Global trends and outlook for forest resources

Introduction

The management and use of forest resources varies greatly across the World, depending on factors such as the amount and type of forests present in a country, local social and economic circumstances, history, traditions and government policies both within and outside the sector. Furthermore, forest management and use continue to evolve over time in response to changes in these external factors as well as changes in the characteristics of the resource.

Forest management is also complex because forests can produce such a wide variety of goods and services. Many of these outputs can be produced simultaneously, but often there are also trade-offs between them, especially between the commercial and non-market outputs from forests. While the demands for these outputs varies between countries and over time, it is probably true to say that they are mostly increasing, leading to ever more complicated and difficult decisions for forest managers and policymakers wishing to satisfy these competing demands.

This chapter will focus on some of the social and economic dimensions of forest management and use and describe how they have affected forest resources in the past and may affect them in the future. This will include a discussion of how policies and extra-sectoral developments affect forests and forest management and, in particular, a discussion of how forest management may adapt to changing circumstances in the future.

The chapter is divided into three sections examining the trends in forest management and use and the driving forces affecting forests, then concluding by presenting a tentative outlook for the future. It will examine developments at the global level, so the analysis will be broad and not necessarily apply to all countries. It will, however, examine differences between regions and groups of countries where that is useful.

Trends in forest management and use

Since the mid-1980s, the Food and Agriculture Organization of the United Nations (FAO) has been systematically collecting information about the trends and current status of forest resources in every country in the World. Gradually, the amount of information collected in each global Forest Resource Assessment (FRA) has expanded to cover many different and diverse measures of the extent of forest resources, their characteristics and information about how they are managed and used. The results of these assessments (plus information from other sources) are presented below to highlight some of the most significant changes in forests that have occurred since the 1980s.

Forest area and characteristics

Table 1 shows recent trends in the area of forests at the global level and in each of the five main regions of the World. At present, forests cover slightly more than 4 billion ha (equal to 31 percent of the global land area). An additional 1.1 billion ha (nine percent of the land area) is classified as "other wooded land" (for details of the definitions used in the FRA, see FAO, 2007).

About 25 percent of the global forest area is located in Europe (including the Russian Federation) and another 22 percent is in Latin America and the Caribbean. These two regions also have the highest levels of forest cover (44 percent and 48 percent respectively). The remaining area is divided roughly equally between North America (Canada, Mexico and the United States of America), Africa and the Asia-Pacific region, but these three regions have lower and quite different levels of forest cover (at 31 percent, 22 percent and 19 percent respectively).

Table 1 Recent trends in forest area

Region	Forest area (m ha)			Change in forest area (%/yr)		
	1990	2000	2010	1980-90	1990-00	2000-10
Europe	989	998	1,005	0.0	0.1	0.1
North America	677	677	679	0.0	0.0	0.0
Africa	749	709	674	-0.7	-0.6	-0.5
Asia-Pacific	775	769	784	-0.3	-0.1	0.2
Latin America and Caribbean	978	933	891	-0.7	-0.5	-0.5
WORLD	**4,168**	**4,085**	**4,033**	**-0.4**	**-0.2**	**-0.1**

Source: FAO (1995, 2010a). Note: the 1980-90 change in forest area is calculated using slightly different definitions to the later figures. Mexico is included as part of North America.

At the global level, forest area has declined over each of the last three decades, but this decline appears to have slowed over the period. This is partly because levels of deforestation have reduced in a number of countries, but it also reflects an expansion of forest area (mostly due to afforestation) in other countries.

The changes in forest area in each of the five main regions are very different, but all show that the trends are gradually improving. Forest area has declined in Africa and Latin America and the Caribbean, but the loss of forest each decade has become smaller. Conversely, forest area has increased slightly in Europe and North America over the last three decades. The Asia-Pacific region is unique in that the change in forest area has reversed from a loss in earlier decades to an increase in the period 2000 to 2010.

Table 2 Forest characteristics in 2010

Region	Primary forest		Other naturally regenerated forest		Planted forest		Not specified	Total
	(m ha)	(%)	(m ha)	(%)	(m ha)	(%)	(m ha)	
Europe	262	26	669	67	69	7	4	1,005
North America	275	41	366	54	38	6	0	679
Africa	48	7	437	65	15	2	174	674
Asia-Pacific	145	19	510	65	127	16	2	784
Latin America and Caribbean	629	71	199	22	15	2	48	891
WORLD	**1,359**	**34**	**2,182**	**54**	**264**	**7**	**229**	**4,033**

Source: FAO (2010a). See FAO (2007) for definitions of the different forest characteristics.

The FRA also asks countries about the area of forests in three different categories: primary forest; other naturally regenerated forest; and planted forest. The latter two categories also each have a sub-category for the area where introduced species predominate. These forest characteristics represent, in a simple way, the degree to which forests have been altered by humans (e.g. no major indications of human activities in natural forest and, at the other end of the scale, trees established by planting or deliberate seeding in planted forests).

Globally, just over half of the World's forests fall into the middle category and about a third of the area is classified as primary forest (see Table 2). Planted forests amount to only about seven percent of the total and a similar amount is unclassified. At the regional level, forest characteristics in Europe, North America and the Asia-Pacific region are quite similar to the global average, although the Asia-Pacific region has a relatively large area of planted forest and a small proportion of primary forest. In Africa, most forest is in the middle category, indicating that very little primary forest remains and that there has also not been much investment in forest plantations. By far the largest area of primary forest is located in Latin America and the Caribbean (i.e. the Amazon Basin).

Historical figures for the area of primary and planted forests have also been provided by most countries and, from these, the area of other naturally regenerated forest can be deduced. Changes in the area of each of these are shown in Table 3. As this table confirms, the change in total forest area is a combination of changes (mostly losses) in primary and other naturally regenerated forest and increases in the area of planted forest. In particular, outside Europe and North America, the other three regions show losses of primary forest that are higher than the global average. The area of planted forest is increasing in all regions, with quite a high growth rate. However, this only has a significant impact on the overall change in forest area in the Asia-Pacific region, where planted forests are relatively important.

Table 3 Change in forest area (percent per year) by forest characteristics and region

Region	Primary forest		Other forest		Planted forest		All forest	
	90-00	00-10	90-00	00-10	90-00	00-10	90-00	00-10
Europe	0.7	-0.1	-0.2	0.1	1.0	0.6	0.1	0.1
North America	0.1	0.1	-0.2	-0.1	3.9	1.9	0.1	0.1
Africa	-1.2	-1.0	-0.6	-0.6	1.1	1.8	-0.6	-0.6
Asia-Pacific	-0.2	-0.5	-0.6	-0.1	2.0	2.8	-0.1	0.3
Latin America and Caribbean	-0.5	-0.5	-0.5	-0.6	2.8	4.3	-0.5	-0.4
WORLD	**-0.2**	**-0.3**	**-0.4**	**-0.2**	**1.9**	**2.1**	**-0.2**	**-0.1**

Source: FAO (2010a). Note: this data only covers countries reporting area of primary and planted forests over the whole period.

In addition to forest area, the quality or condition of forests is another important dimension that should be examined when looking at trends in forest resources. However, changes in this dimension (most commonly referred to as "forest degradation" - i.e. for a negative change in condition) are very difficult to define and measure. For example, Lanly (2003) noted a decade ago that many studies of forest degradation have used imprecise and often subjective interpretations of the term that make it difficult to analyse trends and examine the causes and effects of such changes.

There have been a few global assessments of land degradation that have followed rigorous scientific methodologies (e.g. Bai *et al*, 2008) and these show where the amount of vegetation has changed over time. However, they do not separate changes in forest cover from changes in the condition of forests and they do not examine other important aspects of forest degradation, such as losses of biodiversity, productivity and ecosystem functions.

The FRA does not collect data on forest degradation, but FAO has reviewed the many existing definitions, measures and indicators (FAO, 2011a), with a view to collecting comparable data in the future. One partial indicator of the condition of forest resources is the growing stock volume per hectare and some countries do report their growing stock volume to the FRA as well as forest area (so this can be calculated). However, in some cases, it appears that countries simply calculate growing stock volume in each year as the forest area multiplied by a single figure (i.e. their estimate of volume per hectare), rendering these figures useless for assessing trends in forest stocking.

The countries that do seem to provide independent estimates of forest area and growing stock are mostly temperate countries and in many of them growing stock per hectare appears to be increasing. A similar trend since 1950 was also noted for most European countries in first European Forest Sector Outlook Study (EFSOS) published in 2005 (Gold, 2003; UN 2005). Similarly reliable and comprehensive information is not available for most tropical countries, but it is commonly thought that forest degradation or a decline in volume per hectare is the most likely trend in many of these countries.

Forest management

Since the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, sustainable forest management (SFM) has been the aim of forestry policymakers all over the World. SFM follows the broad principles of sustainable development, in that forests should be managed in a way that meets the needs of the present without compromising the ability of future generations to meet their needs. SFM is an extension of the much earlier concept of sustained yield familiar to most foresters and first described 300 years ago in Germany (Grober, 2007). However, it is concerned with sustaining the social, environmental and economic values or outputs from forests rather than just timber yields (for one commonly accepted definition of SFM, see: MCPFE, 1993).

Box 1 Criteria and indicators for sustainable forest management

The three main systems for measuring progress towards SFM at the national level are as follows:

- **Criteria and indicators for the sustainable management of tropical forests.** These were developed by the International Tropical Timber Organization (ITTO) and issued in 1992, with revisions in 1998 and 2005 (ITTO, 2005). They cover all ITTO producer countries (most major producers of forest products in the tropical zone). The indicators are used, amongst other things, to produce periodic assessments of how much of the permanent forest estate in the tropics is sustainably managed (ITTO, 2011).
- **Pan-European indicators for sustainable forest management.** These were developed by the Ministerial Conference on the Protection of Forests in Europe (MCPFE - now renamed "Forest Europe") and issued in 1994, with a revision in 2002 (MCPFE, 2002). They are used in 46 European countries including Turkey and the Russian Federation (which is also included in the Montréal Process). Reports are produced periodically showing progress under each criterion and indicator for individual countries and European sub-regions (Forest Europe, 2011).
- **Montréal Process criteria and indicators for the conservation and sustainable management of temperate and boreal forests.** These were first issued in 1995, with revisions in 2007 and 2009 (Montréal Process, 2009). They are used in 12 countries accounting for the majority of temperate and boreal forests outside Europe.

Each system contains a number of criteria that describe different aspects of sustainability in the economic, social or environmental dimension and, for each criteria, one or more indicators. These indicators attempt to measure performance of the forestry sector over time against each of the criteria.

To assess progress towards SFM, a number of different organisations have developed methodologies (criteria and indicators) for measuring the multiple values or outputs from forests. There are currently nine different international processes working on criteria and indicators, with some of them working at the national level while others are applied at the level of forest management units (e.g. for forest certification).

At the national level, most of the World's forests are now covered by one of the three main sets of criteria and indicators (see Box 1). However, there are still many challenges with respect to measuring sustainability in the sector, including the following:

- **Data quality:** the quality and availability of data required to measure some of the indicators is limited, particularly in terms of how recently data has been collected (e.g. a lot of information about forest resources is collected in forest inventories that may not be updated very frequently). Furthermore, some of the indicators that appear to be most valid are also the ones where it seems to be most difficult to obtain recent and reliable data.

- **Measurement at the global and regional level:** the three main national criteria and indicator systems currently cover 90 countries, but this is still only about half of the countries in the World. In particular, these systems cover very few small island states and arid zone countries (e.g. in North Africa, the Near East, Central Asia and South Asia) and a few significant countries, such as India and South Africa, are not included under the three main systems. In addition, due to the different indicators used in each system, many of the measures are not directly comparable and can not be aggregated to give a regional or global assessment.

- **Measurement validity:** in a number of areas, criteria and indicators measure inputs rather than outputs (e.g. the proportion of a country's forest area covered by management plans, the proportion of area managed for different purposes or designated as protected areas). These indicators may be a good proxy for achievement in some cases, but some of them are quite subjective and may not reflect real achievements in progress towards SFM on the ground. A related problem is that it is not always clear whether an increase in some of the measures reflects an improvement in performance or not. This is particularly the case with some of the social indicators (where changes may occur due to external factors) and it is somewhat ambiguous whether, say, an increase in collection of non-wood forest products represents an improvement in social welfare. Similarly, the economic indicators that measure the value of production may reflect changes in market conditions much more than changes in the way that forests are managed.

- **Aggregation and comparison across indicators:** one final issue concerning the utility of criteria and indicators is that they can not easily be aggregated to give an overall measure of progress in a country.[1] Reflecting the fact that forests produce multiple outputs, they have been specifically designed to try to capture progress in the different dimensions of SFM, but this makes it very difficult to communicate the results to non-specialists. They also do little to help assess trade-offs or provide an overall picture of whether forests are being managed more sustainably or not. For example, forest area in a country may be declining at the same time as many other indicators appear to be improving, but there would probably be little agreement about whether such a country was making progress towards SFM or not.

The FRA also presents information about progress towards SFM in seven thematic areas: extent of forest resources; biodiversity; forest health; productive, protective and socio-economic functions (three separate elements); and legal, policy and institutional frameworks. While many of the issues described above also apply to the information presented in the FRA, there is agreement that these thematic elements broadly cover the main aspects of SFM measured in the various criteria and indicator processes (FAO, 2004; UN, 2008) and the data collected in the FRA attempts to cover every country in the World.

Table 4 Progress towards sustainable forest management at the global level, 1990–2010

Thematic element	FRA 2010 variables and data availability		Annual change rate (%)				Annual change		Unit
			1990–00		2000–10		1990–00	2000–10	
Extent of forest resources	Area of forest	H	+/-	-0.20	+/-	-0.13	-8,323	-5,211	1,000 ha
	Growing stock of forests	H	+/-	0.13	+/-	0.14	n.s.	n.s.	m3/ha
	Forest carbon stock in living biomass	H	+/-	-0.18	+/-	-0.17	-538	-502	million t
Forest biological diversity	Primary forest area	M	+/-	-0.40	+/-	-0.37	-4,666	-4,188	1,000 ha
	Area for biodiversity conservation	H	++	**1.14**	++	**1.92**	3,250	6,334	1,000 ha
	Forest area within protected areas	H	++	**1.09**	++	**1.97**	3,040	6,384	1,000 ha
Forest health	Area of forest area affected by fire	M	--	**-1.89**	--	**-2.15**	-345	-338	1,000 ha
	Forest area affected by insects	L	--	**-1.88**	--	**-0.70**	-699	-231	1,000 ha
Productive functions	Area for production	H	+/-	-0.18	+/-	-0.25	-2,125	-2,911	1,000 ha
	Planted forest area	H	++	**1.90**	++	**2.09**	3,688	4,925	1,000 ha
	Wood removals	H	+/-	-0.50	++	**1.08**	-15,616	33,701	1,000 m^3
Protective and socio-economic functions	Area for soil and water protection	H	++	**1.23**	++	**0.97**	3,127	2,768	1,000 ha
	Privately owned forest area	H	++	**0.75**	++	**2.56**	3,958	14,718	1,000 ha
	Value of wood removals	M	+/-	-0.32	++	**5.77**	-241	4,713	million $
	Forestry employment (FTE)	M	--	**-1.20**	+/-	-0.11	-126	-10	1,000
Policy and institutional framework	Forest area with management plan	M	++	**0.51**	++	**1.07**	6,964	15,716	1,000 ha
	Staff in public forest institutions	L	--	**-1.94**	+/-	0.07	-23,568	830	number
	Students graduating in forestry	L	++	**15.67**	++	**8.83**	4,384	4,081	number

Source: FAO (2010a). Notes: H/M/L (high/medium/low) indicates that countries providing data for a variable represent 75-100, 50-74, or 25-49 percent of the global forest area and the symbols (++, +/-, --) indicate whether each variable has increased or fallen by more than 0.5 percent (++ or --) or within the range of +/- 0.5 percent.

Table 4 presents the global results from the FRA for the last two decades, with an assumption that an average annual change of more than 0.5 percent represents a major change in an indicator (where this occurs, the figures in the table are shown in bold). As the table shows, there have been major increases in the areas of forests where biodiversity conservation and soil and water protection are the main management objectives, areas affected by fires and insects have declined significantly, protected areas in forests and the area of privately owned forests has increased, as has the area of forests covered by management plans.

1 The one exception to this is the ITTO indicators, where the ITTO reports the area of tropical forests that is sustainably managed (although it is somewhat unclear how the indicators are used to arrive at the final figures presented in their reports).

Two of the variables reflecting the extent of forest resources show a negative trend and the area of primary forests has also declined, although these changes have been less than 0.5 percent per year over the period. Employment and staffing of public forest administrations has also declined significantly, but the number of students graduating in forestry has increased a lot.

As noted previously, it is difficult to say from this evidence whether there has been significant progress towards SFM at the global level, other than to say that many aspects of forest management appear to have improved significantly while a few have not improved.

Forest uses

One important subset of information collected in the FRA is the extent to which forests are used for different purposes. In the FRA, this is referred to as the *"primary designated function"*, which is defined as follows:

> *The primary function or management objective assigned to a management unit either by legal prescription, documented decision of the landowner or manager, or evidence provided by documented studies of forest management practices and customary use.* (FAO, 2007).

Although this definition is partly based on the management objective for an area of forest (rather than its actual use), it can be assumed that the main use of a forest and its management objectives are closely aligned. Therefore, it should give a rough indication of the relative importance of different forest uses over time and, possibly, between countries and regions. However, it should also be noted again that this is an indicator of inputs rather than outputs, so it does not capture the intensity of use. It will also not reflect the importance of some forest uses that can be significant even if they are not the main focus of management (e.g. forest recreation or soil and water protection in forests managed for production).

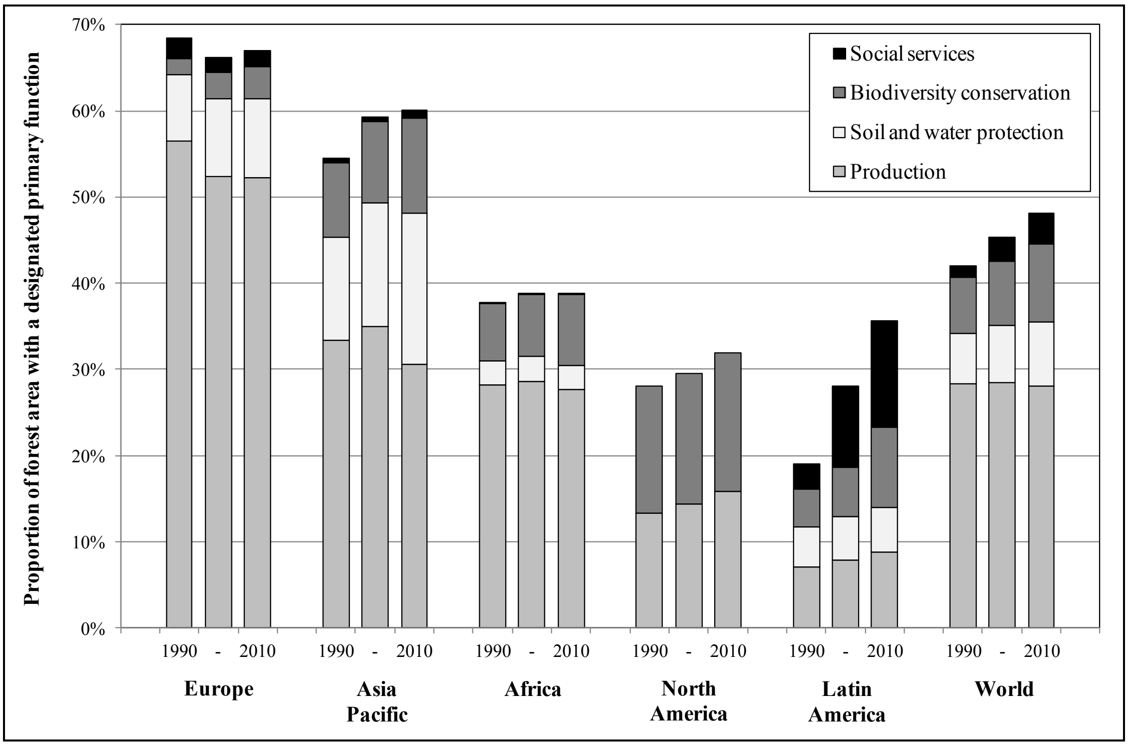
Information is collected in the FRA about the area of forests managed in a country for each of the following primary designated functions:

- **Production:** Forest areas designated primarily for production of wood, fibre, bioenergy and/or non-wood forest products (including subsistence collection of these products).
- **Biodiversity conservation:** Forest areas designated primarily for conservation of biological diversity including (but not limited to) forests in legally protected areas.
- **Soil and water protection:** Forest areas designated primarily for protection of soil and water, including: areas where there are specific restrictions aimed at maintaining tree cover or not damaging vegetation that protects the soil; buffer zones to protect watercourses; areas with steep slopes where forest harvesting is restricted; and areas managed for combating desertification.
- **Social services:** Forest areas designated primarily for social services, including activities such as: recreation; tourism; education; research; and conservation of cultural or spiritual sites.

In addition to the above, countries may also report areas managed for other purposes or for multiple-uses (where no one management objective predominates), or they may report areas with no specific management objectives at all.

Figure 1 presents the trends in forest uses over the last two decades by region and at the global level. As the figure shows, production is the most significant use of forests in most regions and at the global level (accounting for 28 percent of the forest area in 2010). Production also accounts for over half of the total area designated for the four main functions in all regions except Latin America and the Caribbean. The proportions of the forest area used for soil and water protection and biodiversity conservation are similar at the global level (seven percent and nine percent respectively in 2010) and these are the next two most important functions. Apart from Latin America, very few countries report significant areas of forest designated for social services, with many countries stating that most of their forests are used for these purposes at the same time, as they are used for one of the other primary functions, or that areas designated as multiple-use forests are used for this purpose.

Figure 1 Primary functions of forests by region and at the global level, 1990-2010



Source: FAO (2010a).

The figure shows that the decline in the global forest area used for production (reported in Table 4) has also led to a slight decline in the proportion of forest used for production. However, it also shows that there are large differences between the regions in terms of the areas used for different functions and the trends in these variables.

The proportion of the forest area used for production in Europe, Asia-Pacific and Africa has fallen, but is still relatively high compared to the other two regions. Conversely, in North America and Latin America it has increased quite a lot, but from a low base. These increases are probably due to the rapid expansion of planted forests in some countries in these two regions (e.g. Brazil and United States of America). In addition, the relatively small areas designated for any primary function are because almost all forest in Canada is designated as multiple-use forest (87 percent in 2010) and only half of Brazil's forest (51 percent) has a clearly identified primary function.

The proportion of forests used for biodiversity conservation has increased over the last two decades at the global level and in all regions. The highest proportion is reported for North America (16 percent in 2010) and the region where this has increased the most is Latin America and the Caribbean (from four percent in 1990 to nine percent in 2010). The proportion managed for soil and water conservation has also increased slightly at the global level (from six percent to seven percent), although increases at the regional level have only occurred in Europe and the Asia-Pacific region. A number of countries (e.g. United States of America) reported that no forests are designated specifically for protection of soil and water, because this function is embedded in legislation governing the management of all forests. Thus, the importance of soil and water protection as a forest use is no doubt underestimated by these figures.

The FRA also collects information about the proportion of forests in legally designated protected areas and data was provided by 135 countries (covering 91 percent of the global forest area). Countries were asked to include only forest areas in protected areas falling under IUCN categories I-IV (Dudley, 2008), where the emphasis of management is protection of non-productive functions rather than sustainable use. These figures suggest that more than 10 percent of the total forest area is now in protected areas in most countries and regions (FAO, 2010a). This is less than the proportion of forest area managed for the three non-productive functions identified above (20 percent), because not all of these areas will be legally designated as protected areas. However, it suggests that non-productive uses of forests are sufficiently important to be protected by specific legislation and formal designation in many cases.

One final interesting observation about the areas reported for each designated function is the seemingly high proportion of the World's forests that are not clearly associated with one of the four specific uses or functions mentioned above. Approximately one-quarter of the global forest area is designated as multiple-use forest and another one-quarter falls into the other or unknown categories. In many countries, it appeared that some forest areas could be put clearly into the first four use categories and the remaining forest area was simply put into the three non-specific categories because of a lack of information. However, in others, specific justifications and information were provided about why some forest areas should be classified as multiple-use, other or unknown (see Box 2).

Based on the information about forest functions presented in the FRA, a number of more general observations about how forests are managed and used can be made:

- **Competing forest uses:** many countries were able to identify and report areas of forest used for production and biodiversity conservation with little ambiguity. This does not mean that areas used for one of these functions are not used for the other as well, but it does suggest that these two uses are to some extent mutually exclusive. For example, planted forests in almost all countries were designated for production (and where they weren't, they are mostly used for soil and water protection). Conversely, about half of the forest areas used for biodiversity conservation were in legally protected areas that generally place very strict limitations on any harvesting activities.

- **Compatible forest uses:** in some countries, part of the forest estate is specifically designated for soil and water protection, implying that this is so important that protection and production can be viewed as mutually exclusive uses. This was particularly true for arid and mountainous countries. However, many countries reported that soil and water protection was a basic requirement of forest management and reported no areas designated for this function. Even more countries made the same statement about forests used for social services. Thus, it appears that these uses are compatible with production and biodiversity conservation (and may even be complementary to the latter).

- **Management for multiple-uses or specialisation:** the FRA results also give an insight into different forest management philosophies around the World. For example, Canada reported very small forest areas used for production and biodiversity conservation and a huge proportion of the forest designated for multiple uses. A few other countries (Mexico, Norway, United States of America) also reported significant areas of multiple-use forest. At the other extreme, in New Zealand, almost all natural forest was designated for biodiversity conservation and almost all of the plantation area was designated as production forest (with a tiny amount for soil and water protection). This apparently strict and clear separation of function by forest type in New Zealand has developed over many years and after much public and political debate (Reid, 2001; Perley, 2003).

Box 2 Different approaches to the estimation of areas with primary designated functions

The FRA country reports show how countries classified their forests (in terms of designated functions), based on information about legal status, tenure, management objectives and ownership, as well as national forest inventory results and other literature. A summary of some of the approaches is as follows:

- **Australia:** Classification was based on tenure statistics and national forest inventory results. The forest plantation area was classified as production and the area of Nature Conservation Reserves was put in the biodiversity conservation category. Leasehold areas were classified as other and the relatively small areas of unresolved tenure were classified as unknown. All remaining forest was classified as multiple-use forest. Together, the non-specific designations (multiple-use, other and unknown) accounted for 84 percent of the total in 2010.
- **Brazil:** Based on the National System of Conservation Units and the Brazilian Forestry Code, 15 national designations were identified. Forest plantations and National Forests were classified as production, Permanent Preservation Areas were put in the soil and water protection category, Environmental Protection Areas were designated as multiple-use and other designated areas were put into the biodiversity conservation or social services category. Forest areas without any national designation were classified as unknown (49 percent of the total forest area).
- **Canada:** In Canada, forest area is divided into 25 classes of forest ownership and legal status. Most of the private industrial forest was classified as production and federal, provincial and territorial reserved forests were placed in the biodiversity conservation category. Most of the remaining forest was designated as multiple-use, with a relatively small amount placed in the unknown category. These last two classes accounted for 94 percent of the total in 2010.
- **China:** National forest inventories in China recognise 11 forest management functions and areas meeting each of these were reclassified into the FRA categories. In the data reported for 2010, 76 percent of the forest area was placed into one of the four specific categories used in the FRA and the remaining 24 percent was all classified as multiple-use forest.
- **New Zealand:** In New Zealand, classification into designated functions was based on forest ownership and forest type (planted or indigenous). All planted forest was classified as production and all state-owned indigenous forest was put into the biodiversity conservation category (for the year 2010). Most of the privately owned indigenous forest was also put into the biodiversity conservation category, with a small amount classified as production.
- **Russian Federation:** The Russian Forest Code (2006) divides the forest estate into three types: operational forests; protective forests; and reserve forests. For the FRA, operational forests were classified as production and the area of protective forests was divided into the other three specific designated functions and multiple-use forest. Reserve forests are forests in remote areas that are unlikely to be developed for at least another 20 years and these were all classified as other.
- **South Africa:** Forests in South Africa were divided into legally declared wilderness areas, forest plantations and other forest areas (calculated as the residual forest). The forest plantation area was classified as production, wilderness areas were placed in the biodiversity conservation category and the remaining area (71 percent of the total) was classified as multiple-use forest.
- **United States of America:** In the United States of America, none of the national systems used to classify forest land could be easily translated into the FRA categories, so a combination of data and assumptions was used to provide this information. All planted forests and a proportion of some natural forest types was classified as production. Several other types of forest were placed in the biodiversity conservation category and the remaining area (46 percent of the total) was classified as multiple-use forest..

Source: FAO (2010b).

Countries such as China, Vietnam and Russian Federation also appeared to have clearly defined forest areas for different uses, as did many West European countries. The latter result is, perhaps, surprising considering that Europe has a strong tradition of managing forests for multiple-uses (see, for example: CEC, 2006). For the European Union as a whole, only 16 percent of the forest area was designated as multiple-use and only Germany and Spain reported significant areas (and proportions) of forest with a multiple-use designation.

- **Planning for the future:** the significant area of forests where there are currently no clearly identified forest uses suggests that planning for their use will be an important task in the future. This is particularly true in countries where there are many pressures to convert forests to other land-uses. However, this lack of any designation also reflects a lack of information and weaknesses in the capacity of forest administrations in many cases. It seems likely that these countries should be a high priority for capacity building and technical assistance if they are to make further progress towards SFM.

Legal, policy and institutional trends

The FRA also presents information about trends in legal and policy frameworks and forestry institutions in countries. Although changes in these aspects are often more qualitative than quantitative, this information is useful for showing some other general trends in the way that forests and forest management have developed.

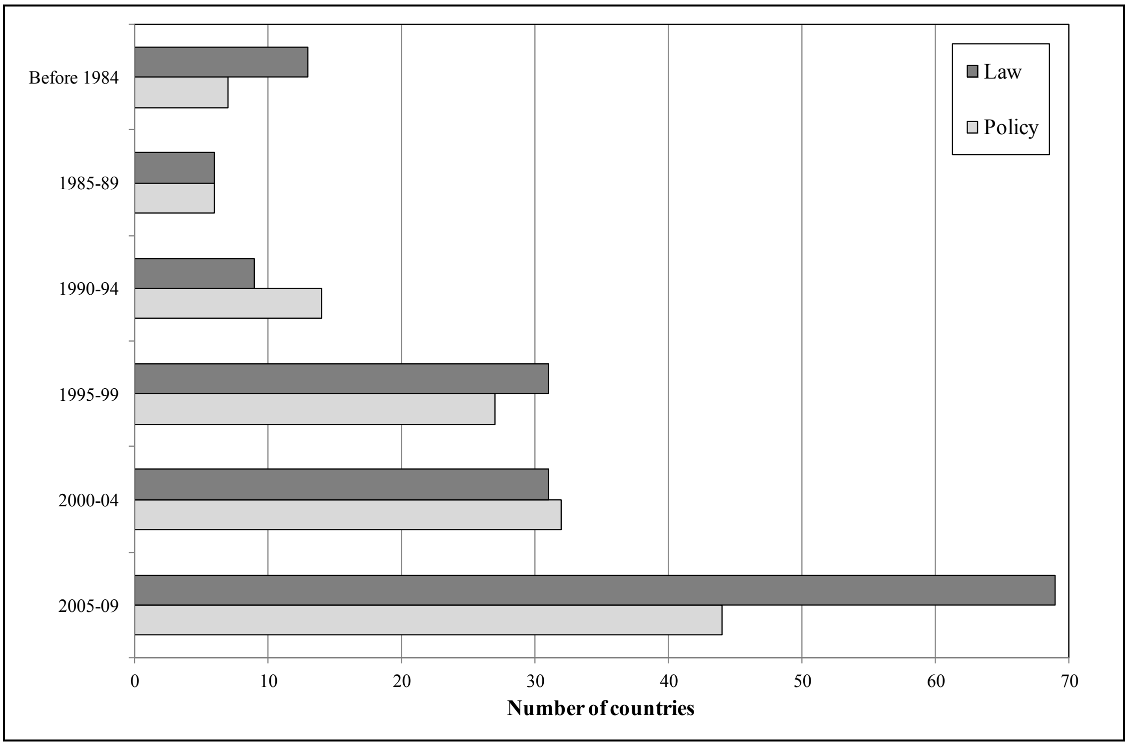
With respect to policies and laws, almost all countries have a national forestry policy (or regional policies in federated states) or a national forest programme. In fact, many countries have both. The main exceptions are the Russian Federation (which does not have a forest policy but does have a national forest programme) and Canada and United States of America (which have policies, but not national forest programmes - probably because they are federated states). In addition, almost all countries have some sort of legislation concerning forests (either a specific forest law or other laws that include forestry).

The FRA also shows that many countries have updated their forestry policies and laws quite recently. For example, about two-thirds of countries have enacted, issued or revised their forest policies and legislation in the last decade (see Figure 2) and three-quarters have developed national forest programmes during the same period. In many cases, these policies, laws and programmes have been developed or revised to take into account international commitments (such as the main environmental conventions on biodiversity, climate change and desertification) and to broaden the scope of policies and laws so that they more adequately reflect the aims of sustainable forest management. However, it is also worth noting that about ten percent of countries still have forestry policies and legislation that date from the 1980s or even earlier.

Another aspect of the legal and institutional framework for forest management is forest ownership and the related issue of who is actually managing forests. In the FRA enquiry, three ownership categories were used (public private and other) and countries were asked about the type of owners of private forest (individuals; businesses or institutions; and communities). For public forests, the FRA also asked about who holds the rights to manage and use forest resources (public administrations; individuals; businesses; communities; and other), because public forests are sometimes managed by non-state actors. This information can be combined to show roughly the proportion of forests that are managed by the state, the private sector and communities and this is shown in Figure 3.

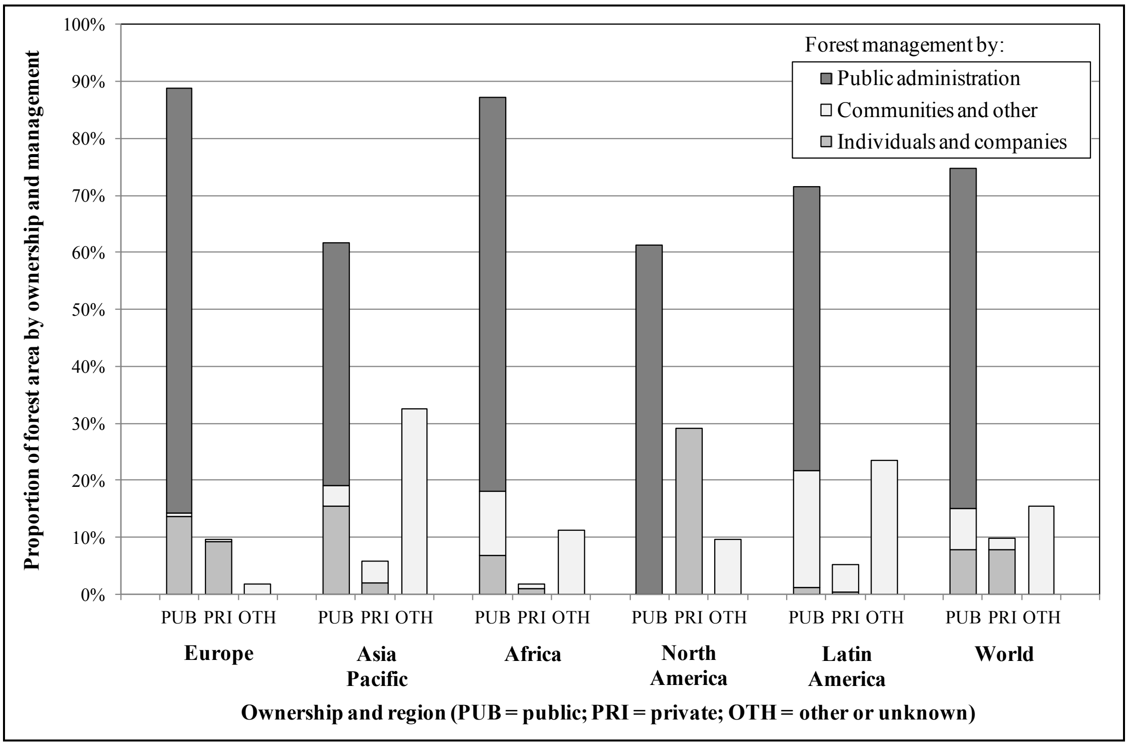
The first major observation from these results is that a significant proportion of the World's forests (75 percent) are owned by the state. Public forest ownership is highest in Europe and Africa, although the results for Europe are heavily influenced by the Russian Federation (where all forests are owned by the state). Excluding the Russian Federation, public forest ownership in Europe is only about 45 percent and private ownership is slightly higher at about 50 percent. Information about ownership has only been collected in the FRA for 2005 and 2010, but it shows that public ownership has declined at the global level (it was about 80 percent in 2005). This is due to privatisation of forests in some regions (e.g. Europe) and establishment of privately-owned planted forests. The one region where there has been little change is Africa, where the state continues to own a significant proportion of the forest estate.

Figure 2 Primary functions of forests by region and at the global level, 1990-2010



Source: FAO (2010a).

Figure 3 Forest ownership and management by region and at the global level in 2010



Source: FAO (2010a).

The next largest share of forest resources (about 15 percent) falls into the "other ownership" category. This includes areas where ownership is disputed or unclear or where the ownership arrangements do not fit the definitions of public or private. In reality, it is likely that many of these areas are under the control of local communities (although often with unclear tenure rights). This category is significant in Latin America and the Caribbean and the Asia-Pacific region (and Mexico, which accounts for all of the area designated as other ownership in North America). The remaining 10 percent of the World's forest resources are privately owned, with the majority of this area located in North America and Europe.

Combining the ownership and management information, it appears that about 60 percent of the World's forests are owned and managed by the state although, as noted previously, this proportion seems to be declining. If it is assumed that communities manage most of the forest designated as "other ownership", then communities manage just under 25 percent of the World's forests. They both own and manage a small proportion of this (about two percent of the global area) and have legally recognised management rights in public forests (another seven percent of the global area), but the majority of this area falls into the other ownership category. Community ownership and management also appears to be increasing, especially in Latin America and the Caribbean and the Asia-Pacific region. For example, in Latin America and the Caribbean, the proportion of forests managed by communities across all ownership categories is close to the proportion owned and managed by the state (both about 45 percent).

The proportion of forests managed by individuals and businesses (the formal private sector) is slightly more than 15 percent, with this area divided equally between areas owned and managed by the private sector and areas of public forests where the private sector have management rights (i.e. forest concessions). This has also been increasing due to privatisation, expansion of forest concessions in a few places (e.g. Russian Federation) and expansion of planted forests.

Another point worth noting is that there appears to be a very clear distinction in ownership and management in Europe and North America (excluding Mexico), where almost all forest ownership and management is designated as either public or private. This no doubt reflects the well-developed legal frameworks for tenure and ownership in these regions compared to much of the developing World.

Driving forces affecting forests

In very broad terms, the main driving forces affecting forest resources are socio-economic trends such as economic growth and demography. Environmental conditions are also important but, until recently (with the prospect of climate change), they largely determined differences between regions in terms of factors such as the productivity of land and forests. The impacts of climate change on forests are largely outside the scope of this chapter,[2] but they may also have major consequences for forests and people over the coming decades that will require the sector to adapt.

Trends in these underlying socio-economic variables result in changes that are more directly observable, such as increased demand for land, increased demand for forest products, changes in the availability and cost of capital and labour and changes in production, consumption and trade flows. In response to these trends, the forestry sector (like the rest of the economy) adapts by introducing new technology and altering management practices. Governments also play a part in this process, when government policies - both within forestry and in other sectors - seek to promote some activities or discourage others in an attempt to increase efficiency or equity for the benefit of societies as a whole.

Socio-economic trends

Despite the fact that forests provide many environmental and social benefits, the management of forests and associated land is still largely driven by economic considerations. Forests are one land-use out of many alternatives and land is one of the three basic factors of production in the economy (land, labour and capital). Thus, like any productive activity, the relative abundance of these three basic factors of production explains quite a lot of the differences in forest management between countries and over time (including why forests are sometimes converted to other land-uses).

2 See Section 3 of this book, especially the chapter by Grace *et al*.

For example, Table 5 presents information about income and population in the five main global regions in 2010. Comparing the two more developed regions (Europe and North America), both regions have good access to capital (as shown by the high gross domestic product or GDP per capita), but Europe has a relatively higher population density and higher proportion of the population living in rural areas (and both of these figures would be much higher if the Russian Federation was considered separately).

Thus, in Europe, capital is abundant and land is relatively scarce, so land is managed intensively on farms and in forests that are quite small in size and with a comparatively large number of people working in forestry and agriculture. Conversely, in North America, land and forests are managed more extensively and at a larger scale, with generally larger landholdings, fewer people working the land and relatively more capital used in agriculture and forestry. Similar differences between these two regions also appear in the management of forest resources with, for example, a higher proportion of planted forests and higher roundwood production per hectare in Europe (excluding the Russian Federation) compared to North America.

Table 5 Income, population density and population structure in 2010

Region	GDP per capita (USD)	Population density (persons/km^2)		Rural Population (percent)	Economically active population (percent)
		Land	Forest		
Europe	25,838	33	73	27	50
North America	37,199	22	67	19	50
Africa	1,699	34	152	60	39
Asia-Pacific	5,140	107	536	58	49
Latin America and Caribbean	8,687	26	54	20	49
WORLD	**9,220**	**53**	**171**	**49**	**48**

Source: FAO (2010a, 2012a).

Comparing the other three regions, the table also shows that the abundance of the three basic factors of production are very different, suggesting that land and forest resources in each of these regions may be on very different development paths.

Latin America has relatively good access to capital and a low population density, suggesting that forestry and agriculture in many of these countries could develop along a similar path to what has already occurred in North America. Conversely, the Asia-Pacific region may follow more of a European path, with more intensive management of smaller landholdings and a gradual substitution of capital for labour when people leave rural areas to migrate to cities. Already in forestry there is some evidence of these changes taking place with, for example, the growing importance of planted forests in Asia.

In Africa, capital is scarce and land is abundant (as shown by the low population density although, of course, a large part of North Africa is uninhabitable). Thus, agriculture and (to some extent) forest management in Africa is typically small-scale and labour intensive, but these activities do not utilise all of the land and forest resources available on the continent. This relative abundance of land in Africa and the currently low levels of investment in land management there partly explain why there is so much interest at the moment in leasing African land for agricultural development (Deininger *et al*, 2010).

Of course, this regional description does not capture the many different socio-economic situations in countries within each region. However, the broad differences described above are also likely to affect forestry development at the country level. For example, the current and future development path for forests in sparsely populated Laos is likely to be very different to neighbouring Thailand and Vietnam. Similarly, the development of agriculture and forestry in the southern part of South America has been very different to, say, the countries of Central America.

Competing land-uses

The brief discussion above focused on forest and land management, but the same factors also affect land-use change and there is a growing body of literature describing how economic and demographic trends result in land-use changes over time.

One of the first attempts to examine this was the paper by Shafik (1994), which presented the hypothesis that the relationship between environmental quality and income follows the path of an inverted U-curve or "Kuznets Curve". This postulates that environmental degradation tends to get worse as economies develop until average income reaches a certain point, then changes in behaviour and mitigation measures result in a gradually improving environment. The paper examined trends in a number of environmental indicators (including deforestation), but presented mixed results. Some indicators followed the inverted U-curve as expected, but others continued to get worse as incomes rose or continuously improved.

In Shafik's paper, the relationship between deforestation and income was one that followed an inverted U-curve, but the results were not significant due to specification and measurement problems. Others have examined the evidence for a deforestation Kuznets Curve in more detail and have arrived at similarly inconclusive results (Mather and Needle, 1999; Ehrardt-Martinez *et al*, 2002). These studies have concluded that the hypothesis of a Kuznets Curve for deforestation is broadly correct (i.e. that deforestation tends to occur in poor countries rather than rich countries), but that the socio-economic drivers of deforestation are far more complex than a simple relationship between income and forest conversion.

Box 3 The four stages of forest transition

Based on analyses of forest cover and changes in forest area (i.e. deforestation and afforestation) in different countries, a number of authors have proposed that countries typically move through four stages of forest transition as they develop economically (for a fuller description of the development of the forest transition hypothesis, see: Rudel *et al*, 2005). The four stages are described as follows:

- **Pre-transition:** Pre-transition countries have high forest cover and low deforestation rates. Population densities are generally low and there is little pressure to convert forests to other land uses.

- **Early-transition:** Early-transition countries have relatively high forest cover and high deforestation rates. Forests are converted to agriculture to feed growing populations, often after access to forests has been increased due to investments in roads for forest harvesting. Forests may also be cleared for other purposes such as mining, infrastructure or urban development.

- **Late-transition:** Late-transition countries have relatively low forest cover, with low (and slowing) deforestation rates.

- **Post-transition:** In post-transition countries, forest cover starts to increase either due to afforestation or natural regeneration on abandoned agricultural land.

The level of forest cover at which deforestation starts to slow and, eventually, reverse will depend on various factors such as population density, the structure of an economy and environmental factors.

More recent studies have included labour and commodity costs in the analytical framework and have proposed that forests go through four transitional stages as economies develop (see Box 3). Similar to the inverted Kuznets Curve hypothesis, these studies also suggest that deforestation becomes gradually worse as incomes rise (from a low level), but then starts to improve and eventually reverse. However, they provide a better explanation of why these changes might occur.

In particular, as described by Rudel *et al* (2005), there are two hypotheses about why deforestation might reverse as economies develop and incomes rise:

- **Rising rural labour costs:** With increasing incomes and urbanisation, rural labour costs will rise and farmers will abandon their more remote, less productive fields and pastures to concentrate labour on their more productive and profitable landholdings.

- **Increasing forest scarcity:** As forest area declines in a country, the potential supply of forest products (from domestic resources) also falls, leading to increased prices of forest products. This improves the financial returns from afforestation and forest management, leading to an expansion of forests and reversals in forest degradation.

The paper by Rudel *et al* describes how a number of countries appear to have moved from the late-transition to post-transition stages since 1990 (for each of the two reasons described above). However, it also describes why some other countries apparently made much less progress towards the post-transition stage for a variety of reasons.[3]

A more elaborate model developed by Hyde (2012) follows a similar logic, to explain why forests in a country might be cleared, degraded or sustainably managed, due to a number of economic forces (including the two mentioned above). This model takes the idea of forest transition a stage further to explain how both land-use change and forest degradation develop over time and how sustainable forest management eventually arises when the value of forest products reaches a level sufficient to justify protection and management rather than simply exploitation of the resource.

Another factor affecting the forest transition is the availability of capital and improved technology. For example, if capital is readily available, then farmers could mechanise if labour costs rise and this would not lead to a reversal in deforestation. On the other hand, the same conditions would tend to support afforestation in the face of forest scarcity. This is why many countries that have successfully reversed deforestation trends have supported reforestation and afforestation with tax incentives, grants and other subsidy schemes to overcome the initial capital costs of tree planting.

The impacts of improved technology at the forest-agriculture interface has been studied by a number of authors (for a comprehensive review, see: Angelsen and Kaimowitz, 2001). Similar to many other economic developments, improvements in technology have both an income and substitution effect that may or may not lead to an expansion of agriculture into forest areas, depending on which effect is stronger. On the one hand, improved technology enables farmers to produce more output at lower cost, but this tends to depress product prices and result in less expansion of agriculture as farmers focus efforts on their best land (a substitution effect, similar to the rising labour cost effect described above). However, by lowering production costs, these developments also raise the profitability per hectare of agriculture (an income effect), which would tend to encourage expansion of agriculture into other areas. With expanding markets for agricultural products (another important impact of rising incomes), the latter effect is likely to be dominant in most places, leading to conversion of forests into agricultural land.

Based on a comprehensive review of documents prepared for REDD[4] projects, Hosonuma *et al* (2012) recently estimated the amount of deforestation in tropical countries that can be attributed to different types of land conversion. The results of this analysis are shown in Figure 4 for the three tropical regions and four stages of forest transition. The results suggest that commercial agriculture accounted for 40 percent of deforestation in the last decade, followed by local or subsistence agriculture (33 percent). Infrastructure and urban expansion account for a further 10 percent each and mining the remaining seven percent.

These results are consistent with earlier studies which show that agricultural expansion is by far the predominant driver of deforestation. However, in contrast to many previous studies, this study shows that commercial agriculture rather than subsistence agriculture is now the most important driver. The study

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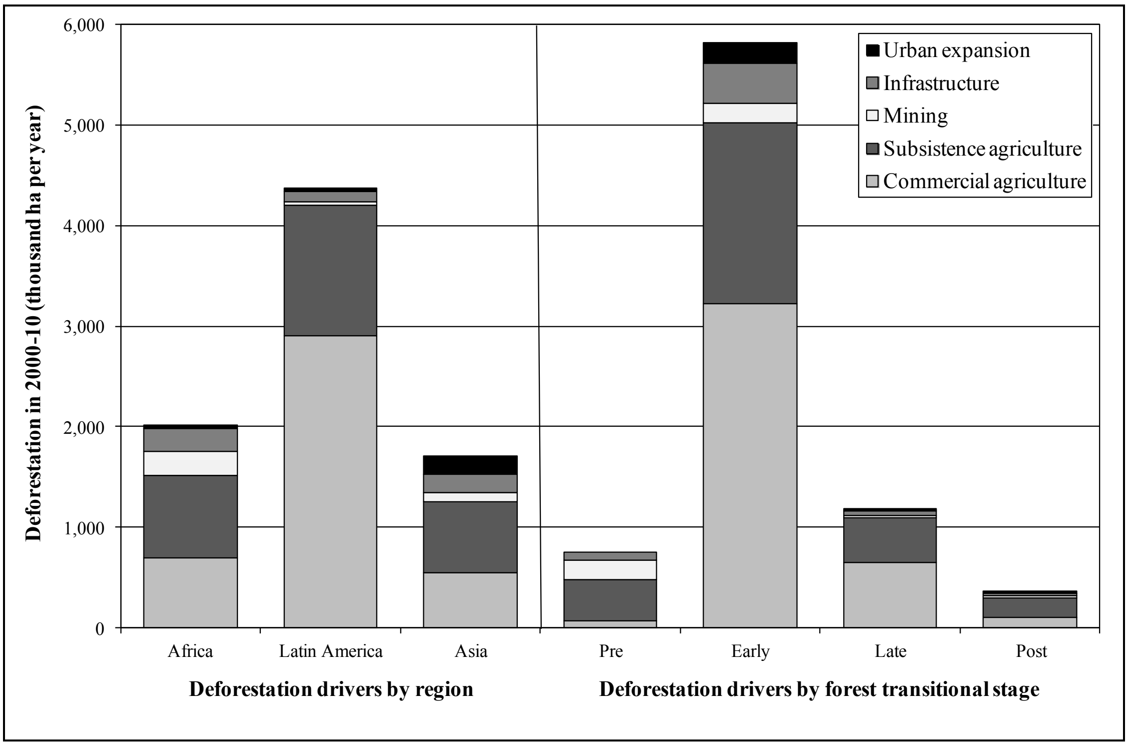
3 See also the chapter by South in Section 4 of this book, which addresses the different types of forest ownership that exist and describes how this might affect how forests are used, now and in future.

4 Reduced Emissions from Deforestation and Degradation - an approach to climate change mitigation in the forestry sector.

shows that conversion of forests for cattle ranching, soybeans and oil palm has grown in importance in recent years, especially in Latin America and Asia. The study confirms the simple analysis presented earlier, showing that commercial agriculture is expanding mostly in Latin America (where land and capital are relatively abundant), while subsistence agriculture remains the most important driver of deforestation in Africa. It also shows how the availability of capital (e.g. for commercial agriculture) is increasing in importance as a driving force behind forest conversion.

The presentation of results by transitional stage is, perhaps, the most worrying indication for the outlook for forest resources. This estimates that about three-quarters of deforestation is currently occurring in countries in the early transitional stage (high forest cover and high deforestation rate), suggesting that many countries will continue to convert forests to agriculture for some years to come before deforestation rates fall or reverse.

Figure 4 Estimated drivers of deforestation in 46 tropical and sub-tropical countries, 2000-2010



Source: Hosonuma et al (2012).

With the expectation that forest conversion will continue for some time to come, there is a growing debate about how to reconcile the need for more agricultural land with the need to protect important biodiversity and ecosystems. In the same way that forests can be managed for multiple uses, some have suggested that "land sharing" - where environmentally-friendly agriculture occurs in multi-functional landscapes - can meet the need to produce more food while protecting biodiversity. The alternative approach is specialisation and intensification to produce more food from existing land and reduce the need to expand agriculture into other areas such as forests ("land sparing").

As with many other studies of land-use change, there is evidence to suggest that both approaches have strengths and weaknesses. For example, a study by Phalan *et al* (2011) examined the density of tree and bird species in Ghana and India with different levels of forest cover and agricultural intensification. Their results suggested that land sparing would be a better strategy for minimising the negative impacts of increased food production. However, another recent study of the Peruvian Amazon (Gutíerrez-Velez *et al*, 2011) showed that 75 percent of the land used for expansion of high yield oil palm plantations was obtained by clearing primary forests compared to only 30 percent for the expansion of small-scale, low-intensity production. The authors suggested that land tenure and fiscal incentives partly explained these differences, showing how government policies are also important driving forces in the conversion of forests to other land-uses.

Increasing demand for forest products and services

In addition to increased demand for agricultural land, socio-economic trends also lead to increased demand for forest products and services. However, at the same time, these trends also lead to improvements in technology, resource management and utilisation that can expand supply and reduce the impacts of increased demand on the forest resource.

Trends in the production of forest products over the last two decades suggest that many countries have been successful in reducing the amount of wood and fibre from forests used to manufacture forest products. At the global level and in most regions and product categories, production of processed forest products has increased since 1990, but there has been no upward trend in the consumption of roundwood by the wood processing sector.

One reason for this has been the continual increase in the recovery and re-use of forest products that has occurred since the 1970s, starting first with recovered paper (or wastepaper) and, more recently, the growth in recovery and recycling of solid wood products in regions such as Europe. Greater use of wood residues from solid wood manufacturing (i.e. sawnwood and plywood production) has also contributed to this effect. For example, the European Forest Sector Outlook Study (UN, 2005) noted that less than half of the wood and fibre now used to manufacture forest products in Western Europe comes from forests and trees, with the majority coming from the use of wood residues and recycled wood and fibre.

Another contributing factor has been the substitution of reconstituted wood panels (i.e. particleboard and fibreboard) for sawnwood and plywood in many end-uses. These products are more efficient in the use of wood raw materials (i.e. less wood is required to manufacture one cubic metre of product compared to sawnwood and plywood) and they can be manufactured with wood residues and recovered wood, as well as smaller-sized trees and species that would not be considered commercially viable for manufacturing sawnwood and plywood.

In the markets for paper, rising incomes and technological change are starting to reduce demand for some types of paper, as people in developed countries switch to electronic media, book readers and communicate more by email. For example, newsprint consumption in North America and some European countries has now fallen to levels last seen in the 1960s. However, with improvements in income and literacy and the development of a service sector, demand for newsprint and printing and writing paper in most developing countries is still growing very fast and it is unlikely that this trend will slow down for many years to come.

The regional trends in paper consumption mentioned above reflect a more general pattern of forest product consumption that has appeared over the last two decades. In most developed countries now, per capita consumption of forest products is relatively high, but growing only slowly and, in some cases (e.g. newsprint), declining. Indeed, it appears as though per capita consumption of some forest products is reaching a natural limit with little potential for further growth. In addition, as noted above, much of this consumption is recycled into new products, reducing the demands placed on the forest resource for wood and fibre.

In contrast, consumption in many developing countries is increasing rapidly (although from a much lower base) and recycling is less well developed in most places. The increases in demand expected in developing countries in the future will result in greater demand for wood and fibre. However, with increasing forest scarcity and the large potential to increase the efficiency of resource use, it seems likely that improvements in technology, recovery and recycling will occur (as they have already in developed countries). Thus, it can be expected that such improvements will make a significant contribution to mitigating the impacts of higher product consumption on the demand for wood raw materials.

Another shift that has occurred in the last few decades is the rapid and significant increase in the area of planted forests and the growing importance of these resources for wood supply. For many decades, five countries with significant forest resources (Canada, United States of America, Sweden, Finland and Russia) accounted for over half of the global production of forest products. However, in the last two decades, the development of fast-growing forest plantations has reduced the dominance of these countries in global forest product markets. In particular, countries in the Southern Hemisphere - such as: Brazil, Chile, South Africa, New Zealand and Australia - have grown to become important suppliers and exporters of forest products based, to a large extent, on their planted forest resources. These countries have recently been joined by China, Indonesia and others that are developing significant planted forests estates.

As noted by Brown (2000), the comparative advantage in production of forest products appears to have shifted somewhat, away from countries with lots of trees to places where trees grow fast. This shift can also been seen within countries and regions with, for example, the increasing importance of forest plantations in the south-eastern United States of America as a source of wood supply and increased wood production in Europe from forest plantations in places such as Ireland, Spain and Portugal. These shifts have not only been supported by research and development in tree breeding, plantation establishment and management, but also by the changes in processing technology and end-uses (mentioned previously) that allow a wider range of wood raw materials to be used in manufacturing.

One of the important impacts of the development of planted forests is that it enables the growing demand for forest products to be satisfied by relatively small areas of forest. The contribution of planted forests to wood supply is not known, because roundwood production statistics are not disaggregated by forest type. However, the potential production from planted forests can be estimated from the planted forest area statistics collected in the FRA, estimates of yield and other information about management regimes.[5]

One of the first attempts to estimate potential wood supply from planted forests was produced by Brown (2000), based on the results of the 1995 FRA. Using a very narrow definition of planted forests,[6] the study estimated that the 3.5 percent of the global forest area classified as industrial forest plantations (in 1995) had the potential to produce 22 percent of the industrial roundwood used in that year. An update to this estimate was produced by Carle and Holmgren (2008), based on the results of the 2005 FRA. Using a much broader definition of planted forests, they estimated that forest plantations (covering seven percent of the global forest area) had the potential to supply two-thirds of global wood production in 2005. Most recently, Indufor (2012) presented an analysis suggesting that there are 54 million ha of fast-growing forest plantations managed for commercial purposes (1.5 percent of the global forest area), with the potential to produce about one-third of current industrial wood supplies.

The large difference between these estimates of plantation wood supply occurs because some planted forest areas may not be used for wood production. Furthermore, actual production may not reach the level of potential production because of a number of operational factors (e.g. lack of local demand, high harvesting costs, tree mortality). However, all of these studies and a number of other similar reports have highlighted how these relatively small areas of planted forest could meet much of the World's demand for wood and fibre at present and in the future.

Socio-economic trends have one other major impact on the demand for forest products and services and this is that people start to demand a broader range of benefits from forests and forest products when incomes rise. Similar to Maslow's hierarchy of human needs (Maslow, 1943), at low income levels demand focuses first on meeting basic human needs, then it expands (as incomes rise) to include demands for products and services that meet higher needs (e.g. information and education) and, eventually, products and services that help people to achieve esteem and self-actualisation. In the markets for forest products, these differences in the structure of demand can be seen in the high proportion of wood used as fu-

5 For example, whether the planted forests in a country are likely to be grown and managed on short rotations for pulpwood or longer rotations for sawlogs or a mixture of pulpwood and sawlogs (based on species, market conditions and other factors).

6 The early FRA definition of forest plantations was: "Forest stands established by planting or/and seeding in the process of afforestation or reforestation, with either introduced species (all planted stands) or intensively managed stands of indigenous species, which meet all the following criteria: one or two species at planting; even age class; and regular spacing. (FAO, 1998). Later versions of the FRA introduced the broader concept of "planted forests", which included the above plus other forests of planted trees that did not meet the criteria set-out above.

elwood and sawnwood (to meet the basic needs of energy and shelter) in poorer countries, with more demand for higher-value wood products (e.g. furniture) and paper at higher levels of income and demand for legal, sustainable and "green" products at the highest levels of income.

As noted in FAO's State of the World's Forests 2011 (FAO, 2011b), many developed countries have already reached a point where concerns about the sustainability of forest products and interest in issues such as corporate social responsibility and the so-called green economy are becoming important factors affecting the future development of the forest industry. The same trend is also leading to increased demand for forest services such as recreation (e.g. in Western Europe - see: UN, 2005) and is reflected in a number of recent developments such as forest certification and legislation to strengthen forest law enforcement.

Government policies

In addition to socio-economic trends, the other major driving force affecting forest resources is the overall policy environment in a country. This includes sectoral policies (both within forestry and in other sectors) as well as broader macroeconomic and social policies. For many years, forestry policy discussions have emphasised how forests and forestry are often influenced more by policies in other sectors than by policies within the forestry sector itself. However, a particularly important feature of the last two decades has been the increased liberalisation of markets, the growth of free trade and the globalisation of the World's economy.

The main impact of market liberalisation and globalisation has been the increase in economic growth that has occurred in the last two decades. In particular, the economies of many developing countries and countries in transition have grown dramatically, due to closer integration into global markets and reductions in central planning and state ownership and control of economic activities. Globalisation has also supported the regional shifts in roundwood supply (noted earlier) and, more recently, shifts in forest industry investment towards developing regions, where labour costs are lower and demand growth is high.

These shifts in production, demand and investment have altered the economics of forest management all over the World, making it more difficult to cover the costs of SFM in some regions. Increased globalisation also means that changes in forest management in one location are more likely to lead to unexpected impacts elsewhere. For example, concerns have been expressed that measures to alter forest management or reduce wood production (in countries where production levels are unsustainable) may simply lead to undesirable changes in other places. These spillover effects are becoming increasingly important for policymakers attempting to improve sustainability through measures such as logging bans and changes in forest law enforcement or by developing new projects for bioenergy production or climate change mitigation (e.g. REDD projects).

The other broad policy area that has a significant impact on forest resources is the arrangements for land-use, land tenure and land ownership in countries. For example, Contreras-Hermosilla (1999) described many reasons why insecure land tenure may result in forest conversion or forest degradation and also why strengthening tenure may not always lead to reductions in these problems unless such measures are complemented by other policy reforms. The results of the FRA show that forest tenure and ownership is still uncertain in a significant proportion of the World's forests (particularly in tropical countries), but that the situation is gradually improving (FAO, 2011c). In addition, measures such as the recently produced "Voluntary Guidelines on Tenure Governance" (FAO, 2012b) should help to strengthen and clarify tenure if implemented by countries.

With respect to cross-sectoral linkages, a number of papers have highlighted how policies in a few specific sectors appear to have the most significant impacts on forests and forestry (Contreras-Hermosilla, 1999; Broadhead, 2001; Dubé and Schmithüsen, 2007). Policies promoting agriculture are the most obvious example of a cross-sectoral impact that tends to have a negative impact on forestry, followed by transport policies (which tend to increase access to forest areas, thus indirectly facilitating forest conversion). Policies in the energy sector are another major source of cross-sectoral impacts, although the impacts on forests may be positive or negative depending on the aim of the energy policy. Conversely, it is little surprise that policies supporting nature conservation and environmental improvement or protection tend to have major beneficial impacts on forests.[7]

The growing concern about climate change is the most recent development that has significant potential to affect forests and forestry. Forests can contribute to climate change mitigation in a number of ways. First, as carbon sinks, they can sequester and store carbon from the atmosphere through afforestation, reforestation or changes in forest management. Alternatively, carbon emissions from forests can be reduced if deforestation and forest degradation is reduced (REDD). Secondly, wood products can be used as substitutes for other products manufactured using more energy (i.e. wood products generally contain less embodied energy than other products), with the additional benefit that the wood products may also store carbon for long periods of time. Woodfuel may also be used in place of fossil fuels, with benefits in terms of lower net carbon emissions if the carbon emitted from combustion is replaced by forest regrowth or if the wood would have decomposed anyway.

It might be expected that policies supporting climate change mitigation should benefit forests and forestry overall, but achievements have been quite limited so far. For example, afforestation is one option to obtain credits for emission reductions, but very few projects have met the rigorous standards required to obtain such credits. Emission reductions through REDD is also being piloted in numerous countries at the moment, but countries have yet to agree if or how credits for REDD activities can be incorporated into global carbon financing mechanisms; and even if there is agreement on an international mechanism for REDD financing, the project preparation, transaction and monitoring costs may result in limited uptake. Beyond forests, the carbon stored in wood products can now be included in a country's carbon accounts, but very few countries have any policies or incentives to promote wood products as low-carbon alternatives to other materials.

The promotion of bioenergy is the one relevant area where many countries have implemented targets, policies and laws in recent years. For example, Cushion *et al* (2010) reported that 57 countries now have targets for bioenergy use (as a share of total energy supply or fuel use), including all developed countries and most of the large developing countries. However, by focusing heavily on energy consumption, the policies for achieving these targets have contradictory implications for the outlook for forest resources.

On the one hand, by stimulating demand for wood, they improve the economics of forest management, providing more income for forest owners and supporting more intensive and active management of forests. However, there is concern that the potentially huge amounts of wood required to meet these targets may be difficult to supply sustainably. Furthermore, because non-wood crops are often more economically attractive sources of bioenergy or biofuel (e.g. sugar crops or oilseeds for liquid biofuel production), these policies have actually increased the pressure to convert forests to other uses in order to meet these new demands. As noted above, these pressures may also occur in places far away from the countries where bioenergy consumption is increasing.

Within the forestry sector, many countries have forestry policies that have been recently updated to reflect international commitments and current best practices. However, while forestry policies may be well designed and strongly supportive of SFM, there remains a lack of capacity in many countries to implement these ever more complex and complicated policies.

The FRA shows that the number of staff in forestry administrations has declined over the last two decades (see Table 4), but it also shows that there is a wide gap between developed and developing countries in the amount of public funding available to support forestry policy implementation. For example, the latest FRA estimated that public expenditure on forestry in 2005 amounted to at least USD 19 billion (or USD 7.30 per hectare),[8] but also that Europe, North America and China accounted for over 85 percent of

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7 It is also interesting to note that these papers all show that broad policies supporting development or strengthening institutional frameworks appear to have as much (if not more) of an impact on forestry than policies in specific sectors. This suggests that planning and trying to mitigate the impacts (on forests) of broad policy changes may be a more suitable approach than the currently high level of interest in how to address cross-sectoral impacts.

8 Only 103 countries (covering 64 percent of the global forest area) reported this information to the FRA, so total global expenditure will be somewhat higher than this figure.

this total. Expenditure per hectare in all three developing regions (excluding China) was below the global average and far below the average expenditure in developed countries (FAO, 2010a).

This lack of implementation capacity may partly explain why policies outside the sector seem to have much more influence on what happens to forests than forestry policies. It has also led to a long-running international debate about how to finance SFM, although this - like REDD-financing discussions - has yet to result in significant financial flows to support SFM. At the same time, forest administrations in many developing countries continue to find it difficult to raise income from the management of public forests (e.g. through higher forest charges) and to compete with other parts of the public sector for funding to support SFM implementation.

The challenges mentioned above could imply that forestry policy is not such an important driving force for the outlook for forest resources, but the lack of capacity in some developing countries may actually result in many unintended (and detrimental) consequences for forests. For example, where weak capacity collides with complex forestry regulations, the tendency for corruption may be higher. This increases uncertainty and reduces the economic viability of SFM, making it more likely that forests will be degraded or converted to other uses in the long-run. Alternatively, if countries try to address this problem by implementing simple policy measures (such as bans on hunting, logging or pitsawing, which are quite common), this may reduce the potential for corruption, but it can also remove any incentive for local people (as well as forest officers) to protect and conserve forests. To put it simply, where institutions are weak, more forestry policies, laws and regulations may increase the pressure to convert forests to other uses that have clearer and more certain policy and institutional frameworks. This issue of capacity will be vitally important for the future of forests, as well as for recent policy measures that try to strengthen forest governance (e.g. the US Lacey Act and EU Timber Regulation).

Outlook for forest resources

The preceding analysis has shown that the global forest area is declining (although at a slowing rate) and that forest degradation is probably increasing in many, but not all, places. However, at the same time, many indicators of SFM appear to be improving and the demands placed upon forests are expanding (both in terms of quantity and the range of goods and services desired).

The links between the main driving forces (economic growth, population change, increased demands), forest characteristics (area, forest type, use, etc.) and forest management are difficult to assess in detail but, at least in the case of forest area, competing demands for land appear to be a major factor affecting the outlook for forest resources. With respect to forest management, intensification (e.g. expansion of forest plantations) and expansion of protected areas appear to be two of the strategies most commonly employed by countries to try to meet the increasing demands placed on the sector.

The FRA has shown that the state is still the dominant force in forestry in most countries, due to its regulation of the sector and, in many places, through its ownership and management of forest resource. However, there are also indications that state forest ownership and management is declining. In addition, the capacity of forestry administrations to implement policies and legislation is quite weak in many places.

In light of the above, this final section will describe the outlook for some of the driving forces affecting forests then examine three main issues: how much forest will there be in the future; what will it be used for; and how will it be managed? This will include some brief thoughts about how stakeholders in the sector might respond to these changes.

Outlook for the socio-economic driving forces

At present, the short-term outlook for the global economy looks uncertain, so detailed projections of economic growth will not be presented here. However, it is possible to present some general statements about likely economic developments over the next few decades.

First, over the last century or so, the historical economic growth rate in most developed countries has been about 2.5 percent per year on average. This rate has been driven by a mixture of population growth, technology and innovations and increased efficiencies in economies. Once the current economic problems have been overcome, it seems likely that growth in these economies will return to a more stable and predictable path. However, with ageing populations and little or no future population growth, a more subdued growth rate (e.g. 1.5 - 2.0 percent per year) may become the norm in many of these countries.

Outside developed regions, long-term economic growth trends have been much less predictable in the past with, for example, some developing countries suddenly expanding very rapidly and others experiencing prolonged periods of little or no growth or even shrinking economies. However, over the last 10-15 years, stable positive growth has gradually appeared in many of these countries. Some of the so-called developing countries already have a relatively long history of solid economic growth that has propelled them into the ranks of the high-income economies (e.g. Republic of Korea, Singapore), with others following closely behind (e.g. Chile, Mexico, Malaysia). In addition, four of the larger countries (the so-called “BRIC” economies of Brazil, Russian Federation, India and China) have expanded to become major forces in the global economy and others (e.g. Mexico, Indonesia, Thailand) may soon join them.

Continued relatively high economic growth of around 2.0 - 4.0 percent per year seems likely to continue (in most of these countries) for the foreseeable future. The countries with even higher rates of growth (e.g. China) may be able to continue growing at these levels for some time, but growth will slow down eventually, due to rising labour costs and demographic changes (see below). The one exception might be Africa, where economic growth rates in many countries have reached unprecedented levels in recent years. Average incomes in Africa are far behind the other global regions, but much of the continent has started to benefit from closer integration into the global economy, high demand for commodities and natural resources, favourable demographic trends and some improvements in governance, peace and security. If these improvements can be sustained, then above average growth could continue for some time to come.

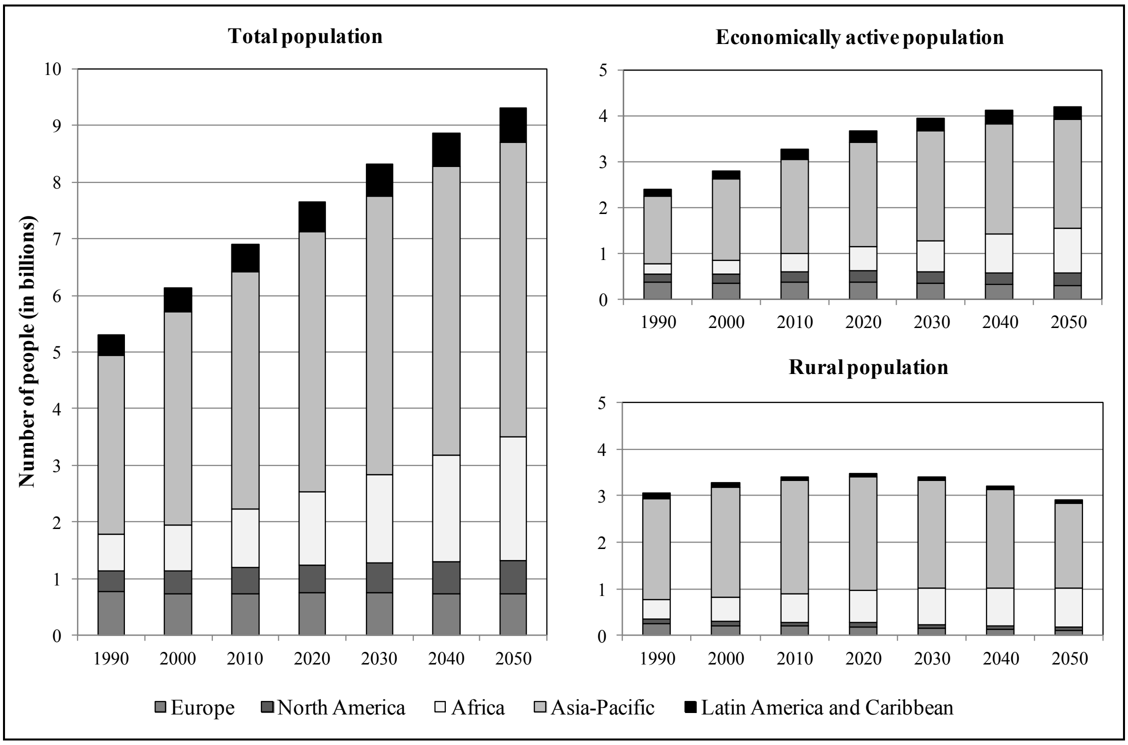
The two main impacts of the economic outlook are as follows. First, growth in the global economy will continue to shift away from the developed regions of Europe and North America to the rest of the World, particularly Asia and Latin America and the Caribbean. Average incomes in these latter two regions will continue to approach the income levels in Europe and North America, although differences between countries within these regions may remain quite large. Average incomes in Africa are likely to continue to remain some way behind the rest of the World, due to the extremely low levels of income there at present.

The second impact will be a significant expansion in the middle-income population (or “middle class”) in many developing countries. As already noted, this will lead to some major shifts in consumer demand, as people move up their needs hierarchy towards higher value products, more consumption of services and greater expenditure on luxury goods and leisure activities. It will also raise labour costs, resulting in more substitution of capital for labour, increased labour productivity and a large reduction in people relying on the informal economy to make a living. These latter changes, combined with demographic trends, could have some profound impacts on the future of forest resources.

Demographic projections are available to the year 2100 (UN, 2011) and are generally more reliable than long-term projections for economic growth. So, current projections for total population in each of the main global regions, along with estimates of the rural population and economically active population are presented in Figure 5.

The global population is projected to increase by over two billion people over the next four decades to reach about 9.3 billion in 2050. Almost all of this increase will occur outside Europe and North America, although population growth is also expected to slow dramatically by the end of the period in Latin America and the Caribbean and the Asia-Pacific region. In contrast, Africa is the one region where population will increase most dramatically (from 1.0 billion in 2010 to 2.2 billion in 2050) and with very little decrease in the population growth rate in the future.

Figure 5 Trends and projections for global population (medium fertility variant), 1990-2050



Source: UN (2011), with economically active population from ILO (2011) to 2020 and estimated thereafter.

The population living in rural areas is currently (2010) about 3.4 billion people or roughly half the total population. This is expected to remain about the same over the next few decades then gradually reduce to less than 3 billion in 2050. The global trend mostly reflects an expected decrease of 0.6 billion in the rural population in the Asia-Pacific region in the coming decades. The rural population in Europe and the Americas is currently relatively small and is also expected to decline slightly in the future. In Africa, it is expected to increase slightly from 0.6 billion to 0.8 billion (2010 to 2050), but start to fall at the end of the period.

The economically active population (ILO, 2011) is currently about 3.3 billion people and this is expected to increase to 4.2 billion people in 2050. However, the age structure of the population is shifting towards higher proportions of older people (including people beyond retirement ages) in most regions. Thus, the economically active population is expected to decline in Europe and remain roughly the same in the Americas. It will increase in the Asia-Pacific region in the next two decades - from 2.0 billion in 2010 to 2.4 billion in 2040 - but will not increase any further. Again, Africa is the one exception to these regional trends, where the economically active population is projected to increase continuously, from 0.4 billion in 2010 to about 1.0 billion in 2050. This is due to the current age structure (many young people) and high fertility that is expected to continue for some time to come.

In light of current thinking about the drivers behind forest transitions, these population projections are likely to have major implications for the future of forest resources in different parts of the World. In the Asia-Pacific region, the expected decline in the rural population and population ageing will result in far fewer people living in forest areas and engaging in activities that have traditionally been viewed as drivers of deforestation and degradation (e.g. shifting cultivation, grazing, fuelwood and non-wood forest product collection). So, to some extent, demography may "save" the forest. However, as also noted above, more capital will be employed in land and natural resource management to compensate for these shrinking and more expensive labour supplies. This will continue to create pressure to replace forests with large-scale commercial agriculture, but it will also encourage more forest plantation establishment (in areas where commercial agriculture is not viable) to meet the growing urban demand for wood products. In other words, the transition will really be one from a small-scale production or subsistence landscape to one that is more actively managed at a larger-scale and for more commercial production. This will not necessarily be detrimental to forest resources in all places, but could have both positive and negative implications for forests and forestry.

Parts of Latin America (where population density is relatively high) could follow a similar path to the Asia-Pacific region, because most of these demographic shifts are also expected to occur there. However, in the parts of this region where population densities are low, significant areas of land and natural resources are already very actively managed (although extensively and at a larger scale) with a strong focus on commercial production of forest and agricultural outputs. In these places, the transition will not be from a subsistence to managed landscape, but more likely an expansion of managed landscapes into areas that are currently lightly used.

These same demographic trends are also expected in Europe and North America, as well as Australia, Japan and New Zealand. In these countries, most land is already actively managed, land-use change is often regulated (e.g. through local planning systems) and land-uses tend to be more stable. An ageing and shrinking rural population may continue to encourage forest expansion in some areas for a variety of reasons. For example, farmer retirement and out-migration can lead to land abandonment (and natural regeneration) or deliberate tree planting to continue to use the land but with much lower input requirements. Alternatively, land ownership can change, replacing ownership by working farmers with new owners that may have more of an interest in tree planting (e.g. for long-term investment or non-commercial purposes). Management intensity (of both agricultural land and forests) might also increase to meet increasing product demand with lower labour availability, but much will depend on the policies and incentives present in a country.

The one clear exception to the future scenarios described above is Africa. In Africa, all of the demographic trends are the opposite, with an increasing total population, rural population and economically active population expected in the future. Here, the pressure to convert forests to other land-uses will increase. However, two factors could mitigate the impact of demographic changes on forest resources.

The first is that population density is quite low (especially in most of the countries with significant forest areas). Thus, deforestation may be quite limited in the countries with large populations (because they already typically have few remaining forest resources), while the demographic pressures may be reflected more in forest degradation (rather than deforestation) in the countries with high forest cover.

Secondly, there is still much potential to increase the productivity of agriculture in Africa. As noted by Langyintuo (2011), African cereal yields are less than a quarter of the global average, the use of fertilisers is minimal (often leading to soil degradation) and average yields of individual crops are between a half and one-fifth of what is technically feasible. Similarly, Africa has a lot of potential for the development of forest plantations (South Africa being a notable example of this), but the continent has not so far been able to take advantage of this.

Numerous studies have highlighted three main constraints to the development of agriculture, forestry and fisheries in Africa, namely: lack of access to investment capital; poorly developed markets; and unclear land tenure arrangements (FAO, 2003 and 2012c). The first constraint may ease in the future with rising incomes and foreign investment in the sector, but the other two issues require broad policy reforms that will need to be addressed if the continent is to achieve its potential.

Outlook for future demand for products and services from forestry and agriculture

The more direct forces affecting the outlook for forest resources are the growing demands for products, land and other environmental services expected in the future. This includes not only forest products but also the products from alternative land-uses and forest services or what the Organisation for Economic Co-operation and Development (OECD) has referred to as the “Five Fs” - food, feed, fibre, fuel and forest conservation (see: OECD, 2009). Recent projections for some of these outputs are available and are presented below.

Table 6 Trends and projections for global production of agricultural products, 1990-2050

Region	1990	2000	2010	2020	2030	2040	2050
All food and non-food commodities							
Developed countries	93	96	100	107	115	118	122
Near East and North Africa	62	80	100	117	137	155	174
Sub-Saharan Africa	55	75	100	128	164	202	248
South Asia	62	80	100	121	146	166	189
East Asia	49	73	100	114	129	136	143
Latin America and Caribbean	53	75	100	118	140	152	164
WORLD	66	83	100	114	129	140	152
Meat							
Developed countries	88	94	100	107	115	117	119
Near East and North Africa	49	71	100	127	161	193	233
Sub-Saharan Africa	56	75	100	133	177	236	314
South Asia	67	79	100	154	237	329	457
East Asia	45	69	100	121	146	154	164
Latin America and Caribbean	45	70	100	118	140	149	159
WORLD	64	81	100	116	135	148	163

Source: derived from Alexandratos and Bruinsma (2012). Note: the units above are index numbers, based on 2010 = 100.

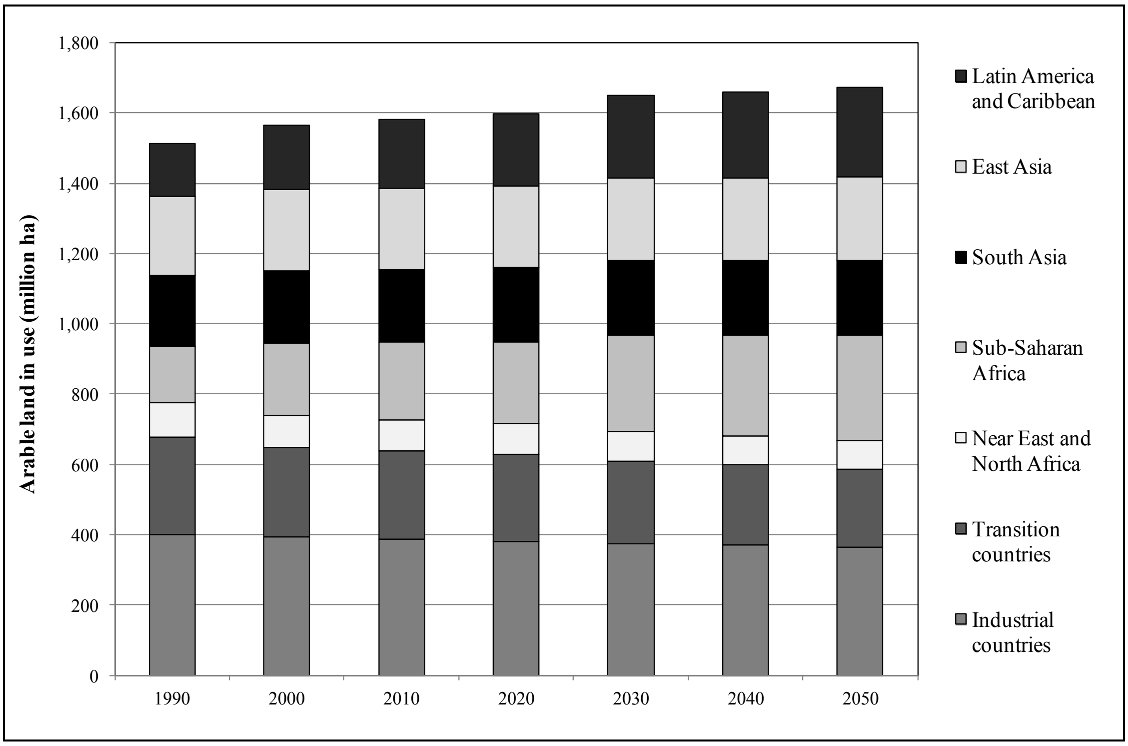
FAO regularly produces projections of future supply and demand for food and the results of the latest projections to the year 2050 are shown in Table 6. The figures in the top of the table represent the total amount of production of all food and non-food commodities converted to an index number (with 2010 set to 100). Thus, this includes products such as cereals, oilseeds, fruit, vegetables, meat, milk and eggs, roots and tubers, as well as non-food products such as tobacco.

The information is presented using regions that are slightly different to those shown earlier, but the link between population trends and food production is quite clear. Production of food in developed countries, where population growth is minimal, is only expected to increase by about 22 percent by 2050. In contrast, an increase of almost 150 percent is expected in Sub-Saharan Africa and increases of about 50 percent or more are expected in all other regions. In addition to the regional trends, these increases in production are likely to decline over the next 40 years, with a lower growth rate (in percent) from 2030 to 2050 compared to the period 2010-2030.

The lower part of the table shows the projected production of one commodity - meat - over the same time period. An important impact of rising incomes is that people will increasingly be able to afford more expensive food products (such as meat) in the future, so diets will change. This will have beneficial effects on nutrition, but it will also increase the demand for natural resources such as land and water, because production of meat is resource intensive compared to other types of food (i.e. for a given level of calories, production of meat generally requires more land, water and other inputs). As the bottom of the table shows, meat production is expected to increase by even more than total food production in all regions except developed countries and Latin America, with three or four-fold increases expected in some places by 2050.

Increases in agricultural production can be achieved in three main ways, namely: increases in yields (production per hectare during one crop cycle); increases in intensity of production (reducing fallow or unused areas and increasing the number of crop cycles achieved in a year); and expanding the area of arable land. Historically, improvements in yields have contributed to most of the increases in agricultural production (about 77 percent of the total increase in global production from 1961-2007), with increased cropping intensity and expansion of agricultural land accounting almost equally for the remaining share. The two main exceptions have been Sub-Saharan Africa and Latin America and the Caribbean, where expansion of arable land has been more important (for further details, see: Alexandratos and Bruinsma, 2012).

Figure 6 Trends and projections for the global area of arable land in use, 1990-2050



Source: derived from Bruinsma (2011).

The projections for food production have been combined with projections for technological improvements (i.e. cropping intensities and yields) to produce projections of how much arable land might be used for agriculture in the future and these are shown in Figure 6. Overall, the global area of arable land is expected to increase by almost 100 million ha in the next 40 years, from 1,580 million ha in 2010 to 1,675 million ha in 2050.[9]

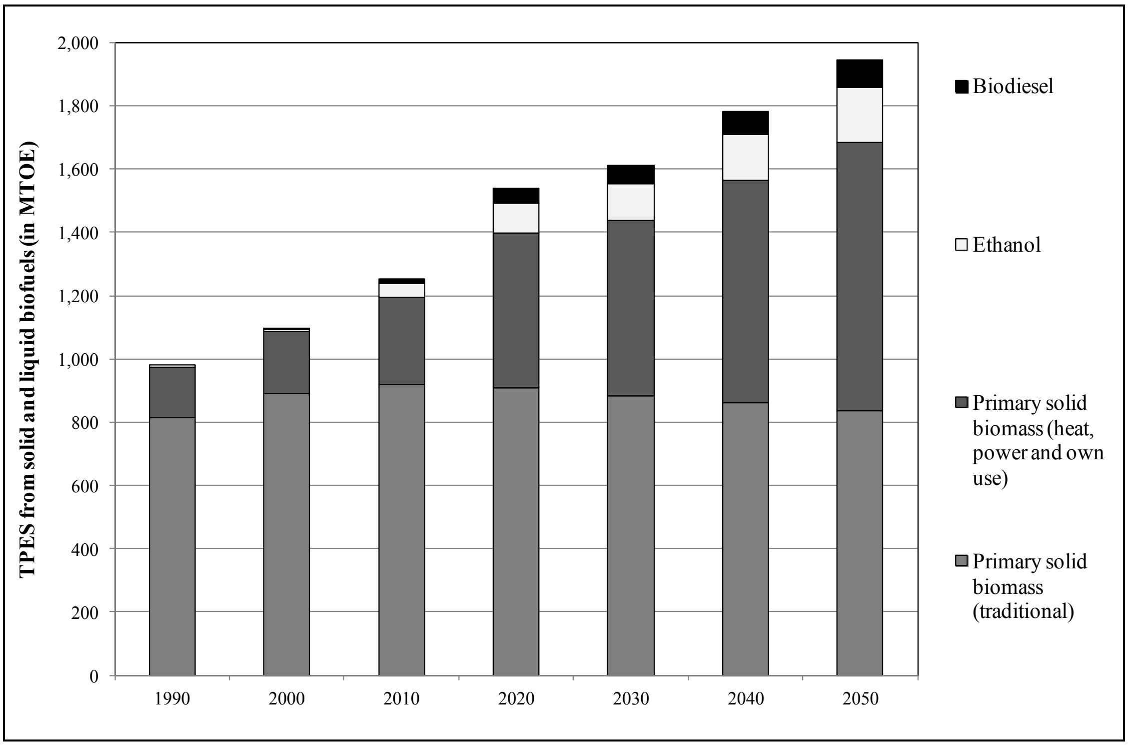
These projections are consistent with the explanations of the driving forces and land-use development paths described earlier. Thus, for example, increases in food production in Asia are expected to be achieved by increases in yields and cropping intensity (due to more investment in inputs, capital and better management), with almost no expansion of arable land. In industrialised and transition countries, these same improvements will actually expand production per hectare faster than the projected increase in total food production, leading to a fall in the area of arable land required for food production.

The two regions where arable land is expected to increase are Sub-Saharan Africa (with an increase from 220 million ha to 300 million ha from 2010-50) and Latin America and the Caribbean (with an increase from 195 million ha to 255 million ha). In the case of Latin America, land expansion is relatively more important because the potential to increased yields is limited (i.e. yields are already quite high, because industrial-scale agriculture is already well developed in parts of this region). In Africa, yields will increase, but they will be limited by the availability of finance for investment in agriculture and they will not be able to keep up with the huge increases in production expected in the future.

9 It should be noted that the text above only refers to arable land. Other land used in agriculture includes permanent crops, grazing land and land used for shifting cultivation. Including these, the total area of land used for agriculture is three to four times greater than the area of arable land. However, projections for future requirements for these other types of land are not currently available.

The projections above do include an expansion in production of biofuel feedstocks (oilseeds, sugar, cassava and cereal crops), but they only assume an increase in production to the year 2020, then production held at that level for the rest of the period. They also do not present any projections of the use of wood for bioenergy. A more comprehensive study on bioenergy produced by the Word Bank (Cushion *et al*, 2010) shows that bioenergy production will continue to increase to 2030 (if all current bioenergy targets are achieved) and scenarios by the IEA suggest that production could continue to grow significantly after this if these policies are continued (IEA, 2012).

Figure 7 Global trends and projections for solid and liquid biofuel production, 1990-2050



Source: trends and projections to 2030 derived from Cushion et al (2010), with an extrapolation to 2050 based on IEA (2012). Note that these figures are for all biofuel and not just biofuels made from wood. MTOE = million tonnes oil equivalent.

Figure 7 presents a projection for total primary energy supply (TPES) from solid and liquid biofuels, from the analysis of Cushion *et al* (2010) and an extrapolation to 2050. The amounts are shown in million tonnes oil equivalent (MTOE) and one MTOE is equivalent to the energy content of about 3.8 million tonnes of woodfuel (on average).

The figure presents a number of important features in the trends for current and future bioenergy use:

- **Declining traditional uses of wood energy:** At present, most wood energy is consumed in developing countries in the form of fuelwood and charcoal used for cooking and, sometimes, for heating.[10] This is very different to what is often called "modern" uses of woodfuel, such as burning wood in power stations or modern heating boilers. So-called modern uses of wood energy also include the use of wood in sawmills and pulpmills for heat and energy generation (although this is not a modern phenomenon and has been done for many years).

  With rising incomes and urbanisation in many developing countries, growth in traditional consumption of woodfuel is slowing, because people now have greater access to other fuels (e.g. kerosene, bottled gas) in towns and cities and the income to purchase these more expensive fuels. Cur-

10 Until recently, FAO statistics presented data about production of fuelwood and charcoal. However, the data now is presented for woodfuel and charcoal. Woodfuel is the wood burned directly for energy (what used to be called fuelwood) plus the wood used for making charcoal.

rent analyses suggest that traditional use of woodfuel will not increase any more at the global level and may even decline slightly in coming decades.

The one region that is an exception to this is Africa, where urbanisation will not be accompanied by sufficient increases in income to encourage switching to non-wood fuels. In Africa, people will switch from fuelwood to a more convenient fuel, but this will be charcoal. Producing one metric tonne of charcoal uses about six cubic metres of wood (much more than if the wood was used directly for energy), so woodfuel consumption is expected to rise dramatically in this region in the future.

- **Increase in modern uses of wood energy:** Until recently, most industrial users of wood energy were in the forest products industry and growth in wood energy use was largely a by-product of growth in the production of these products. However, with the implementation of renewable energy policies and targets, wood is increasingly being used in power stations either for co-firing with other fuels or for use in facilities designed specifically for wood power generation. In addition, installation of new, modern wood heating boilers has increased significantly in the last few years.

  If these policies drive growth in consumption as expected, wood used in this part of the bioenergy sector could double by 2020 (the target date for achievement of many of these policies) and may continue to increase by about the same amount again by 2050. Taking into account that almost all of this bioenergy is produced from wood, this use of woodfuel will become much more important than traditional uses in the future.[11]

- **Use of wood for liquid biofuels:** Agricultural crops are currently used for the production of almost all liquid biofuels. However, a number of countries have policies and programmes specifically to support and encourage the development of liquid biofuels made from other types of biomass (usually wood, but also including grasses and, sometimes, algae).

  Liquid biofuel production is likely to double by 2020 then increase again (by the same amount) over the period 2020-2050. The proportion of this that will be produced from non-food crops is highly uncertain, but most governments seem to be aiming for about one-third as a long-term ambition.

Out of all these development, liquid biofuels are likely to have most of an impact on land-use change, because they are mostly made from agricultural crops. However, not all of these changes will necessarily involve the clearance of forests for biofuels. For example, Whiteman and Cushion (2009) showed that less than half of the additional land needed for biofuels might come from forests (about 45 million ha) and that 25 million ha of this could be development of energy crops (i.e. non-food biomass crops) that might include wood grown on short-rotations for this purpose (see Table 7). Furthermore, their estimate did not include any assumptions about increases in yield which, as shown by Alexandratos and Bruinsma, (2012), would also significantly reduce this new demand for land.

11 Comparing FAO woodfuel statistics and IEA solid biomass energy statistics, it appears that wood currently accounts for only about half of the traditional production of energy from solid biomass (woodfuel production in 2010 was 1,880 million cubic metres, equal to about 500 MTOE). Other materials used in this sub-sector include dung, crop residues and other forms of biomass. For heat, power and own use, wood accounts for almost all production and the only other significant biofuel used is bagasse. It is suspected that very little of this is captured in FAO's current woodfuel statistics because, until recently, most of this came from the unreported use of black liquor, wood residues and waste and very little came from forest harvesting.

Table 7 Additional land required for biofuel production by 2030 (at current yields)

Region	Potential land-use change and impact on forests (in million ha) by crop type and type of land likely to be used						
	Existing agricultural land		Degraded land	Potential conversion from forest to bioenergy use			Total for all crops
	Sugar beet and cereals	Temper-ate oil-seeds	Jatropha, cassava, sorghum	Biomass energy crops	Sugar cane	Tropical oilseeds	
Net biofuel importers							
North America	11.5	6.3		10.0			27.9
European Union	8.9	12.2		15.0			36.2
East Asia and Pacific	1.0	5.2	5.9		1.4	3.5	17.0
South Asia			6.8		0.4		7.3
Net biofuel exporters							
Europe and Central Asia		3.0					3.0
Latin America					4.3	8.0	12.3
Africa			1.4		1.3	2.8	5.5
WORLD	**21.5**	**26.8**	**14.2**	**25.0**	**7.4**	**14.2**	**109.1**

Source: Whiteman and Cushion (2009). Note: the above figures assume no increases in yield.

Assuming that yield and other productivity increases might meet half of the growing demand for biofuels, it appears that maybe about 10 million ha of forest land might be converted to produce crops for biofuels by 2030 and another 10 million ha for the period 2030-2050. Most of this conversion would occur in tropical regions as a direct or indirect consequence of expansion of sugar and oilseed production.

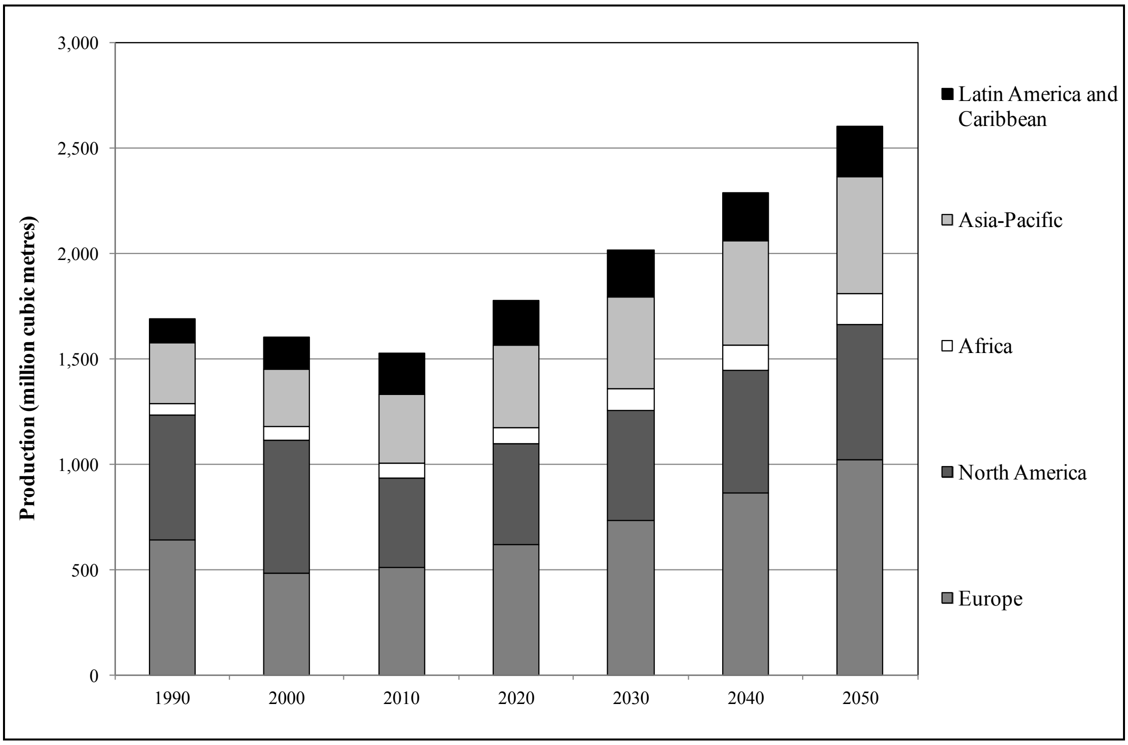
Land required for the first period is already included in the projections presented earlier (showing arable land increasing by about 100 million ha from 2010-2050 - see: Figure 6), so the second amount would be in addition to this and would be required for the later years of this projection. In addition to this, 25 million ha of forest might be converted to energy crops by 2030 and the same amount in the second period (2030-2050), although much of this might remain as intensively managed forest plantations if that is the preferred option.

With respect to the use of woodfuel, additional annual production of up to 250 million cubic metres would be needed by 2030 to meet the expected demand for liquid biofuels made from energy crops (depending on how much wood or other types of cellulose are used for this). A second increase of a similar amount would be required during the following two decades. However, a far greater expansion in wood use is expected for heat and power generation. The projected increases shown in Figure 7, when converted from million tonnes oil equivalent (MTOE) to wood use, amount to a new additional demand for about one billion cubic metres of wood in each of the two 20-year periods. Some of this will be met from non-wood sources and increased use of black liquor, but the majority is likely to come from increased use of wood and fibre.

In addition to increased demand for woodfuel, production of other forest products will rise in the future as populations and economies expand, creating additional demand for industrial roundwood. The last global projections of production and consumption of forest products were published in FAO's State of the World s Forests 2009 (FAO, 2009). These have since been negated by recent economic events, but a simple revision of the outlook for industrial roundwood production (also extrapolated to 2050) is shown in Figure 8.

For both of the next two 20-year periods, production of industrial roundwood might increase by slightly more than 500 million cubic metres, leading to a projected level of production in 2050 of 2.6 billion cubic metres, compared to the current (2010) level of production of about 1.5 billion cubic metres. Europe is expected to account for about half of this increase (mostly due to increased production in the Russian Federation), with the Asia-Pacific region and North America accounting for most growth in the rest of the World.

Figure 8 Trends and projections for industrial roundwood production, 1990-2050



Source: trends and projections to 2030 derived from FAO (2009), with an extrapolation to 2050.

Coming to the last of the "Five Fs", it is difficult to predict exactly how the increasing demand for more forest conservation will affect forest resources. Schmitt *et al* (2009) have recently produced an independent analysis of forest protected areas (based on satellite data), which shows that only 7.7 percent of the World's forests are within protected areas in IUCN categories I-IV. For a number of reasons (data sources, definition of forest, date of the study), this figure is lower than the result from the FRA, but it does suggest that more areas of forest might be put into legally protected areas in the future. However, the FRA also showed that a much larger area of forest is already managed for conservation (with or without legal protection), so it seems likely that protected areas will mostly expand into these areas rather than other areas that are currently used for production or may be converted to other uses.

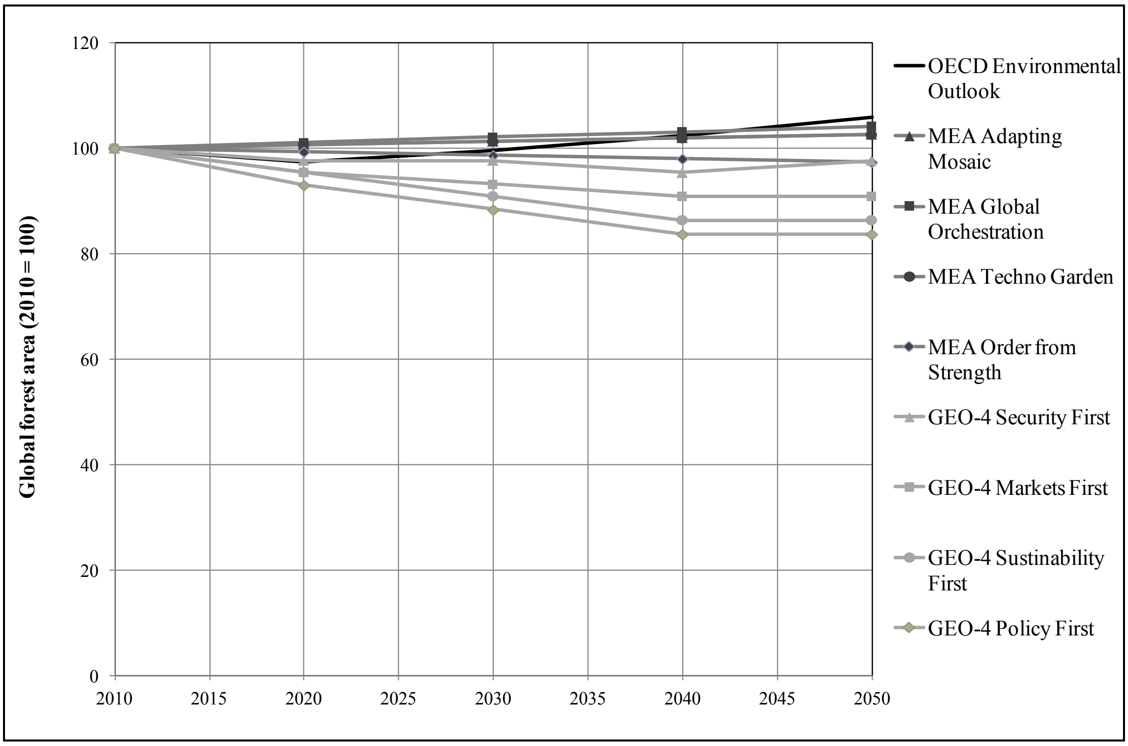
A more important question for the future is whether increased demand for biodiversity conservation will lead to broader measures that affect forests used for production (either now or in the future). Protected species legislation can result in large forest areas being taken out of production, as can stricter limitations on areas that can be harvested (e.g. on slopes, near watercourses or in particular forest types). More general conservation measures (e.g. requirements for environmental impact assessments and other planning measures) can also increase the costs of wood production, making some areas less economically viable for production. In some cases, countries may also simply choose to ban all production in certain types of forest (e.g. logging bans in natural forests, which are quite common in some regions). What does seem likely is that current forestry policy and management trends are likely to continue, discouraging harvesting in natural forest and pushing countries towards relying more heavily on planted forests for future wood production.

Future scenarios for the global forest area

Constructing projections for the future area of forests in the World is difficult because of the complex forces driving land-use change and the limited availability and quality of spatially referenced data on land-use, soils, climate, population and other relevant variables. Furthermore, compared to producing projections for production and consumption, it is more difficult to model land-use change in a deterministic way. Thus, most attempts to project land-use change have tried to combine various spatial models (for population, economics, trade, climate, land use, etc.) and use a range of possible changes in underlying variables to produce different scenarios for the future (see, for example: PBL, 2012).

The three most recent global outlooks for land-use change have been produced for the Millennium Ecosystem Assessment (MEA, 2005), the fourth Global Environmental Outlook GEO-4 (UNEP, 2007) and the OECD Environmental Outlook (OECD, 2012). Although all three of these studies used different definitions of forests and different land-use data sets, they all produced projections of forest area to 2050 under a variety of different scenarios. The projections from these three studies are shown in Figure 9, with the forest area figures from each of them converted to an index number (2010 = 100) for comparability.

Figure 9 Scenarios for future forest area, 2010-2050



Source: derived from OECD (2012), UNEP (2007) and MEA (2005).

The nine scenarios presented in Figure 9 show some significant differences in terms of the forest area expected in the future. The OECD projection shows a forest area in 2050 about six percent higher than at present (equal to an additional 230 million ha, based on the FRA estimate of total forest area in 2010). The MEA scenarios range from an increase of four percent to a decrease of three percent (+170 million ha to -100 million ha), with three of the four scenarios suggesting that forest area will increase. The GEO-4 scenarios are all much more pessimistic about the future, showing a decrease in forest area of two percent to 16 percent (or a loss of about 90 million ha to 660 million ha).

Despite these differences, all of the scenarios also show some similarities. For example, they all suggest that the forest area in Europe, North America and the Asia-Pacific region is likely to stay roughly constant or increase in the future and that most deforestation will occur in Africa and Latin America. The MEA and GEO-4 scenarios also show how changes in assumptions about policies can have significant impacts on land-use change.

One of the main differences in the scenarios is the extent to which afforestation and forest restoration appear in the future. For example, the OECD projection suggests that deforestation will slow in most tropical countries over the next 10 to 20 years and that the expansion of forest plantations will increase in the future in temperate countries and places such as India, Brazil and China. This leads to the high projected increase in global forest area over the next four decades. A similar development occurs in the higher projections from the MEA. In contrast, expansion of forest plantations is not a major factor in the GEO-4 projections, suggesting that their projection model does not include a strong link between economic growth and forest plantation expansion.

From the scenarios presented above, it is difficult to get a clear idea of exactly how much forest there might be in the future, although it looks like there will probably be less forest in Africa and Latin America and more forest in the rest of the World (or at least, about the same amount as now). This general impression is also consistent with the historical trends reported in the FRA and the projections for arable land shown earlier.

Another important message from these scenarios is that continued deforestation in tropical countries is no longer as certain as it once seemed, with four out of the nine scenarios suggesting that forest area might actually increase in the future. The uncertainty here will be whether the socio-economic drivers (rising wood demand and falling rural populations) will be sufficient to overcome some of the current obstacles to afforestation and reforestation. Improvements in governance, land tenure and other factors enabling investment would seem to be crucial in this respect.

Some final thoughts about forest management and use in the future?

The analysis presented here confirms the statements in the introduction to this chapter that the demands placed upon forests are expanding in terms of both the quantity and variety of benefits that people expect to obtain from forests. Many of the implications of this for forest management and use have been described in the previous sections on driving forces and outlook. This final section presents three broader implications for consideration by stakeholders in the sector.

Intensity of forest management: The projections for forest product demand suggest that woodfuel consumption might increase by about half in the next four decades and industrial roundwood consumption may increase by about two-thirds. Increases in demand for other forest benefits can not be estimated precisely, but the growth in global population alone suggests that they might also increase significantly. At the same time, most projections of forest area show a decline or, at best, a very modest increase in forest area in the future. Thus, in order to satisfy these demands, the intensity of forest management will have to increase.

The challenge here will be to adapt forestry policies and management techniques to intensify management in ways that are sustainable and economically viable. For wood production, some fairly clear strategies are already available and well-tested (e.g. establish more forest plantations and increase recovery and recycling of wood and fibre). Furthermore, to a large extent, developments such as these will occur naturally in the future, being driven forward by market forces. However, when it comes to increasing the intensity of forest management for other social and environmental benefits, the techniques and strategies that can be employed are not so clear and their effectiveness is far less certain.

For example, in the case of biodiversity conservation, the most common approach currently used by many countries to meet this demand is simply to increase the area of forests in legally protected areas. Indeed, there is a specific, globally agreed target to do this. Taking a similar approach, conservation measures used in other forest areas are also often focused on restricting activities to protect biodiversity (although, in some cases, countries find it difficult to enforce these rules). While these measures no doubt, in principle, go some way towards helping to conserve biodiversity, they are not the same as actively and intensively managing forests to increase biodiversity. Some developed countries have the knowledge and resources to take a more active approach to biodiversity conservation in forests (and are doing so), but many other countries lack this capacity and, unfortunately, these are often exactly the places where demands for more biodiversity conservation are highest.

With other more easily measured environmental factors (such as carbon and water), scientific knowledge about how to manage forests for these outputs is more advanced. However, there is still probably quite a long way to go before this knowledge can or will be applied in the field in many countries. In particular, the benefits of storing carbon in forests and wood products are relatively easy to understand and measure, but only a limited number of options are widely discussed at present, clear management prescriptions are not generally available and incentive structures are not yet in place to make a significant difference to current practices.

In the social dimension, the situation is a little better, because many countries have a lot of experiences of different approaches and techniques they have used to try to increase the social benefits provided by forests. Of course, many of these benefits are highly context-specific and their production probably depends as much on local socio-economic situations as it does on how forests are managed. However, beyond a few general prescriptions (e.g. increase access to forests, strengthen tenure and local governance), there has not really been a systematic assessment of the linkages between forest management and policies and the delivery of these benefits.

If the forestry sector is to meet the growing expectations of society for more forest benefits, then some of these challenges will have to be overcome, particularly if public funding is required to invest in production of some of these benefits. This will require not only better management of forests for these benefits, but also better communication of the results. If not, the sector will continue to remain vulnerable to developments in other sectors and will fail to achieve its potential to contribute to a more sustainable future for the World.

Managing the forest transition: The text earlier described forest transitions in terms of forest cover and deforestation rates, but a broader transition is also taking place (at least in many developing countries) and this is the increasing importance of economic or commercial factors in decisions about land-use and land management. As shown in Figure 4, commercial agriculture is becoming relatively more important as a driver of deforestation, so the sector will have to adapt to this. In particular, forestry administrations in many places may have to start placing less emphasis on defending forests from shifting cultivators and focus more on developing forest land-use plans that justify why areas should not be converted to other uses.

With the expected developments in agriculture and food production, some forest clearance in the future will be inevitable and desirable. More intensive forest management for wood production will also result in changes in forest characteristics (i.e. more forest plantations). Thus, it will become increasingly important to identify the management objectives for different forest areas, so that planned and rational land-use change can take place. As recent experiences in Brazil have shown (The Economist, 2012), attempts to try to formalise and rationalise land-use change are likely to be publicly and politically sensitive, but many more countries are likely to have to face these challenges in the future.

A related issue is that increasing the commercial benefits from forest management is likely to become even more important in the future if forests are to compete with other land-uses. This means that forestry stakeholders will have to explain more effectively how using wood creates value for forests and helps to protect them (rather than destroy them), as well as supporting rural livelihoods. It also means that forests and forest management will have to deliver more local economic benefits to the people living in and around forests, not only as a social benefit but as an incentive to keep land under forest cover.

This transition to more commercial landscapes will also present a number of opportunities for the forestry sector. For example, many different types of land will be unsuitable for commercial agriculture (e.g. steep slopes, stream banks, rocky areas) and it is likely that many commercial landowners may be interested in planting trees as an additional business to use their spare land. For generations small-scale tree planting on farms has been common in Europe and North America (for a variety of reasons) and, more recently, tree planting for wood production has accelerated dramatically in places such as India and China. In a similar way, with smaller rural populations and less shifting cultivation, there may be much more potential in some places to promote forest restoration. If these opportunities can be identified, forestry administrations could play a very positive and active role in supporting such developments in the future.

The outlook for forest resources in Africa: One final observation concerns the outlook for forest resources in Africa. While much of the analysis above has shown some remarkable similarities between regions, Africa is notable as the one global region that has a very different socio-economic outlook. Here, the population is expected to continue to grow quite rapidly in the future. It will also remain quite a young population, but with relatively low income and a significant number of people remaining in rural areas. In addition, despite having rather abundant forest and land resources, the projections for production of food and forest products suggest that Africa is still some way from achieving its full potential.

Here, the outlook for forest resources is much less predictable, but it seems likely that the need to demonstrate local economic benefits from forest management will be more important than elsewhere, if forests are to compete with other land uses. Furthermore, given the huge demands that will be placed upon governments to provide public goods and services to these fast-growing populations, the dominance of the public sector in the control and management of forest resources looks likely to become increasingly untenable in the future.

If forests and forest management in Africa are to progress towards meeting their full potential, it may be necessary for forest policies and institutions there to create more space for small-scale, private-sector development within the sector. Already, some countries have made significant progress with community forestry and small-scale enterprises for production of non-wood forest products. A number of countries have also shown how partnerships between large companies and small-scale producers can be successful (in agriculture, forestry and plantation crops). Building upon these successes and replicating them in other countries may be the best way to generate local economic benefits and support forest management in the future.

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