al research and development, climate action policy and wood building education and advocacy.

FORESTS TODAY

As long ago as 2001, the United Nations Food and Agriculture Organization (UNFAO) determined that, in Europe and North America at least, loss of forest cover is no longer a quantitative issue. In parts of Europe, the United States and Canada, the area of forests is actually increasing, with North America now approaching the level of forest cover it had when the first European settlers arrived in the early 17th century.[1]

The nature and make-up of contemporary forests varies significantly from country to country according to local climate, geographical latitude and elevation [ill. p. 14 top]. Forests that are regulated and managed for commercial wood production also vary greatly. In some jurisdictions, such as New Zealand, commercial timber for structural applications comes from plantation forests where a single exotic species, in this case Monterey or radiata pine (*Pinus radiata*), predominates, and native hardwood forests are set aside as reserves. In Tasmania, where growing conditions are very similar, long-established plantations of radiata pine are now being supplemented by stands of native eucalyptus on an experimental basis.

In Northern Europe, forests are dominated by two indigenous species, Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*), although the forests also contain Central European varieties such as oak (*Quercus robur*) and beech (*Fagus sylvatica*). Central and Eastern Europe have significant areas of broadleaf (hardwood) forests. Approximately 70% of Europe's forest cover is semi-natural, having been modified to some degree by human intervention, yet retaining natural characteristics. Only 8% is plantation forest, found mainly in Denmark, the Netherlands, Portugal, Ireland and the United Kingdom.

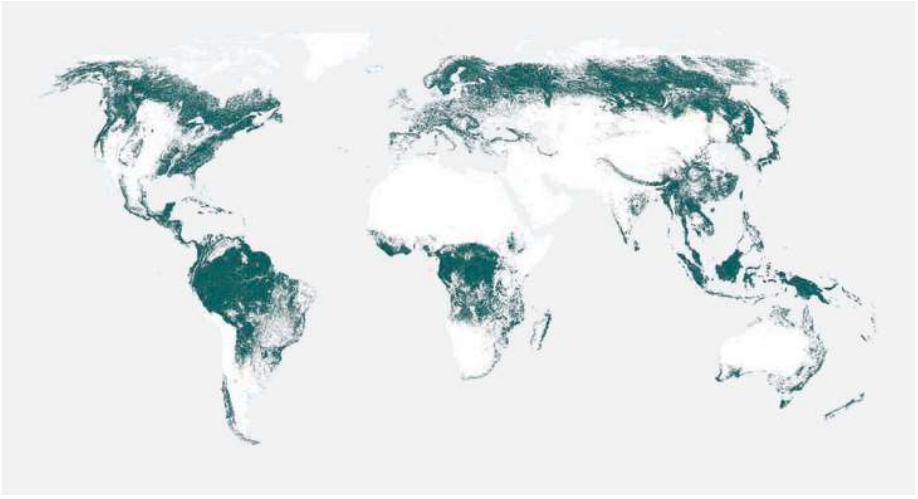
In the boreal regions of Canada, black spruce (*Picea mariana*) and white spruce (*Picea glauca*) predominate, while on the west coast (and in the Pacific Northwest region of the United States) forests in wetter regions contain a mixture of Douglas fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*). In drier parts of the west coast, a combination of spruce, pine and fir species prevails.[2] In the southeastern United States, the naturally mixed forests consist of a variety of pine species, generally referred to collectively as 'southern yellow pine'.[3] Together, the forests of North America constitute 20% of the world's total.

To a greater or lesser degree, all healthy forests provide the kinds of ecological services mentioned above, and can continue to do so when commercial wood production is sensitively managed. Even the exotic plantation forests of New Zealand have an under-storey of native shrubs that support a greater degree of biodiversity than would be found in open prairie or agricultural land.

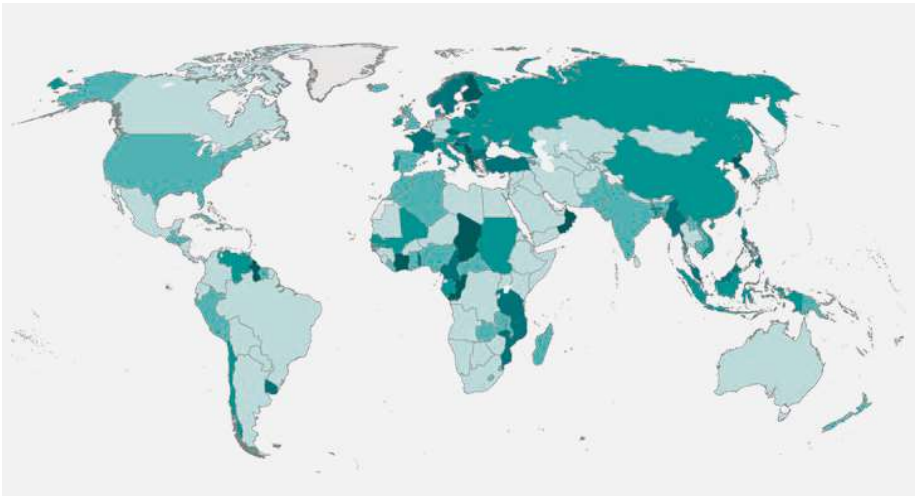
Some countries, such as Estonia and Scotland, are actively reforesting unproductive grassland, recognizing both the economic and environmental benefits this can bring. Overall, the regions that are the primary focus of this book have either stable or increasing areas of forest cover [ill. p. 14 bottom].

SUSTAINABLE FOREST MANAGEMENT

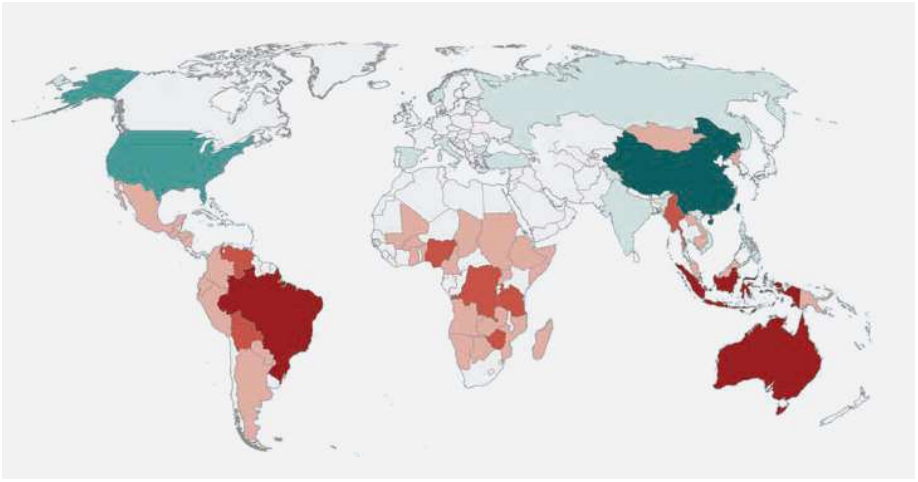
Despite the great variety of natural, semi-natural and plantation forest types, there are third-party administered, internationally recognized sustainable forest management (SFM) protocols applicable to each. These protocols provide assurance to governments, industry, architects and the public alike that the quantity of wood fibre harvested does not exceed the quantity of wood fibre produced by tree growth on an annual basis, nor compromises the ecological services the forest provides. Such protocols are well established in Scandinavia, Western and Central Europe and North America and the area of forests under SFM is increasing rapidly in Eastern Europe, Central America and Asia [ill. p. 15].



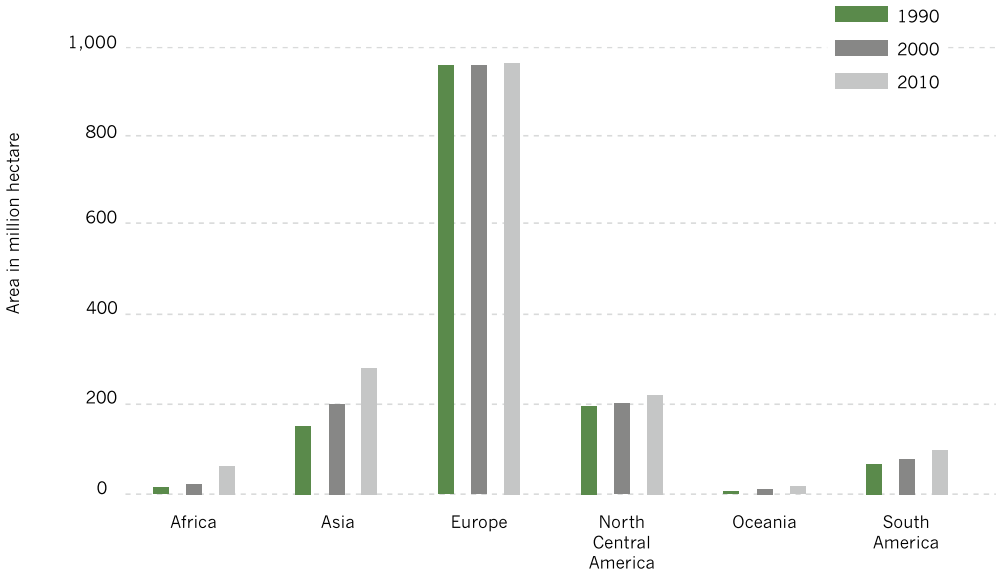
World map depicting overall forest cover (2005)



World map depicting proportion of land area dedicated to commercial forestry (2010)



World map depicting annual decrease and increase in forest cover (2005–2010)



Area of forest certified under sustainable forest management by region

Regardless of forest type or jurisdiction, sustainable forest management is typically founded on the following core principles:[4]

- Conserve biodiversity;
- Maintain the productive capacity of forest ecosystems;
- Maintain the vitality and health of forest ecosystems;
- Conserve and maintain soil and water resources;
- Maintain the forest contribution to global carbon cycles;
- Maintain and enhance long-term, multiple socio-economic benefits to meet the needs of societies; and
- Provide legal, institutional and economic frameworks for forest conservation and sustainable management.

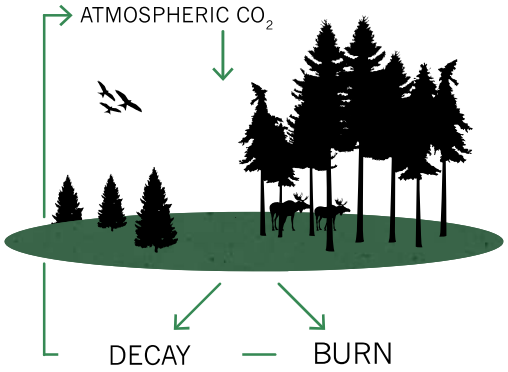
Third-Party Certification

Based on these principles, national and regional standards are developed in consultation with a variety of stakeholders to set parameters for the desired age and density of trees and composition of tree species within individual management areas; and the distribution of forest types and age classes (i.e. stands of trees of similar age) within a region.

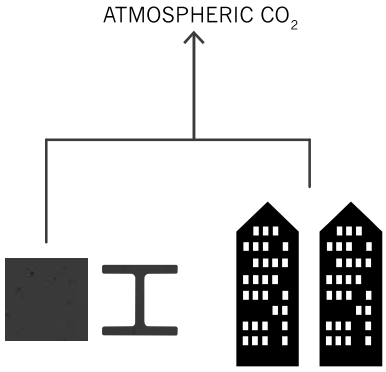
Internationally, the efficacy and integrity of the majority of regional and national systems is endorsed by the Programme for the Endorsement of Forest Certification Schemes (PEFC). PEFC is a non-profit, non-governmental organization based in Geneva, Switzerland, that works throughout the entire forest supply chain to promote good forestry practices. Applying the core principles listed above, PEFC certification assures that timber and non-timber forest products have been produced with respect for the highest ecological, social and ethical standards. Between 2000 and 2014 sustainable forest certification increased from a mere 14 million hectares to 438 million hectares. From the available data, forests certified under the umbrella of PEFC constitute approximately 58% of the world's certified forests, with the remainder under the Forest Stewardship Council (FSC)[5].

Countries with PEFC-endorsed national certification systems include Australia, Austria, Canada, Finland, France, Germany, Italy, Norway, Sweden, Switzerland, the United Kingdom and the United States. The second-most popular forest certification system is administered by the Forest Stewardship Council (FSC). FSC is also a non-profit, multi-stakeholder organization that sets standards, certifies forests and administers a 'chain of custody' labelling program.

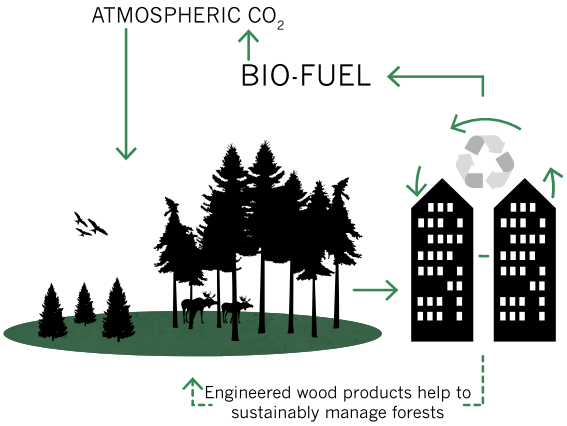
Increasingly, PEFC and FSC are seen by governments and industry as having very similar objectives and standards, although these are realized through different approaches. PEFC is a 'bottom up' organization, as it facilitates mutual recognition between nationally developed standards; whereas FSC is a 'top down' or-



Carbon cycle for a natural forest



Carbon cycle for a managed forest yielding traditional solid sawn wood products



Carbon cycle for a managed forest yielding engineered wood products

ganization, developing its own standards and adapting them to a variety of regional bio-climates and forest types.

In the spring of 2016, the US Green Building Council, which had previously recognized only the FSC standard as eligible for credit under its Leadership in Energy and Environmental Design (LEED) rating system, extended that recognition to include PEFC.

THE ROLE OF FORESTS IN THE CARBON CYCLE

With SFM protocols firmly in place in most developed countries, what makes sustainable forest management of continued interest is the fact that, because growing trees sequester and store carbon dioxide and other greenhouse gases from the atmosphere, increasing the responsible use of wood can actually contribute to the long-term mitigation of climate change.

Historically, the composition of the Earth's atmosphere was held in balance in part by the ability of forests to absorb carbon dioxide and release oxygen. For most of its life, a growing tree uses the sunlight it receives to sequester CO_2 and convert the carbon it contains into cellulose, the main component of wood fibre [ill. p. 16]. This carbon remains in the wood until the tree begins to decay or is destroyed by fire, at which point it is released again as CO_2. This process is part of a complex system of global carbon exchange known as the carbon cycle.

However, the capacity of this system has been compromised by deforestation, population growth and by the increased per capita impact of human activity dependent on fossil fuel. This process has accelerated rapidly in the last 200 years and we are now entering a period of unprecedented climate instability.

Maintaining Forest Carbon Stocks

Forests and the soils that support them are a major component of the terrestrial biosphere, which, in turn, is one of the five reservoirs in the Earth's carbon storage and exchange system. Across the vast temperate and boreal forests, the proportions of total forest carbon stored in the trees and in the soil varies con-

An analysis of the wood structure and finishes of the Eugene Kruger Building, Laval University, Gauthier Gallienne Moisan Architectes, 2005, in Quebec City, Canada demonstrated a significant reduction in embodied energy compared to a steel equivalent.

The imported solid wood structure of the Forte Building, designed by Andrew Nieland/Lend Lease Corporation and built in 2012 in Melbourne, Australia, has a lower carbon footprint than a similar structure built from local concrete.

siderably. The Global Forest Resources Assessment undertook a study of the global carbon storage capacity utilizing IPCC data, estimating that in temperate forests nearly 63% of carbon is stored in soil with 37% stored in above ground vegetation, while in the boreal forests up to 84% is stored in soil with as little as 16% stored in vegetation[6].

Left undisturbed, the most common mechanism of renewal in forests is fire (although disease, insect attack and windfall also play a part). While fire releases large amounts of carbon from the vegetation it burns, it leaves the carbon in the soil largely intact. By contrast, harvesting has little impact on the carbon in the vegetation, but can release large quantities of carbon from the soil it disturbs. This amount varies considerably with the harvesting method employed.

Over large areas, it is difficult to accurately estimate the volume of wood and other vegetation (and hence the total carbon stored) in a forest. Such calculations must rely on aerial photography and limited field measurements of tree sizes and spacing.

However, within smaller tracts of land where more comprehensive field measurements are achievable, or in plantation forests where tree size and spacing is consistent, it is possible to refine these calculations considerably. Sophisticated computer modelling tools enable forest regulators and forestry companies to compare the environmental impacts of different harvesting methods, and to ensure that (when all impacts and benefits are measured) these activities do not diminish overall forest carbon stocks or contribute to climate change.

Carbon Sequestration

In addition to measuring forest carbon stocks, sustainable forest management techniques can also enable