forest inventories are data collection efforts designed to report on the extent, state, and condition of the forestland and resources of a given country. Decision-makers use such estimates to develop land-use policies for the nation. Periodic national assessments provide trend information which further influences land management policies and decisions. International organizations, such as FAO, combine national inventories and other information from countries to provide regional and global assessments. These in turn influence international policies and trade agreements, and are often the basis for research on global environmental and social trends.

2.1 History

In Switzerland and France in the 1890s, foresters determined increment by the comparison of two periodic inventories plus records of removal volume. This early work gave rise to continuous forest inventories (CFI), which are very popular today. Foresters often employed strip cruises (surveys) at this time. While foresters were using sampling, the statistics to permit the calculation of the reliability of the inventories obtained were not available. Information sought included volume and increment.

Norway started a national inventory in 1919, and by the 1920s, all Nordic countries had some type of national effort in place. In addition to being able to calculate the reliability of the surveys, inventory planners could, for the first time, use statistics to design data collection efforts to achieve predetermined allowable sampling errors. This gave the best possible relations between the permitted expenditure and required precision. Thus, foresters could use mathematical sampling techniques instead of costly larger enumerations, and subjective visual or representative sampling.

The US launched its first statistically-designed inventories to provide state and national statistics in 1930.

World War II brought many forest inventories to a halt. Following this war, CFI and permanently-established, systematically-located, fixed-area plots became a standard for large-area surveys in many parts of the world.

Until the early- to mid-1970s, the emphasis of most national forest inventories was to obtain estimates of timber growing stock and trends. Since that time, however, there has been an increase in interest in other forest products and in the environmental, economic, and social roles that forests play locally, nationally, and globally. The impact of these new needs are discussed later in the article.

2.2 Approaches to National Forest Inventories

There are two basic approaches for carrying out a national inventory. One is the single data collection effort where one sampling method is designed with one group formed specifically to provide statistics for a country. The other method is by aggregation of existing inventories which may be of different designs, and be conducted by different organizations.

2.2.1 Single Effort

Through the single effort inventory, data are collected by one group, using the same design across the entire country. Nationwide inventories conducted in one single effort are common in the Nordic countries and in relatively small countries. Lately, the single effort has become very popular where researchers use satellite-imagery to map the forest cover across a nation or groups of nations.

There are essentially two kinds of designs used for single-effort national inventories—those that rely primarily on sampling without stratification, and those that use remote sensing as a base for stratification and allocation of samples. A refinement of the latter is an inventory that uses wall-to-wall mapping as both a product and a basis for sampling. The methods discussed in this section may also be options for the subnational inventories mentioned above.

Mapping-based inventories rely on remote sensing (aerial photography or satellite-based imagery) to produce type maps or maps of forest cover. At a minimum, image interpreters use ground truth to help with the development of the maps. In this case, the primary product of the inventory is the type map and estimates of forest area. More sophisticated designs use the mapping in a post-stratification of randomly-selected field plots, yielding both maps and the more traditional timber statistics. The use of pictorially-displayed forest information will be one of the most important additions to the available management tools in the future.

2.2.2 Aggregation Effort

Aggregation of existing information or subinventories is by far the most common for large countries like Australia, Canada, and the US. Smaller countries, such as Tanzania, may also use this method.

A central unit specifies the information needed or the tables cooperators must complete. Participating elements collect the data for their areas of responsibility, using any of the designs listed under the single method. The cooperating units, in turn, provide summary information to the coordinating unit. If the collaborating units belong to the same organization as the central unit then there can be strong control. The directing organization specifies end product, sample designs, data collection techniques, and standards.

The strength of the central or coordinating unit and the relationship to the contributors is paramount to the success of the inventory. A strong organizing unit with subunits belonging to the same organization, as found in the USDA Forest Service, is one of the more strong inventory structure possibilities.

If the participating elements belong to different organizations, such as found in Canada and Tanzania, the control is less stringent. The accumulating organization specifies the data required and when it is required. Participating elements are free to use whatever data collection method they wish, as long as they can provide the necessary data to the standards required by the lead organization. National assessments based upon the

accumulation of management plan inventories have been common in Central Europe.

The advantages of the aggregation technique are:

- There is less impact on the cooperators. They are free to use whatever techniques that are suitable for the environmental, physical and economic situations they face.
- There is less opportunities for conflicting data as the cooperating units provide the data for their lands.
- There is less cost to the central unit as most of the expense is carried by the participating units.

The disadvantages are:

- Collaborating elements or the head unit may have to do considerable manipulation of the data before it can be combined and used by the central unit for national reporting.
- Data may not truly be additive because of the different standards and techniques used or the different times (reference years) when the data are collected.
- The error affecting the final outputs remains unknown at a fixed level of significance.
- The quality of the final data or report is only as good as the weakest participating group.

Many of the problems of aggregation may be overcome by using a low intensity sample to calibrate and monitor the aggregated data.

2.3 Monitoring

In addition to knowing how much timber is available and where it is located, most countries need trend information. This is obtained from monitoring. Monitoring is the periodic measurement or observation of selected physical, chemical, and biological parameters for establishing baselines and for detecting and quantifying changes over time. Change can simply be measured by comparing two assessments of the same area performed at two different times. Most, if not all, nations have such a minimal monitoring program. More sophisticated schemes make use of networks of permanent sample plots and/or periodic remote sensing. Many of the Scandinavian countries use networks of permanent plots for measuring change and predicting trends. Austria, France, the Netherlands, and the US also have a network of permanent plots across most forestlands. Some have been measured as often as five times.

2.4 Digest

National forest inventories are data collection efforts designed to report on the extent, state, and condition of the forest resources of a given country. Few national inventories result from a single sample. Most are aggregations of several different efforts. There are some nationwide estimates of forest cover resulting from wall-to-wall aerial photography or satellite-based remote sensing, especially in the tropics. The methods and roles of inventories have changed over time and will continue to do so in the future.

Information needs are increasing to the point that there is now a need to design holistic, multiple resource inventories. These inventories must meet global needs as well as national and local needs.

3. Global Information Needs

Parties to the Earth Summit—the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992, identified and agreed to common global goals including improving the quality of life and the environment, maintaining biodiversity, reducing deforestation, mitigating climate change, and promoting sustainable resource management. The US, with some 177 other governments, signed the UNCED Agreements (The Rio Declaration, Agenda 21, and the Forestry Principles) that may affect how nations conduct resource inventories, and the data that will be needed for future global assessments. The Forestry Principles have led to the creation of regional guidelines for Criteria and Indicators for Sustainable Development.

While agreements and the conventions lack the force of international law, they carry a strong moral obligation to insure their full implementation. Those in force are described in the following subsections.

3.1 The Rio Declaration

The Rio Declaration on Environment and Development is a political document or proclamation that outlines lifestyles that insure the planet's integrity as habitats for humankind and all living creatures. There are 27 principles presented. Two in particular should influence a nation's forest inventory program in relation to global assessments.

- Principle 2 indicates that “States have...the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.” This shows the need for international standards for sharing and comparing environmental data. National inventorying and monitoring programs have to include these standards.
- Principle 10 states that “At the national level, each individual shall have access to information concerning the environment that is held by public authorities... States shall facilitate and encourage public awareness and participation by making information widely available.” The implication of this principle is very obvious—the general public should have access to the data countries collect.

3.2 Agenda 21

The “Programme of Action for Sustainable Development for Now into the Twenty-First Century,” or Agenda 21, is a longer, negotiated text of action steps, four sections, and 40 chapters. Each chapter deals with a different substantive area, identifying desirable outcomes, and the steps necessary to achieve them. The following chapters offer specific needs relating to national forest inventory programs:

- Chapter 8. Integrating environment and development in decision-making.

- Chapter 9. Protection of the atmosphere.
- Chapter 10. Integrated approach to the planning and management of land resources.
- Chapter 11. Combating deforestation.
- Chapter 12. Managing fragile ecosystems: combating desertification and drought.
- Chapter 13. Managing fragile ecosystems: sustainable mountain development.
- Chapter 14. Promoting sustainable agriculture and rural development.
- Chapter 15. Conservation of biological diversity.
- Chapter 16. Environmentally sound management of biotechnology.
- Chapter 17. Protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas and the protection and rational use and development of their living resources.
- Chapter 18. Protection of the quality and supply of freshwater resources: Application of integrated approaches to the development, management and use of water resources.
- Chapter 40. Information for decision-making.

For a country such as the US, which has forests, mountains, inland waters, coasts, and deserts, all chapters apply.

3.3 Forestry Principles

The objective of the “Non-Locally Binding Authoritative Statement of Principles For a Global Consensus on the Management, Conservation and Sustainable Development of all Types of Forests” (Forestry Principles) is for governments to contribute to the management, conservation, and sustainable development of forests, and to provide for their multiple and complementary functions and uses. The main emphasis of the principles is for governments to manage forestland on a sustainable basis to meet the social, economic, ecological, cultural and spiritual needs of present and future generations, including forest products and services, such as wood and wood products, water, food, fodder, medicine, fuel, shelter, employment, recreation, habitats for wildlife, landscape diversity, carbon sinks and reservoirs, and other forest products.

Since UNCED, many national and international initiatives have been launched to promote sustainable forest management. Amongst these, the most comprehensive and far reaching have been the Criteria and Indicators for Sustainable Forest Management (C&I). C&I are tools for assessing trends in forest conditions and forest management. They provide a common framework for describing, monitoring and evaluating progress toward sustainable forest management.

Over 100 countries have committed to one of the eight “processes” that have been developed in different regions of the world as follows:

- The International Tropical Timber Organization (ITTO) proposals.
- The Pan-European Helsinki Process (Helsinki Declaration)—38 Pan European Countries.
- The Montreal Process Working Group (Santiago Declaration)—12 non-European temperate countries.

- The Tarapoto Proposal—eight countries in the Amazonian Cooperation Treaty.
- The Central American Initiative of Luperón (seven Central American countries).
- The Dry Zone Africa Initiative—28 countries.
- The North Africa/Near East Initiative.
- The African Timber Organization (13 countries in Central Africa).

While each process has different numbers of C&Is to meet regional and national needs, all incorporate elements of the following seven criteria:

- Extent of forest resources.
- Biological diversity.
- Forest health and vitality.
- Productive functions of forests.
- Protective functions of forests (e.g., soil and water conservation).
- Socioeconomic benefits and needs.
- Legal, policy and institutional framework.

These criteria are being worked into current forest resource inventories and assessments.

3.4 Convention on Biodiversity Conservation

The “United Nations Convention on Biological Diversity” is developed to ensure effective mechanisms to halt the destruction of biological species, habitats, and ecosystems. The goals of the convention are the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the use of genetic resources, by mechanisms including appropriate access to genetic resources, appropriate transfer of relevant technologies, considering all rights over those resources and to technologies, and appropriate funding.

3.5 Convention on Climate Change

The “United Nations Framework Convention on Climate Change” has the goal to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Governments should achieve such a level within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

The tracking of changes in vegetation cover is implied in this convention. Vegetation cover, such as forests, serves as sinks of carbon dioxide and as reservoirs in the form of biomass. Loss of vegetation cover thus increases the level of greenhouse gases in the atmosphere. Maintaining or increasing vegetation cover, especially the forest cover, can help to mitigate climate change, both by preventing emissions, and by sequestering the carbon content of standing vegetation crops and forests.

3.6 Convention on Desertification

The objective of the “United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification Particularly in Africa” is to combat desertification and mitigate the effects of drought through effective action at all levels. Like the other conventions, monitoring of vegetation is required.

Information gathered from UNCED or from the Conventions is to be reported to and monitored by either the United Nations Commission on Sustainable Development (UNCSD) or by the Conference of the Parties (COP) in the case of the Conventions. Information relating to forests generally comes from national forest inventories, global forest resource assessments and global assessments of forest cover.

3.7 Digest

Forests are important to humanity. With growing human populations, the concern to preserve yet increase production of forest goods and services has increased. The Earth Summit emphasized the importance of the forest resource.

Since 1992, the need for forest information beyond timber production has increased—with reference both to the protection of forests and to sustainable development. These new information needs need to be included in national inventories and forest assessments at the global level.

There are two types of assessments—forest resource assessments and assessments of forest cover—both provide the basic data decision-makers need in the modern environment:

- **Global Forest Resource Assessments (FRA).** These are an evaluation of the worldwide forest resource base—amount, type, availability, and extent. National-level forest inventories provide the basic resource information for the assessments. FAO and the United Nations Economic Commission for Europe (UN/ECE) conduct the Global Forest Resource Assessments. These are most important both for national and for global planning. The 2000 FRA was recently published. in 2001.
- **Global Forest Cover Assessments (GFCA).** This is a mapping effort derived to determine the extent and location of existing world forests to establish a base for monitoring changes. These are generally conducted by space agencies and non-governmental organizations (NGOs).

The two types of assessments are described in Section 4 and Section 5.

4. Global Forest Resource Assessments (FRA)

Current global forest resource assessments focus on land use, and are the most detailed and important worldwide studies carried out to date. They are conducted by the FAO Forestry Department and by the Timber Section of the UN/ECE. The FRAs generally use an aggregation technique.

Data are acquired locally (nationally), adjusted to a common standard, and then summarized for global statistics. This process has certain advantages and limitations.

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Biographical Sketch

H. Gyde Lund currently runs a small international consulting firm - "Forest Information Services" - specializing in networking, web and library searches, literature synthesis and report writing plus technical support in resource inventories and assessments. Prior to becoming a consultant, Mr. Lund worked for nearly 40 years with the U.S. Federal Government in the field of forest resource inventories and assessments. His last position with the USDA Forest Service was as the International Resource Assessment Liaison, providing technical backstopping to the USFS international forestry and research staffs in the fields of remote sensing, GIS, resource inventory and monitoring. In the same position, Mr. Lund served as an expert on numerous United Nations task forces dealing with land classification and global assessments.

He has nearly 200 published papers and reports on resource inventory and assessment. Mr. Lund holds forestry degrees from Utah State University and the University of Washington. He is a Fellow of the Society of American Foresters and a member of the International Society of Tropical Foresters, the International Union of Forestry Research Organizations, and the Global Association of On-line Foresters.