Global forest land-use change from 1990 to 2005

Initial results from a global remote sensing survey

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A new remote sensing survey provides improved estimates of changes in global forest land-use area

The essential role of forests as providers of wood, food, medicinal products and environmental services at the local, regional and global levels is better appreciated now than ever before. In many places, however, even basic information on forest area is still lacking or unreliable.

The use of satellite imagery can substantially improve knowledge on changes in forest area as a result of deforestation, afforestation and natural forest expansion. This summary outlines some of the initial findings on forest land use and land-use change of a global remote sensing survey carried out to complement the country reporting process as part of the Global Forest Resources Assessments led by the Food and Agriculture Organization of the United Nations (FAO). This Survey was conducted by a partnership between FAO and its member countries, the European Commission Joint Research Centre (JRC), South Dakota State University, the United States Geological Survey (USGS) and the US National Aeronautics and Space Administration (NASA).

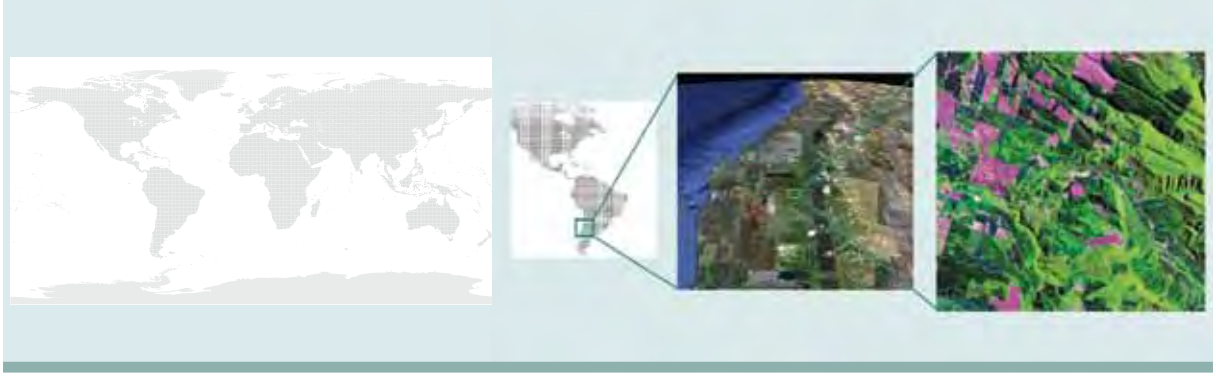
SURVEY METHODOLOGY

A systematic sampling design delivers globally consistent, statistically reliable results

A grid sampling design was used involving sites located at the intersection of each degree of longitude and latitude (Figure 1). Globally, the survey involved over 13 000 sample sites approximately 100 km apart. No sample sites were located at latitudes higher than 75 degrees north or south where there are few trees. At most sites (see full report for exceptions) the area surveyed was 10 km x 10 km, providing a sampling intensity of about one percent of the global land surface.

FIGURE 1

The global 1-degree sampling grid, zooming to a sample of Landsat imagery in South America



Best-available Landsat satellite imagery was used to track change in forest area

Most of the data was provided by the USGS Landsat Global Land Survey, which comprised the best Landsat satellite images acquired closest to the target years of 1990, 2000 and 2005. Landsat imagery was used as the primary source of data because its global coverage, long time series, spectral characteristics and 30 m spatial resolution made it suitable for the detection of tree cover and change in tree cover over time. Image samples were classified to land cover and land use using an automated, supervised approach. Nearly 7 million polygons were analyzed at each time interval to enable detection of forest area, forest gains and forest losses 5 hectares or greater in size.

Forest land use and land-use change reported

Land cover is the observed biophysical properties of the land surface, whereas land use is defined by the human activities and inputs on a given land area. This brochure summarizes changes in forest land use. Changes in land cover are explored elsewhere.[1]

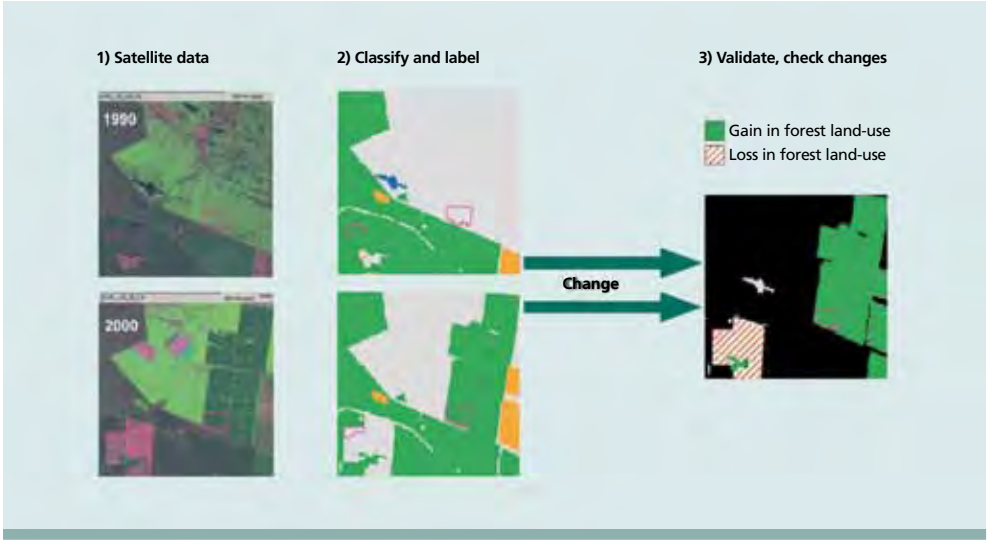
Treating forest as a land use is consistent with the forest definition used in FAO's Global Forest Resources Assessment country reports and national reports to the United Nations Framework Convention on Climate Change (UNFCCC). Forest land use may include periods during which the land is devoid of tree cover, for example during cycles of forest harvesting and regeneration. In such cases, a land use is considered to be forest land use when management or natural processes will, within a reasonable time, restore tree cover to the point where it constitutes a forest. Figure 2 shows a simplified example of the main steps used in processing Landsat data for 1990 and 2000 to determine land use and changes in land use.

National experts in over 100 countries reviewed data

The automated draft maps of the sample areas were reviewed by over 200 national experts in 106 countries. The review process helped improve results and also helped introduce new remote sensing tools in countries where remote sensing methods were not well developed.

FIGURE 2

Determining forest land-use change from satellite imagery



[1] See background material and forthcoming papers, which will be available at www.fao.org/forestry/fra/remotesensingsurvey/en/.

SURVEY RESULTS

The area in forest land use declined between 1990 and 2005

The survey shows the total forest area[2] in 2005 was 3.69 billion hectares, which is 30 percent of the global land area. Table 1 shows that there was a net reduction in the global forest area between 1990 and 2005 of 72.9 million hectares.

Just over half the world's forests are in tropical or subtropical climatic domains

The spatial location of the samples enables the results to be presented by six regions (Figures 3 and 4) and by five major climatic domains (Figure 5). The world's forests are distributed unevenly with just under half the world's forests in the tropical domain (44% of total area), about one third in boreal (34%) and smaller amounts in temperate (13%) and subtropical (9%) domains (Figure 6).

Forest loss and gains estimated at a global scale

Worldwide, the gross reduction in forest land use caused by deforestation and natural disasters (14.2 million hectares per year between 1990 and 2000 and 15.2 million hectares per year between 2000 and 2005) was partially offset by gains in forest area through afforestation and natural forest expansion (10.1 million hectares per year between 1990 and 2000 and 8.8 million hectares per year between 2000 and 2005). This resulted in net losses of 72.9 million hectares of forests over 15 years between 1990 and 2005.

The annual net conversion from forest land use to other land uses averaged 4.9 million hectares per year over the 15-year period. The rate of net forest loss increased from 4.1 to 6.4 million hectares per year between 1990 to 2000 and 2000 to 2005, respectively (Table 2).

There were important regional differences in forest loss and gain

Figure 7 shows notable regional differences in the rate of change in forest area. The highest rate of forest conversion to other land uses in both periods was in South America, followed by Africa. Asia was the only region to show net gains in forest area in both periods consistent with the extensive planting that has been reported by several countries to be larger in area than the regional losses in area of natural forests.

TABLE 1

Global forest area (1 000 ha), 1990, 2000 and 2005

	Mean	Lower limit*	Upper Limit*
1990	3 767 000	3 683 000	3 850 000
2000	3 726 000	3 643 000	3 808 000
2005	3 694 000	3 611 000	3 776 000

* *Note:* Lower and upper limit represent the 95% confidence interval[3].

[2] The estimates and discussion refer to changes in the area of forest land use, but for convenience the term 'land use' is omitted.

[3] A confidence interval indicates the range of values within which the average may lie based on extrapolating the sample to the population and does not include other potential sources of error.

FIGURE 3

Map of the six regions used in this survey

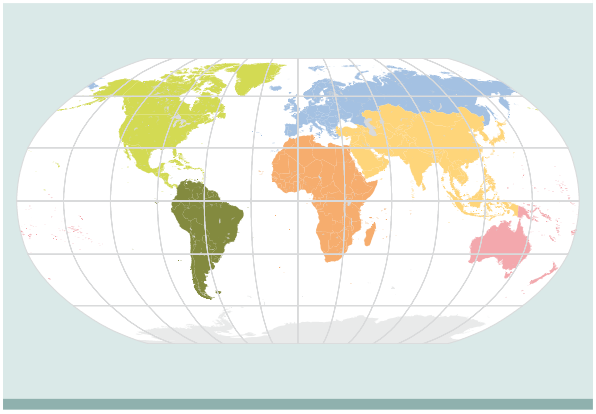


FIGURE 4

Distribution of global forest area (2005) by region

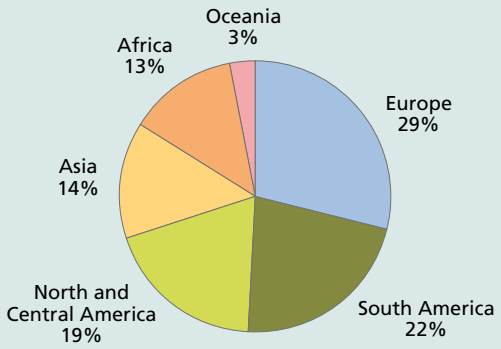


FIGURE 5

Map of the five broad climatic domains

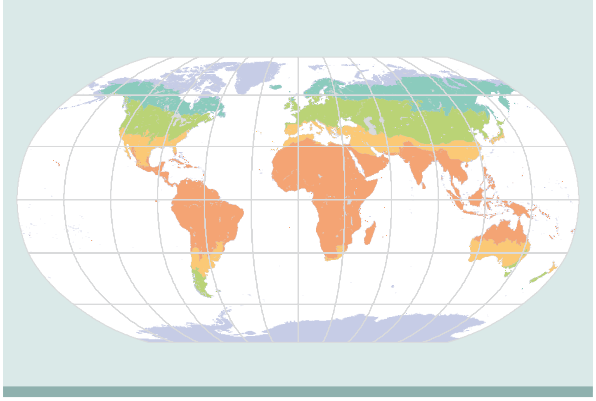


FIGURE 6

Distribution of global forest area (2005) by climatic domain

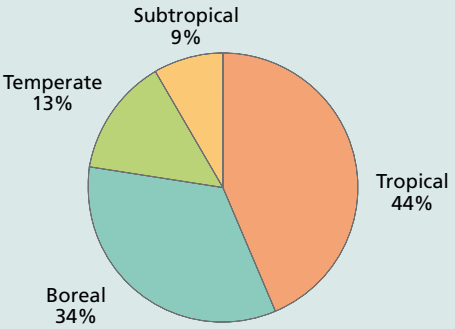


TABLE 2

Global forest area change (1 000 ha/yr), 1990–2000 and 2000–2005

	Mean	Lower limit*	Upper Limit*
1990–2000	-4 100	-5 300	-2 900
2000–2005	-6 400	-8 000	-4 700

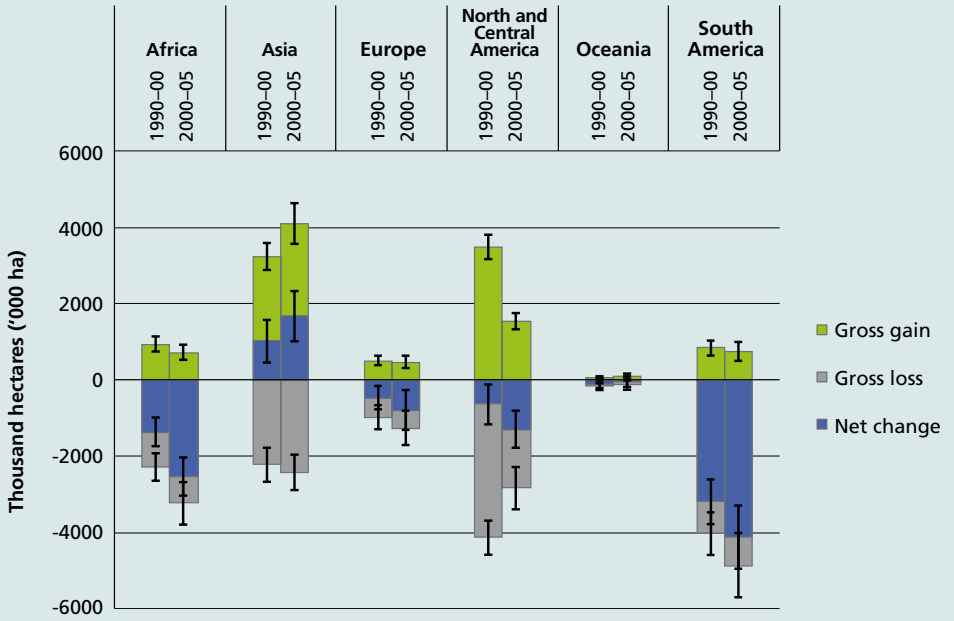
* *Note:* Lower and upper limit represent the 95% confidence interval.
The total forest area used in these tables is based on the 13 057 samples representing the land area with good sample data and excludes Antarctica, and the polar ecological zone where there are no or few trees.

Forest loss was highest in the tropics and there were slight net gains in other climatic domains

Net forest loss was highest in the tropical ecological domain in both time periods (Figure 8), going from 6.3 million hectares per year in the 1990s to 8.0 million hectares per year between 2000 and 2005. Three climatic domains – subtropical, temperate and boreal – appeared to have had slight net increases in forest area in both periods, although these were not always significant at the 95% confidence interval level.

FIGURE 7

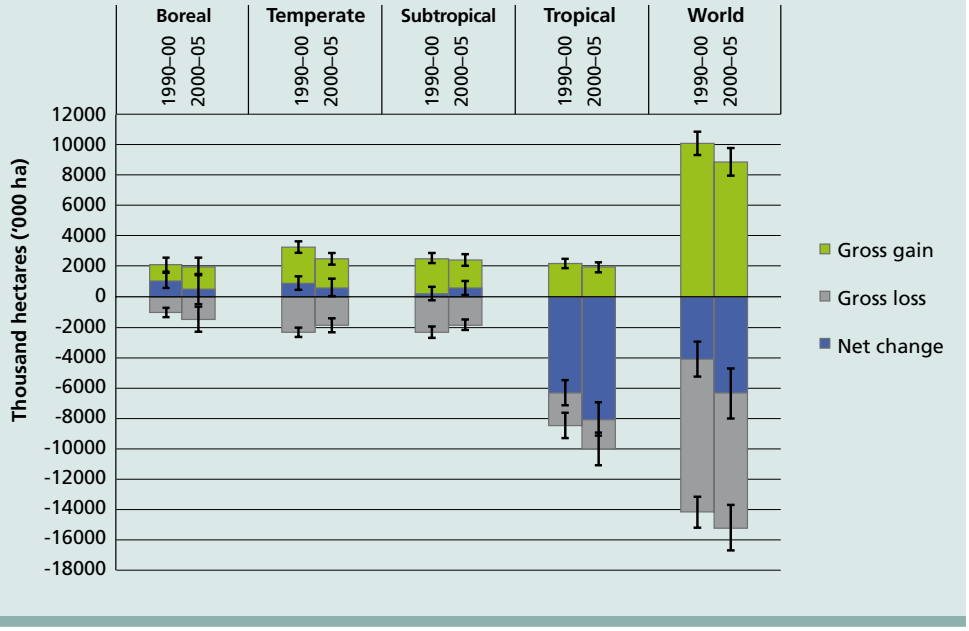
Annual change in forest land-use area (1990–2000 and 2000–2005) by region



Note: Note the net result (blue) is the result of the sum of the gross gains minus losses. A negative net result indicates overall forest conversion to other land uses.

FIGURE 8

Annual change in forest area (1990–2000 and 2000–2005) by climatic domain



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COMPARING THE REMOTE SENSING SURVEY AND THE GLOBAL FOREST RESOURCES ASSESSMENT 2010 RESULTS FOR FOREST AREA

The remote sensing survey estimates of global forest land use and changes are different from the FAO Global Forest Resources Assessment 2010 (FRA 2010) estimates. This is because they come from two very different sources – the FRA reporting comes from compiling country reports and the numbers reported in this document from remote sensing that is more consistent globally and across the three time periods. The FAO Global Forest Resources Assessment (FRA 2010) estimated the total global forest area in 2005 at 4.06 billion hectares, compared with the remote sensing survey estimate of 3.69 billion hectares, a difference of about 9 percent, which is a good result considering the differences in methods.

On the other hand, the FRA 2010 reported a substantially higher net loss in forest area from 1990-2005 (107.4 million ha) than found in the remote sensing survey (72.9 million ha) or a difference of 32 percent. FRA 2010 suggested that the rate of net forest loss decreased in the period 2000–2005, while the remote sensing survey detected an increase in rate. The largest difference between the two assessments was in Africa where most countries still have very old data and were most often from forecasts, which reduces the accuracy of change estimates. Furthermore, neither assessment approach is suited to accurate assessment of tree cover at lower canopy cover densities (e.g. between 10 and 30 percent canopy cover). This introduces some uncertainty in the accuracy of numbers – particularly in dry regions and for degraded forests.

Overall, for changes in forest land use area, the use of remote sensing has the advantage of consistency in data and methodology and this survey has been specifically designed to detect and report on forest area changes at a global, regional and ecological zone scale. It complements the country-based FRA process, which collects a wide range of other information that is also needed to monitor and report on the worlds forests. Importantly, the remote sensing survey provides information on changes in forest land use in different climatic domains - something which is currently impossible to obtain from a compilation of national data.

The methods developed through the remote sensing survey will be used to improve the measurement and reporting of forest area and change in forest area over time as part of the continual improvement of the FRA process and can be adapted for use at national scales. These results can be an important input to national and international reporting processes where forest area and change statistics are needed such as the Convention for Biological Diversity and the emerging initiative for Reducing Emissions from Deforestation and Forest Degradation in Developing countries (REDD+) under the UN Framework Convention on Climate Change.

Global Forest Resources Assessment

For more information on FRA, please go to
www.fao.org/forestry/fra or contact fra@fao.org
More information on the remote sensing survey, including the full report,
is available at www.fao.org/forestry/fra/remotesensingsurvey/en/.

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The views expressed herein can in no way be taken to reflect the official
opinion of any of these governments or organizations.

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