Management, conservation and sustainable development of forests

As forests are complex ecosystems requiring balanced and sustainable management, one of the main challenges today is to reconcile the often conflicting priorities of those who depend on them for a whole range of goods and services. It is also necessary to take into account the ways in which forests affect and are affected by policies outside the forest sector. Such a comprehensive approach requires innovative partnerships and better linkages at all levels and across sectors. Indeed, this imperative has never been greater, as demonstrated by the examples in this chapter.

A summary of six case studies in developing countries with low forest cover shows that various government departments, organizations and other interested parties need to work together to resolve issues related to planted trees in arid and semi-arid zones, in urban as well as rural areas. In 2002, the International Year of Mountains drew attention to the contributions that mountain forests make to hundreds of millions of people, and the forestry community welcomed a new international alliance for sustainable mountain development. The chapter also highlights integrated management plans for forests in the Mediterranean basin, which have long called for the involvement of stakeholders in their development and implementation. Forest fire management around the world also requires collaborative approaches, and international interest in coordinating responses and sharing personnel and equipment in emergency situations is growing. Solutions to unsustainable hunting in tropical forests, especially in Africa, are being sought through a number of collaborative arrangements. Lastly, in the context of international agreements on climate change, in which the unique role of forests is recognized, partnerships between and among countries from the North and the South are the basis on which Joint Implementation and the Clean Development Mechanism are built.

ROLE OF PLANTED TREES IN DEVELOPING COUNTRIES WITH LOW FOREST COVER: FINDINGS FROM SIX CASE STUDIES

Deforestation and forest degradation, coupled with difficult ecological conditions in several parts of the world, have seriously reduced forest cover in many countries. The situation is exacerbated where low rainfall slows regeneration and reforestation and where forest land is subject to pressures from shifting cultivation, livestock grazing and the uncontrolled gathering of fuelwood. In developing countries, natural and planted forest land is critical to rural communities, and the loss of forest productivity and biological diversity is a serious threat to livelihoods and the quality of life.

FAO's Global Forest Resources Assessment 2000 (FRA 2000) estimated that 56 countries are low forest cover countries (LFCCs), having less than 10 percent of their area classified as forest (Table 4). In contrast, the global forest area is almost 30 percent of total land area (FAO, 2001a). LFCCs, which are found primarily in arid and semi-arid zones of Africa and the Near East, often reflect severe ecological degradation that directly affects people's lives. The LFCCs have a total land area of 2 726 million hectares and a total population of about 900 million, of which 64 percent lives in Asia. Of these 56 countries, only 13 have more than 0.1 ha of forest per capita. However, low

forest cover does not always coincide with country borders, so the problem might be more widespread. In addition, some countries, such as China, have more than 10 percent forest cover yet a low area of forest per person.

In LFCCs in Africa, Asia and the Near East, planted forests account for only a small proportion of the forest cover. Algeria, Bangladesh, Ireland, the Islamic Republic of Iran, Morocco, Pakistan, South Africa and Uruguay are the only countries with more than 500 000 ha of planted forests and trees, whereas half the countries have less than 10 000 ha. Most tree planting programmes were started between 1960 and 1980, although in Denmark, Ethiopia and South Africa large-scale efforts began earlier. The annual new planting rate is substantially higher in Asia and the Near East than in Africa, but there is considerable variation among countries. Only ten of the developing countries plant 10 000 ha or more per year.

Many LFCCs in the developing world, particularly those in arid zones, rely on trees to prevent erosion, halt desertification and protect biological diversity, crops, settlements and watersheds. In addition, their rural populations depend on trees for fuel, poles, construction wood and a range of non-wood forest products (NWFPs) such as fodder, food and medicine. In these countries, there is little potential for producing industrial wood, so it is nearly impossible to fund development of the sector from the sale of wood.

Case studies

In 2002, regional workshops were held in the Near East (Iran) and Africa (Kenya) to develop strategies, action plans and proposals to enhance the role of planted forests and trees outside forests in LFCCs. In preparation for the workshops, visiting FAO teams undertook case studies in six countries in Africa and the Near East: Ethiopia, Iran, Mali, Namibia, Oman and Tunisia. The case studies (to be published in 2003) focused on countries where problems were the most serious because of dry climate and low forest cover. Ethiopia, Iran and Mali are representative of large countries, Namibia is medium-sized, and Oman and Tunisia are relatively small. Ethiopia is densely populated,

TABLE 4

Estimated planted forest areas and annual planting rates in low forest cover countries, by region[a]

Region	Number of countries	Total land area *(million ha)*	Total forest[b] *('000 ha)*	% forest cover	Planted forests[c]		Annual planting *('000 ha)*
					('000 ha)	*(% of total forest area)*	
Africa	20	1 407	55 985	4.0	3 739	6.7	85
Asia and Oceania[d]	27	1 238	46 067	3.7	4 976	10.8	141
Americas	5	57	1 503	2.7	656	43.6	53
Europe	4	24	1 470	6.0	944	64.2	n.a.[e]
Total	**56**	**2 726**	**105 025**	**3.9**	**10 315**	**9.8**	

[a] Low forest cover countries are defined as those countries with less than 10 percent of their land area under forest.
[b] Forest land is defined as having more than 10 percent crown cover and an area of more than 0.5 ha, and excludes land predominantly used for agriculture.
[c] Planted forests do not include plantations of less than 0.5 ha in area or less than 20 m in width, and thus some agroforestry plantings and trees outside forests are excluded.
[d] Includes the Near East, Asia and the Pacific.
[e] Not available.
Source: FAO, 2001a.

very rural and very poor. At the other extreme, Oman is largely urban and the people are wealthier. Arid and semi-arid climates dominate, although different types of climate do exist within each country. All the countries have deserts, and animal herding on rangeland is more common than agriculture.

Each case study outlined the causes and effects of forest degradation, described lessons and proposed strategies and methodologies to address issues. This section summarizes the main findings and observations (Table 5).

Findings: common features and issues

Environmental degradation. Although not always well documented, the six countries studied had all experienced substantial deforestation, forest and soil degradation and an increase in the area of bare land over the years. The need for fuelwood and grazing is the main cause of forest degradation, frequently leading to loss of forest cover and biological diversity, erosion, desertification and reduced water resources. The situation is especially serious in the countries with large rural populations and high birth rates (Ethiopia, Mali and Namibia). In all the countries except Oman, the herding of animals on rangelands that are often partly forested is a major land use. Rural populations rely on forests and woodlands for energy and fodder rather than for timber. These resources are also important for poles, craft materials, shade and NWFPs such as fruits and medicine. In addition, they support wildlife, hunting and tourism, and are rich in biological diversity.

Forest resources assessment data. The lack of reliable data on natural and planted forests, except in Tunisia, poses a significant constraint to formulating and implementing national forest policies and plans, and to monitoring and reporting current conditions and trends. Until data are improved, analysis of future scenarios may not provide a true assessment of the potential of planted forests.

Change in forest cover. Tunisia was the only country to increase its forest cover (+ 0.2 percent) between 1990 and 2000 (FAO, 2001a). The annual loss in Ethiopia, Mali and Namibia was 0.7 to 0.9 percent, while in Iran and Oman there was no substantial change. Except possibly in Tunisia and Iran, natural forests were under serious threat. In this regard, the studies noted the need to conserve and protect representative samples of natural ecosystems and unique forest types.

TABLE 5
Data for the six low forest cover countries studied

Country	Land area *('000 ha)*	Total forest *('000 ha)*	Forest *(%)*	Annual forest cover change		Planted forest *('000 ha)*	Population per km²	Rural population *(%)*	GNP per capita *(1997 US$)*	Predominant climate
				('000 ha)	*(%)*					
Ethiopia	110 430	4 593	4.2	-40	-0.8	216	61.1	83	112	Arid to temperate
Iran	162 201	7 299	4.5	n.s.	-	2 284	41.2	39	1 581	Continental/arid
Mali	122 019	13 186	10.8	-99	-0.7	15	9.0	71	259	Arid to semi-arid
Namibia	82 329	8 040	9.8	-73	-0.9	0.3	2.1	60	2 196	Arid to semi-arid
Oman	21 246	1	0	n.s.	-	1	11.6	18	9 500	Primarily arid
Tunisia	16 362	510	3.1	+1	+0.2	202	60.9	35	2 092	Mediterranean

n.s. = not significant.
Source: FAO, 2001a and FAO, country case studies (in preparation).

FAO/15859/R. FAIDUTTI

Millet cultivation under **Acacia albida** *in Mali's parkland agroforestry – the trees improve nutrient cycling and alter microclimate, increasing crop production while providing fuelwood, fodder, pods and shade for animals*

Role and extent of planted forests. The areas of planted forests in Ethiopia, Mali, Namibia and Oman are small compared with the size and needs of these countries. Both farmers and the public sector plant forests for non-industrial uses, primarily fuelwood and poles, but the survival and productivity of the trees are often low. While the current expansion of planted forests is about 2 000 and 700 ha per year in Ethiopia and Mali, respectively (FAO, 2001a), it does not compensate for the loss of natural forests.

In Tunisia, the loss of forest area has largely stabilized as a result of forest planting, other land management changes and a decreasing rural population. The difficulty in distinguishing between planted and natural forests for some native species and the lack of a recent inventory mean that the total area of planted forests is not known. However, the annual planting rate is estimated at about 14 000 ha.

Planted forests in Iran cover 2.3 million hectares and are expanding at 63 000 ha per year. They include a wide variety of indigenous and introduced hardwood species. Industrial purposes account for about 10 percent of the total, with the remainder used for environmental protection, soil stabilization, fuelwood and poles. As a result of the government's promotion of fast-growing industrial planted forests, the area of poplar plantations is estimated at between 110 000 and 150 000 ha (FAO, 2000a).

Role of trees outside forests. Trees outside forests take a variety of forms, with agroforestry, village and urban plantings, roadside plantings and orchards being the most widespread.

Between 1986 and 2000, Mali's agrosilvicultural and silvipastoral activities consisted of the planting of 4 000 km of shelterbelts, 14 000 ha of woodlots and 5 000 ha around water points and in pastures. Mali is also noted for its parkland agroforestry based on natural trees, a formation that covers 39 percent of the country. In traditional Sahelian parklands, millet and sorghum are often grown with *Acacia albida.* On these infertile soils, production of crops grown within a 5- to 10-m radius of the trees has doubled or trebled over that of crops grown in the open, because of improved nutrient cycling and a changed microclimate. In addition to increasing crop yields, the trees provide fuelwood, fodder, pods and shade for animals during the dry season. There are also extensive areas of other parkland systems in Mali where indigenous trees such as karité (*Vitellaria paradoxa*) produce oil, while *Acacia senegal* produces gum arabic.

Namibia has similar parkland systems. In the north, where most people live, trees that produce fruits, oils, nuts, medicinal products or craft materials also improve soil fertility or provide shade, and are therefore often left standing in agricultural fields. Law and customary practice acknowledge their importance, imposing penalties and fines on people who cut them down. In addition, shade and fruit trees are planted around homesteads and farm woodlots

and as living fences. The Directorate of Forestry is currently promoting tree planting in woodlots.

In Tunisia, agroforestry practices include the planting of *Acacia*, *Atriplex* and *Medicago* species for browse and forage within and beyond forest areas, and the planting of windbreaks, which were protecting around one-eighth of irrigated agricultural land by 2000. Emphasis is also being placed on planting multipurpose species (such as walnut, pistachio, pecan, hazel and carob), particularly in mountainous areas and in forest clearings.

Establishing woodlots in villages and near urban centres relieves pressure on natural forests for fuelwood, poles and fodder. In cities, tree planting is stressed for aesthetic and recreational benefits. While urban, peri-urban and roadside planting is promoted in all the countries studied, Tunisia has perhaps been the most active. Initiatives include establishing a green belt around Tunis, creating parks, lining boulevards and motorways, planting coastal esplanades and implementing a national programme for heritage trees.

In Mali, about 22 000 ha of plantations have been established in villages and urban areas since 1986, and there has been additional planting along roadways. Iran has been active as well, with a network of urban and peri-urban planted forests and parks. Often, however, problems arise when irrigation cannot be sustained in the long term because of water shortages. The use of treated wastewater from cities is therefore seen as an opportunity for urban and peri-urban tree planting in several countries.

Combating desertification. Combating desertification is a major objective for all the countries, with Iran and Tunisia seeming to make the most progress. Iran has established 140 desertification control stations since 1963. Now, after 40 years of concerted effort, it reports that it has controlled one-fifth of its seriously affected lands. In Tunisia, 17 200 ha of planted forests were established to fix dunes between 1990 and 1999, with an additional 5 700 ha planted as windbreaks and shelterbelts.

Institutional capacity and national planting plans. Problems of poor records and underfunded government institutions without clear strategies to address forest issues were particularly noticeable in Ethiopia and Oman. Tunisia, on the other hand, is aiming to plant 70 million trees annually, and Iran also has a major planting programme. Namibia, independent only since 1990, has developed bold forest policies and legislation advocating tree planting and recognizing the role of forests and woodlands. Mali has a relatively small planting programme, preferring to focus on managing natural forests.

Centralized decision-making, restricted landownership and a lack of research are other common issues identified in the countries studied. In addition, it was noted that several agencies sometimes deal with the same problems in an uncoordinated manner, thereby hindering results.

Planting trees enhances urban environments

In the next three decades, rapid urban population growth will become a major issue, possibly affecting more than 50 percent of the African and Asian population and 75 to 80 percent of people living in Central and South America (FAO, 1999a). This fast expansion, often on erosion-prone hillsides or in swampy areas, means that most settlers live in poor conditions and face food insecurity, lack of clean drinking-water, inadequate energy for domestic use, shortage of construction materials, air pollution and unsanitary disposal of waste and sewage.

Since the quality of the urban environment is closely linked to the economic and social regeneration of cities, tree planting for amenity brings several benefits, with beautification stimulating outside investment, business development and, hence, employment. Using treated sewage water for tree planting also improves urban environments. While wastewater storage and disposal problems are reduced, the planting protects reservoirs from erosion and siltation, stabilizes hilly or sloping urban areas, provides additional green spaces and generates income. Notable improvements to the environment and human health can thus be achieved.

Lessons

The following observations are based on the case studies.

- The loss and degradation of forests and woodlands and subsequent soil erosion and desertification are largely the result of human activities, aggravated by arid and semi-arid conditions and compounded by the many rural and poor people who depend on scarce natural resources, have large animal herds and use fuelwood in an unmanaged way. Water scarcity and unpredictable droughts add to the problem.
- Strong government policies, strategies and institutions are required, in addition to a decentralized approach, and need to be supported by competent and knowledgeable personnel.
- Intersectoral and interdisciplinary approaches are needed to address problems of forest loss and environmental degradation that are not solely forestry driven but result from such factors as demographic changes, competing land uses (e.g. grazing and agriculture), lack of alternative income, food insecurity and low levels of education.
- Participatory processes, emphasizing the needs of local people and traditional knowledge, are essential.
- Planting new forest resources or regenerating and sustainably managing natural forests and woodlands will reduce pressure for fodder and fuel, as well as possibly providing or diversifying household income and improving the environment.
- Planting trees on farms (agroforestry) and other activities outside forests offer employment opportunities and immediate benefits to smallholders and the rural poor for subsistence, provide refuges for wildlife, improve the local climate and enhance landscapes.
- Programmes to plant trees, coupled with efforts to reduce the impoverishment of forests, can stabilize and reverse deforestation and degradation in arid climates. Two of the six countries studied, Tunisia and Iran, illustrate this point well.
- Large government planting programmes can be successful, but this approach alone will not necessarily assist the rural poor or solve the problem of overgrazing in forests or rangelands. In this regard, agroforestry practices and community planting programmes, coupled with improved animal and crop management, are very important.
- In addition to participatory approaches, families and communities need to have secure land tenure and to benefit from planting trees. Farmers will seldom plant trees for fuelwood alone, as there are usually other immediate energy alternatives. They are far more likely to be interested if they know that they will also draw benefits in the form of food, fodder, shelter, shade or income.
- In arid and semi-arid environments, planting trees can be difficult and costly. Labour shortage can also be a constraint, since the planting period usually coincides with that in the agricultural sector. Tunisia and Iran have shown that land can be rehabilitated by planting trees, but planted trees currently have a minor role in the other countries studied.

FAO/13985/I.SAAC

In Tunisia, forest planting at the rate of about 14 000 ha per year has helped stabilize and reverse deforestation and degradation

The way forward

The following suggestions, among others, may help to improve the contribution of trees to the environment and to sustainable livelihoods in developing countries with low forest cover.

- Integrated and holistic approaches must be implemented in order to reduce pressure on forest and range resources. The planting of trees, whether as forests or tree clusters, is part of the solution, as are the regeneration and management of natural forests.
- With regard to providing rural people with an alternative income, approaches include large-scale planted forests for industrial purposes, commercial orchards, small-scale projects for NWFPs and tourism.
- Most LFCCs need better information on the status of their resources so that they can monitor change and develop integrated

Urban forest watershed management: an example of partnership

TreePeople, a non-profit organization based in Los Angeles, United States, demonstrates the benefits of partnerships in providing cities with sustainable water supplies. The following is TreePeople's account of a successful project to help Los Angeles meet half of its water needs through urban watershed management, while at the same time improving the quality of life. The project builds on ten years of research, design, cost-benefit analysis, demonstration projects and multistakeholder processes.

FLAWS IN TRADITIONAL MANAGEMENT OF INFRASTRUCTURE SYSTEMS

Most cities were not designed, organized or managed as part of the natural ecosystem. Water supply, wastewater, solid waste and storm water infrastructure systems are managed by separate government agencies that typically do not coordinate operations. As cities expand, these systems often grow further apart, compete for scarce funds and unwittingly undermine each other's efforts as they struggle individually to cope with increased flooding, polluted storm water runoff and water shortages. As the problems and costs accrue, solutions become increasingly elusive and fewer resources are available to meet other social needs. Through integrated approaches based on the urban forest watershed, cities can achieve environmental, economic and social sustainability.

Los Angeles is seeking technical and economically feasible solutions for the range of problems associated with urban infrastructure management. An average annual rainfall of 15 inches (381 mm) provides the city with up to half the water it needs for the year. However, because nearly three-quarters of its area has been rendered impermeable by sprawl (buildings, parking lots, paving) and building codes require all runoff to be directed to storm drains, more than 85 percent of the city's rainfall has become a toxic and dangerous flood threat. To deal with this, various agencies planned separate construction projects which would have totalled more than US$20 billion but did not, taken together, offer sustainable solutions.

A PARTNERSHIP APPROACH

In 1992, TreePeople proposed using watershed management practices to resolve these problems, but the proposal was rejected as too expensive for the single purpose of flood control. To counter the fact that relevant agencies did not have the tools or the authority to take into account such additional benefits as water supply, pollution prevention, energy conservation and economic development, TreePeople assembled a multi-agency partnership in 1994, consisting of the United States Forest Service, the Los Angeles Department of Water and Power, the Los Angeles Stormwater Management Division, the United States Environmental Protection Agency, the Metropolitan Water District, the City of Santa Monica and the Los Angeles County Flood Control District. The project, known as the Trans-agency Resources for Environmental and Economic Sustainability (TREES), designed best management practices to overhaul and manage the city's use of watersheds, tested the technical viability of the designs through pilot projects, created a cost-benefit modelling tool and conducted a cost-benefit analysis, and then applied the results more broadly.

RESULTS OF AN INNOVATIVE APPROACH

The information and demonstrations of the TREES Project resulted in substantial changes in Los Angeles public works agencies and

management policies and plans. Tunisia has made the most progress in this regard, and its approach could be used as a model for others.

- Countries with similar problems need to share experiences and adapt approaches to local conditions. Both Tunisia and Iran offer insights here, as do Australia, South Africa and the United States. The expertise of international agencies such as FAO, the United Nations Environment Programme (UNEP), the World Agroforestry Centre (ICRAF) and the Center for International Forestry Research (CIFOR) should also be tapped.
- An alternative to using scarce irrigation water, especially in urban and peri-urban planting programmes, is to utilize treated wastewater from cities. FAO (2001b) is a good source of information for arid countries, drawing from its own experience and that of current projects in Egypt, Jordan, Kuwait and Yemen.

local policies. By 2000, the Los Angeles County Flood Control Agency had changed its name to the Watershed Management Division, reflecting its changed mission. The City of Los Angeles followed suit a year later, transforming its Stormwater Management Division into the Watershed Protection Division.

The TREES Project was awarded a contract to remodel a 1 100-ha 8 000-household urban subwatershed of the Los Angeles River. After a lengthy feasibility study, the Los Angeles County Watershed Management Division is developing the management plan, environmental impact documents and large pilot projects for the Sun Valley watershed. Engineers originally planned to build a US$42 million storm drain to combat one of the county's largest and most intractable flooding problems. Instead, the new urban forest watershed may cost as much as US$100 million, but can produce in excess of US$400 million in benefits, including nearly US$180 million in conserved water, 370 new jobs, energy savings, cleaner air and "green" schools. Best management practices under consideration include capturing, cleaning and infiltrating storm water in such locations as parks, schoolyards, commercial parking areas and, potentially, the lawns of individual homes.

Successful implementation of the Sun Valley watershed scheme requires an extensive multi-agency partnership to design, fund, manage and monitor the project. It also requires a new spirit of collaboration among government, individuals, families, businesses and community organizations. Recognizing this, Los Angeles County is committed to the stakeholder planning process and is conducting an unprecedented community education and outreach programme.

Further information on TreePeople and its projects can be found on the Internet: www.treepeople.org.

The greening of the paved grounds of an elementary school near Los Angeles, California

TREEPEOPLE

A meeting of LFCCs in Tehran in 1999 (FAO, 2000b) emphasized the need for concerted action, government commitment and collaboration among countries with similar problems. The declaration establishing the Tehran Process calls for increased investment from within the region, the donor community and international agencies. It also suggests that non-governmental organizations (NGOs), the private sector, research and training institutions and the rural poor could have a positive role, especially at the local level. The Tehran Process has much potential to make a real difference in the future, particularly if efforts are geared to national forest planning, forest management and planting programmes aimed at increasing forest cover and meeting the needs of rural people.

MOUNTAIN FORESTS AND SUSTAINABLE MOUNTAIN DEVELOPMENT

Twenty-eight percent of the world's closed forests are mountain forests (FAO, 2001a) (see Table 6), and their importance for sustainable mountain development is increasingly recognized. Indeed, mountain issues are receiving more attention than ever as a result of the observance of the International Year of Mountains in 2002.

As part of highly complex ecosystems, including watersheds, mountain forests capture and store rainfall and moisture, maintain water quality, regulate river flow, reduce erosion and protect against landslides, avalanches, falling

International Year of Mountains: building partnerships

In 1998, the United Nations General Assembly declared 2002 the International Year of Mountains and invited FAO to be the lead agency in preparing and coordinating activities to:

- increase awareness of and knowledge about mountain ecosystems;
- encourage conservation and sustainable development of mountain resources;
- promote and defend the cultural heritage of mountain communities;
- find solutions to the conflicts that frequently arise in mountain areas.

At the World Summit on Sustainable Development in 2002, the Government of Switzerland, on behalf of several countries, UNEP and FAO, launched the International Partnership for Sustainable Development in Mountain Regions. Its objectives are to promote and strengthen cooperation among donors, implementing agencies, NGOs, the private sector, mountain communities and others. Operating on the basis of common goals, commitments and priorities, the partnership addresses such issues as poverty, conservation of biological diversity, food security and key institutional concerns. FAO has been active in the partnership since its inception, and also organized a satellite meeting during the 2002 World Food Summit: five years later conference, at which participants formally declared their support.

Further information on the International Year of Mountains and the partnership can be found on the Internet at www.mountains2002.org.

FAO FORESTRY DEPARTMENT/FO-0279/T. HOFER

The Himalayas in Nepal

TABLE 6
Mountain forest types by area and by dominant region

Mountain forest types	Total area		Main regions
	('000 km²)	*(%)*	
Tropical and subtropical moist mountain forests	2 237	25	Tropical Andes, Central America, East Africa and Madagascar, Southeast Asia
Tropical and subtropical dry mountain forests	534	6	Southern Africa, India
Temperate and boreal evergreen conifer mountain forests	2 762	30	North America, Europe, Central Asia, Himalaya
Temperate and boreal deciduous conifer mountain forests	1 317	14	Central Asia, Northeast Asia
Temperate and boreal broad-leaved and mixed mountain forests	2 247	25	North America, southern Andes, Europe, Himalaya, East Asia
Total	**9 097**	**100**	

Source: UNEP-WCMC, 2000.

rocks and floods. They often have higher biological diversity and endemism than adjacent lowland forests, although the value of this has not yet been fully understood. On the other hand, mountain forests are sensitive to fluctuations in climate, which could influence – both positively and negatively – their capacity to continue providing important services to mountain inhabitants and hundreds of millions of people living downstream. Hence there is a need to improve understanding of possible climate changes so that planning for the potential impact can begin.

In mountain communities, forests are often part of multiple land-use systems as pastures and sources of organic material for agriculture. In many mountain areas, particularly in developing countries, wood is the main fuel source for local inhabitants as well as for people in nearby settlements in the foothills and plains. Mountain forests also provide NWFPs and recreational facilities, and add to the scenic beauty of landscapes, national parks and protected areas. In many regions, they also enshrine sacred groves and trees, and are thus culturally important.

In many industrialized countries, mountain forests consist of overmature planted species that are underexploited today because fuelwood has been replaced by other sources of energy and because they are not economically viable to harvest. As a result, the vitality of these forests is reduced and their protective function impaired. In many developing countries, the opposite holds true: forests are overexploited because of high demand for fuelwood and agricultural land, unsustainable forest practices and the excessive granting of timber concessions.

Mountain forests need to be managed as an integral part of mountain ecosystems, and the involvement of local communities is essential. There are a number of examples, particularly in mountainous parts of Europe, where community forestry has been practised for centuries, creating employment and generating income. Today, community forestry is also being implemented successfully in the mountain areas of many developing countries.

As a major event of the International Year of Mountains, the Fourth International Consultation on Mountain Forests was held in Navarra, Spain, in June 2002. One of its main conclusions was that the fate of mountain forests often depends on government policies and incentives in other sectors, such as agriculture, energy and trade. For example, mountain forests

in Europe are at present recovering because of reduced pressure from grazing, decreased air pollution and a general improvement in the rural mountain economy as a result of tourism and other activities (see also EOMF, 2000).

To safeguard mountain forests and ensure their multiple contributions, forest policy and practices need to integrate better their productive, protective, social and cultural functions. This requires improved knowledge about the roles of forests in mountain ecosystems and about their benefits, including those that reach beyond mountain areas. Lastly, opportunities need to be expanded for capacity building and training related to the management, conservation and development of mountain forests. The establishment of the first post-graduate course in mountain forestry at the University of Vienna's Soil Science Institute is a step in the right direction.

International Association for Mediterranean Forests: a multidisciplinary approach

The International Association for Mediterranean Forests (IAMF) fosters the exchange of knowledge and experience to address problems related to Mediterranean forests. It uses national networks of experts from across sectors to find solutions, including ways for policies to reflect action that needs to be taken. In partnership with the European Community, national and regional governments and others, IAMF recently led a project that culminated in the Marseilles Declaration on Mediterranean Forests. This declaration draws attention to the poor understanding of the characteristics of Mediterranean forests and the lack of coordinated decision-making on matters pertaining to their sustainable management. It also calls for a first Mediterranean conference on forests and natural land environments in 2003, with a view to consolidating the effectiveness of the networks so that greater consideration can be given to Mediterranean forests in drafting sustainable land-use and management policies.

Further information on IAMF and on Mediterranean forests is available on the Internet at www.aifm.org.

FORESTS AND WOODED LANDS IN THE MEDITERRANEAN BASIN

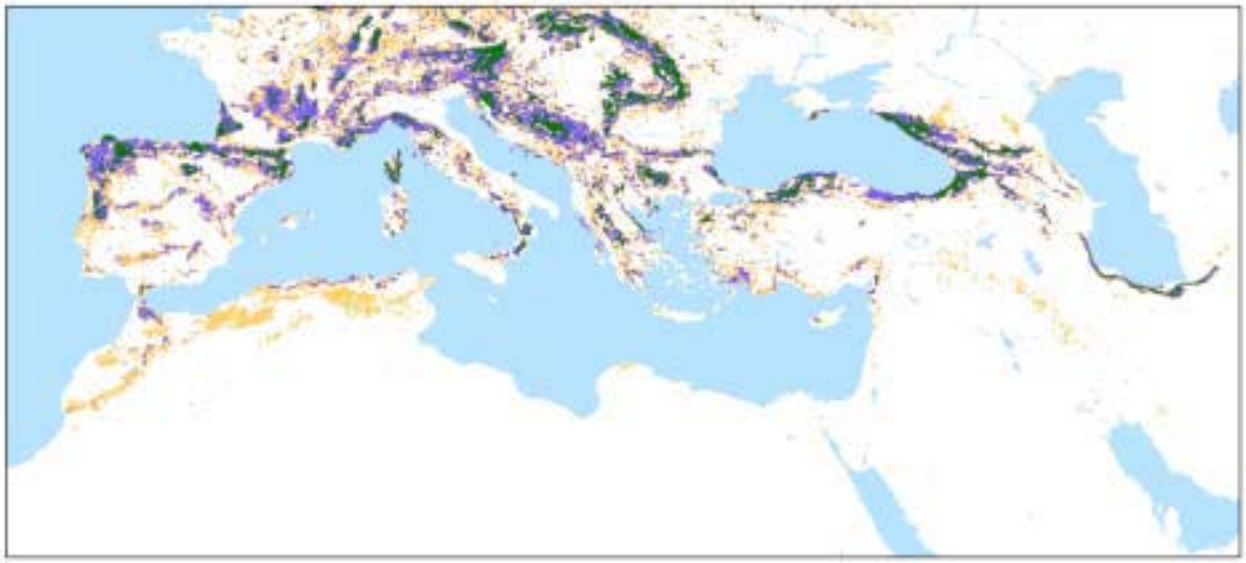
Vegetation in countries within the Mediterranean basin is fragmented into a mosaic of different types as a result of variations in climate, topography and soils, as well as a long history of human activity. Landscapes range from unexploited natural ecosystems to those shaped by centuries of human habitation. The rich flora includes some 25 000 higher plant species, of which approximately half are endemic (FAO, 1999b). Of significant ecological, historical and cultural value, the forests and wooded lands are mostly managed for a wide variety of non-wood products (fruits, seeds, gums, resins, bark, fodder) rather than for wood. They also control erosion, help restore soil fertility and maintain suitable conditions for agriculture.

Forests in the northwestern Mediterranean area are currently facing an increasing risk of wildfire because of the lack of management, encroachment and the abandonment of agriculture. On the other hand, heavy pressure on forests in the southeast is resulting in deforestation and forest degradation.

Working from the premise that issues can be resolved only after considering the institutional, social and economic conditions of people living in or near forests, Mediterranean foresters were among the first to design truly integrated multipurpose forest management plans that call for collaboration among administrations, local and national institutions, NGOs and the private sector. Cooperation among countries in the region has long been the norm, reinforced by the efforts of international organizations and, more recently, the European Community (EC) and local governments.

The Committee on Mediterranean Forestry Questions – *Silva Mediterranea*, a committee of the African Forestry and Wildlife Commission, the European Forestry Commission and the Near East Forestry Commission – has been supporting various aspects of forestry in the Mediterranean for more than 50 years. *Silva Mediterranea* recently underwent a reorganization to enable it to respond better to emerging needs and concerns. During its eighteenth session, it identified priority activities that FAO and other partners will undertake in areas that include the socio-

FIGURE 3
Forests of the Mediterranean basin



Closed forest – land covered by trees with a canopy cover of more than 40 percent and height exceeding 5 m. Includes natural forests and forest plantations.
Open and fragmented forest – land covered by trees with a canopy cover of between 10 and 40 percent and height exceeding 5 m (open forest), or mosaics of forest and non-forest land (fragmented forest). Includes natural forests and forest plantations.
Other wooded land – land either with 5 to 10 percent canopy cover of trees exceeding 5 m in height, or with shrub or bush cover of more than 10 percent and height less than 5 m.

Source: FAO, 2001a.

economic aspects of sustainable management, desertification control and the application of research results (FAO, 2002a).

COORDINATED RESPONSES TO FIGHTING FOREST FIRES

An International Expert Meeting on Forest Fire Management, organized by FAO and the International Tropical Timber Organization (ITTO) in 2001, emphasized the importance of a coordinated international response to forest fire management. As a follow-up to the experts' recommendations, FAO is reviewing mechanisms for establishing inter-State agreements to promote and facilitate the sharing of resources, personnel and equipment in emergencies. To this end, it has compiled an inventory of international agreements dealing with forest fires, particularly in cases of emergency, and identified common elements. The results of this analysis were used as the basis for a standard outline on which countries can draw when they wish to develop a forest fire agreement. However, the relevance of each element to individual countries and to specific environments depends on the particular conditions of the parties entering into an agreement and on the type of agreement desired. The outline includes the following elements:

- parties to and purpose of the agreement;
- definition of terms;
- executive bodies involved;
- financial responsibilities;
- information and coordination requirements;
- operating plans and guidelines;
- border-crossing modalities;
- liabilities and compensation;
- general and final provisions covering such matters as duration, amendment, termination and dispute settlement.

FAO has also inventoried national legislation specific to forest fires, as well as forest-related legislation covering forest fires. In addition, the

Fighting fires in Southeast Asia

In June 2002, environment ministers of the Association of Southeast Asian Nations (ASEAN) signed an agreement to increase cooperation and reinforce measures to prevent forest fires in the region. In the past, such fires have led to huge clouds of haze and cross-border pollution. The agreement establishes early warning systems and calls for stronger fire-fighting forces. Its implementation will complement ongoing efforts of Project FireFight South East Asia, a joint initiative of the World Wide Fund for Nature (WWF) and the World Conservation Union (IUCN). Initiated in March 2000 with the support of the European Community, the project operates at the national and regional levels to address harmful forest fires more effectively through policy and law reforms. It has published several reports on the state of knowledge in its three programme areas: economics of fire uses; community-based fire management; and legal and regulatory aspects of forest and land fires.

Addressing unsustainable hunting practices

A recent review of hunting in tropical forests (Bennett and Robinson, 2000) identified actions that could be taken to address unsustainable practices. The following are some examples.

- Governments could offer land tenure and resource rights as incentives for local communities to use bushmeat sustainably.
- The development sector could quantify the value of bushmeat and include this in rural livelihood assessments.
- Various sectors could jointly develop alternative livelihood strategies, agreeing that protected areas are the best means of conserving biological diversity.
- The private sector could reduce the illegal hunting and sale of bushmeat within its concessions.

Global Forest Fire Assessment 1990–2000, including country forest fire profiles, is available on CD-ROM.

Working with partners, FAO will continue to expand its network, strengthen country capacity, assist governments in developing strategies and policies in forest fire management and respond to requests for help in drafting agreements.

Further information is available on the Internet at www.fao.org/forestry/fire.

HUNTING WILD ANIMALS FOR MEAT: A THREAT TO SUSTAINABILITY

The sustainability of hunting in tropical forests, especially in Africa, is a major forest wildlife issue today. For example, the quantity of meat from wild animals (bushmeat) being harvested annually in the Congo basin is calculated at about 5 million tonnes (Fa, Peres and Meeuwig, 2002), indicating an extraction rate that is double the production rate. In comparison, about 0.15 million tonnes of bushmeat are harvested in Amazonia, corresponding to an extraction rate that is 0.081 of the production rate – 30 times lower than in the Congo basin.

Although these figures are indicative and provisional, they support concerns expressed during a number of regional and international discussions that wildlife in Africa's tropical forests is severely threatened. In the absence of remedial action, forest wildlife will be drastically reduced, with serious consequences for food security, forests and their ecological integrity.

Recognizing the urgent need to seek solutions, the eleventh Conference of the Parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), held in April 2000, established a working group to study the bushmeat crisis (see p. 51). Other international responses include the

formation of the Ape Alliance, a coalition of conservation NGOs concerned with the plight of primates, and the United States-based Bushmeat Crisis Task Force, a consortium of conservation organizations and scientists dedicated to conserving wildlife populations threatened by commercial hunting.

In September 2001, FAO and partners held an international workshop to identify future steps. FAO is also assisting with the development of national bushmeat action plans in Cameroon and Gabon, as well as working with several organizations and agencies to strengthen protected area management and law enforcement in Central Africa and to engage local communities in managing and protecting forest wildlife.

RECENT DEVELOPMENTS IN FORESTS AND CLIMATE CHANGE

Forests in climate change negotiations

Following continuous negotiations since agreement was reached on the Kyoto Protocol in 1997, the parties to the United Nations Framework Convention on Climate Change (UNFCCC) set a new landmark in the battle against climate change with the signing of the Marrakech Accord at the seventh Conference of the Parties (COP-7) in November 2001. The parties acknowledged the four major roles of forests in climate change: as a source of carbon dioxide when destroyed or degraded; as a sensitive indicator of a changing climate; as a source of biofuels to replace fossil fuels; and as a carbon sink, when managed sustainably. By removing carbon dioxide from the atmosphere, storing it in biomass, soils and products, and offering a sustainable alternative to fossil fuels, forests provide a unique environmental service.

Failure to reach agreement about forests ranked high among the issues contributing to the collapse of negotiations at COP-6 in November 2000. It also threatened the successful conclusion of resumed discussions in July 2001, and forests remained controversial up to the final hours of COP-7 in Marrakech. Now, however, they may contribute the lion's share to the parties' commitments during the first commitment period (2008–2012) (Figure 4).

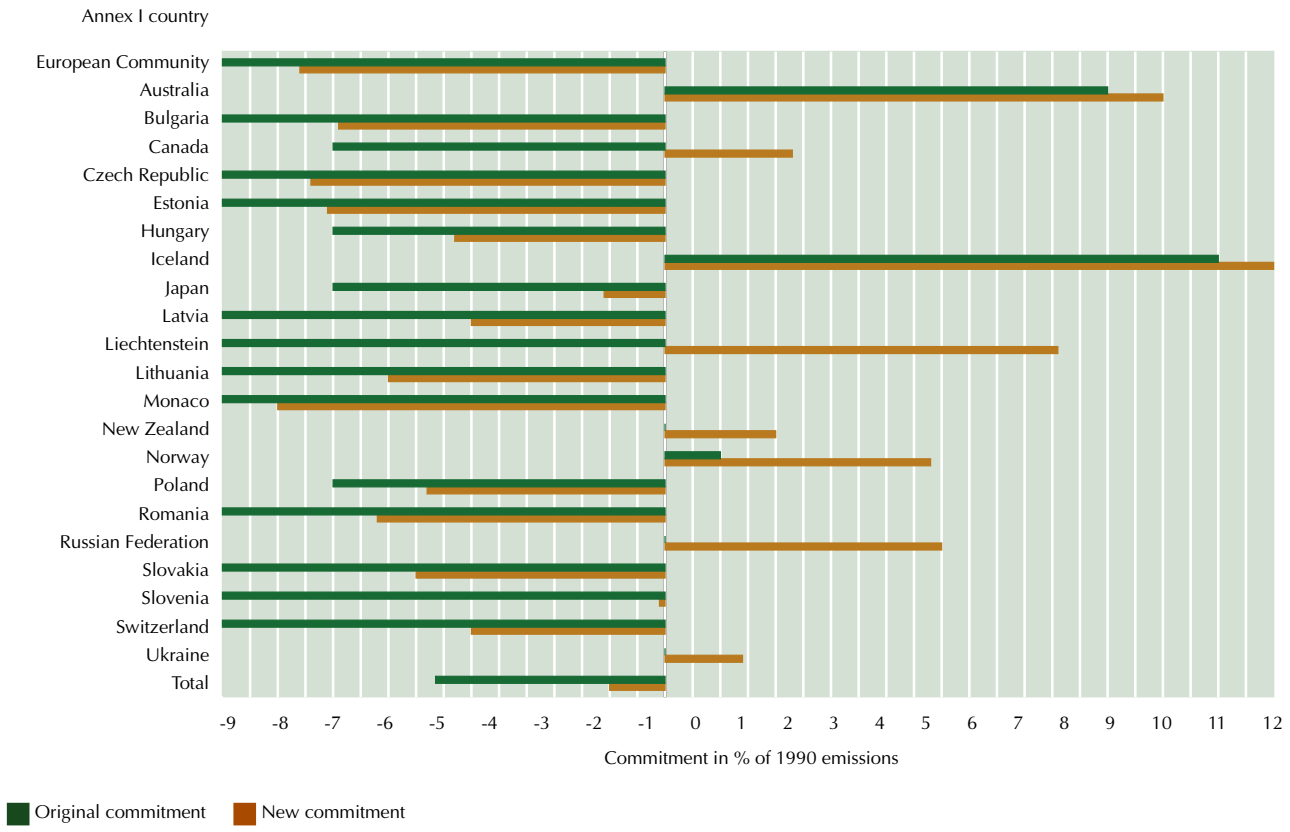
Third Assessment Report

The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2001) lifts some of the uncertainty still shrouding climate change and highlights its current and future dimensions, its causes and the perils to terrestrial ecosystems and society. Changes observed in the world's forest ecosystems during the past decades may foreshadow events to come.

The IPCC report also highlights the need for adaptation. Forests may be advanced in this respect because, given the natural longevity of most forest trees and the long rotations employed in their management, most of the forests established today will experience many changes in climate over their lifetime. Foresters have devised and implemented strategies for shielding forests from, and adapting management to, climate change (Spiecker, Lindner and Kahle, 2000). In many instances, these practices also represent good management under current conditions, and climate change merely accentuates their importance.

At times, the adaptation that is taking place today may reduce future timber yields and maximal carbon storage, but may enhance the permanence of carbon storage and biological diversity (see chapter on forests and biological diversity, p. 86). This occurs, for example, when highly productive but risk-prone Norway spruce (*Picea abies*) is replaced by less productive but low-risk native oak (*Quercus petrea, Q. robur*) or beech (*Fagus silvatica*) in many parts of central Europe (see Figure 5). Douglas fir (*Pseudotsuga menziesii*) is an exotic species in Europe that has a long, successful history there, producing durable timber at high growth rates. It is well adapted to summer droughts and mild winters. While some may contend that planting this exotic species on suitable sites will have an impact on biological diversity, doing so combines adaptation, climate change mitigation and economics. Given the possibility of irreversible interactions in the spheres of climate, ecology and socio-economics, such early adaptation seems necessary. However, the assessment report

FIGURE 4
Contribution of forests towards country commitments in the Marrakech Accord



Carbon sequestration in land use and forestry

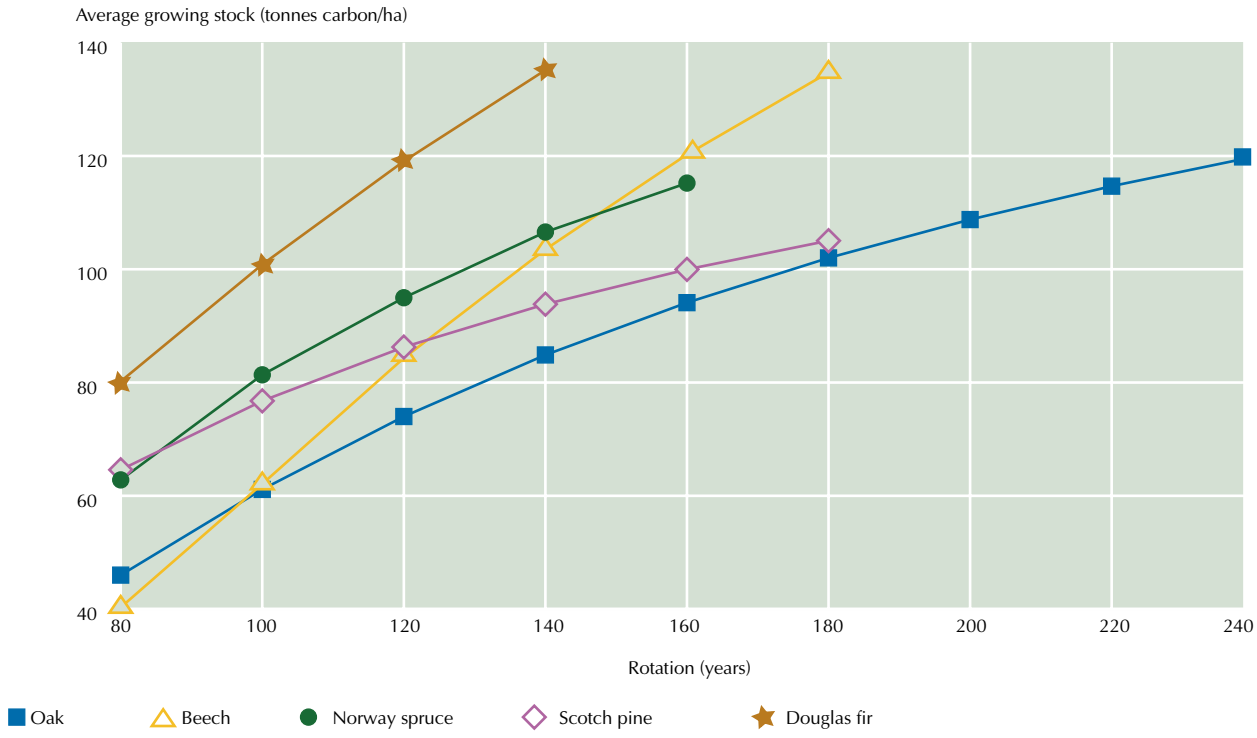
Forests, agricultural land and other terrestrial ecosystems offer significant potential for storing carbon. The conservation and sequestration of carbon, although not necessarily permanent, may provide enough time to exercise other options. The cumulative global potential of options related to biological mitigation of climate change is in the order of 100 gigatonnes of carbon by the year 2050, equivalent to 10 to 20 percent of projected fossil fuel emissions. The largest potential is in tropical and subtropical regions. Cost estimates vary significantly from US$0.1 to $20 per tonne of carbon in tropical countries and from US$20 to $100 in non-tropical countries (IPCC, 2001).

clearly states that adaptation cannot replace climate change mitigation. In this context, the panel specifically points out the important role of forests.

Biomass energy, particularly wood energy, constitutes a vital component of future strategies to mitigate greenhouse gas emissions, with a potential contribution of up to 30 percent of total emission reductions between 2030 and 2050. Many Annex I countries (industrialized countries and countries in transition to a market economy) consider wood energy an important component of their emission reduction efforts. The European Commission, for example, has launched an ambitious programme to enlarge the share of renewable energy, including bioenergy, in overall energy use from 5 to 12 percent by 2010. Bioenergy from agricultural and

FIGURE 5

Increase in mean carbon storage as a function of rotation for various species, calculated for a site in Germany



Source: *Schoene and Schulte, 1999.*

Measures for adapting silviculture and forests to climate change

- Select provenance and species, including perhaps suitable exotics
- Match species and provenance to sites
- Adapt planting densities
- Favour mixed, structurally diverse and uneven-aged forests, where possible
- Avoid monocultures
- Promote wind resistance
- Adapt tending and thinning
- Adapt rotations
- Adapt harvesting techniques
- Adapt stand nutrition to match enhanced growth
- Adapt fire management to changes in climate and forest growth
- Rehabilitate degraded forests
- Gradually replace off-site stands
- Eliminate additional stresses
- Reduce forest fragmentation
- Survey pests and pathogens
- Prepare for calamities and timber salvage
- Adapt regeneration to altered reproduction and competition
- Protect and maintain rare habitats
- Protect genetic stocks

Forest ecosystems respond to changes in climate

PERMAFROST THAWING IN CENTRAL ALASKA THREATENS NATURAL LOWLAND BIRCH FORESTS

The degradation of permafrost is widespread, for example in China, Mongolia, Canada and the state of Alaska, United States. When layers of ice in fine-textured soil horizons melt under the influence of warmer temperatures and enhanced snow cover, soils settle unevenly, forming a pitted landscape referred to as "thermokarst". In Alaska, it was observed that natural stands of paper birch (*Betula papyrifera*) on these soils die and aquatic species invade, forming lowland fens and bog meadows within 30 to 40 years. Contrary to expectations, the collapse of the permafrost layers and the associated forest ecosystem enhances carbon sequestration, as organic matter accumulates rapidly in these bogs, more than compensating for the carbon loss from trees. However, bogs emit methane, a greenhouse gas with a global warming potential 21 times higher than that of carbon dioxide, making the overall feedback to global warming hard to predict (Jorgenson *et al.*, 2001).

FOREST GROWTH CHANGES IN MANY WORLD REGIONS

Enhanced photosynthesis and/or tree growth has been observed in many regions of the world. In Austria, the annual increment of Norway spruce (*Picea abies*) increased by about 17 percent, mainly as a consequence of increased temperature and the temperature-related lengthening of the growing season during the period 1961 to 1995 (Hasenauer, 2000). However, forest growth may be enhanced only temporarily and in site-, age-, species- and genotype-specific patterns (Egli *et al.*, 2001). Growth may also be reduced, for example in boreal forests, if warming is accompanied by drought stress (Lloyd and Fastie, 2002). Competitive balance in mixed forests may change, species may become more or less prone to breakage, and self-pruning may be delayed (Spinnler *et al.*, 2001). The effects of greenhouse gases may have an impact on the phenology of forest trees, affecting such processes as budding, flowering, fruiting, leaf senescence, frost hardiness, wood quality, branching and insect susceptibility, in a highly species-specific manner (Jach, Ceulemans and Murray, 2001).

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Where permafrost has been degraded in central Alaskan lowlands, collapsing birch forests are being replaced by floating mat fens and bogs of* Sphagnum *moss

forestry residues and energy crops would then supply about 7 percent of the total energy consumed.

An emerging regime for forests in climate change

Together, UNFCCC, the Kyoto Protocol and the Marrakech Accord provide rules and modalities for forest and land use to mitigate climate change, as well as to record, monitor, report and verify carbon stock changes and fluxes in all relevant sectors (Torvanger, 2001a). In addition, detailed guidelines (IPCC, OECD and IEA, 1996), which are now being updated, establish methods for assessing carbon stock changes and propose formats for reporting on land use and forestry.

All parties to the convention must file periodic national communications in which they also report on forests. In addition, developed countries must provide information on carbon inventories on a yearly basis. These annual reporting requirements are rigorous in that developed countries may lose their eligibility to participate in the flexible mechanisms, including emissions trading, if they fail to report adequately on forests.

During the commitment periods from 2008 onwards, all industrialized countries will accumulate credits and debits for carbon stock changes from afforestation, reforestation and deforestation since 1990. During the first commitment period, special waivers apply to debits from harvesting short-rotation forests, and also to net debits that occur for many parties when newly established young forests cannot offset debits from clearing established, usually older, forests.

Besides cropland, grazing land management and revegetation, parties may designate the management of forests established prior to 1990 as an eligible activity. However, specific allowances (see Figure 4) limit the credits that countries may acquire or lose annually from forest management. For most parties, these allowances reflect the lower of two values: 15 percent of the annual forest carbon stock change, or 3 percent of total carbon emissions in 1990. Allowances are considerably higher for Canada, Japan and the Russian Federation.

In discounting carbon increases by 85 percent in forests established prior to 1990, the Marrakech Accord seeks to factor out benefits from routine planting of the young, rapidly growing forests that are dominant in most developed countries, as well as indirect, human-induced growth enhancement from carbon dioxide, nitrogen emissions and global warming. Countries are free to fulfil these forest management allowances through business-as-usual activities or through additional projects that enhance carbon sequestration.

The Kyoto Protocol also establishes flexible implementation mechanisms. Of these, Joint Implementation and the Clean Development Mechanism include forestry projects. With Joint Implementation, developed countries undertake projects in other developed countries and repatriate credits. Such projects, except those involving afforestation and reforestation, lower the host party's allowance for credits from domestic forest management.

A separate allowance, amounting to 1 percent of 1990 emissions, limits the credits that developed countries can claim for undertaking afforestation and reforestation in developing countries under the Clean Development Mechanism. Such projects can accumulate credits retroactively from 2000, provided that they meet prerequisites, which are to be defined by 2003. By then, definitions, rules, guidelines and modalities for clean-development forestry projects must also be decided, covering particularly the social, environmental and developmental aspects of projects and safeguarding against the possible reversal of carbon sequestration in trees.

While afforestation and reforestation remain the only eligible forestry activities under clean development during the first commitment period, forest conservation, adaptation and rehabilitation projects may receive financial assistance from the Special Climate Change Fund, the Least-Developed Countries Fund and the Adaptation Fund.

Future directions

Negotiations for the next commitment period will begin in 2005. Issues will include the treatment of carbon stored in wood products, forest-related definitions and differentiation between direct human-induced carbon stock changes and those from other causes. Countries will have to establish domestic regimes for climate change mitigation and to decide how these will integrate forests and their owners. Aiding this process, the harmonization of definitions (FAO, 2002b) and methods for measuring forest carbon stocks and their changes are rapidly becoming new fields in forest resources assessment (Brown, 2001; MacDicken, 1997).

In March 2001, the United States announced that it would not ratify the Kyoto Protocol, and in February 2002 it established its own Climate Change Initiative, containing, among other measures, voluntary emission intensity reductions. Nevertheless, United States companies may purchase credits from parties to the Kyoto Protocol (Torvanger, 2001b). Alternatively, the United States may establish its own type of carbon offset project abroad.

The role of forests and forest products in climate change and in emerging carbon markets will evolve, commensurate with prices for carbon; the extent to which adaptation and mitigation measures are perceived to be urgent; further progress in negotiations; and provisions for forests and wood energy in domestic regimes. Forest-related decisions taken at UNFCCC COP-7 and new insights from IPCC's Third Assessment Report may significantly affect the future state and management of the world's forests and the use of their products. ◆

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