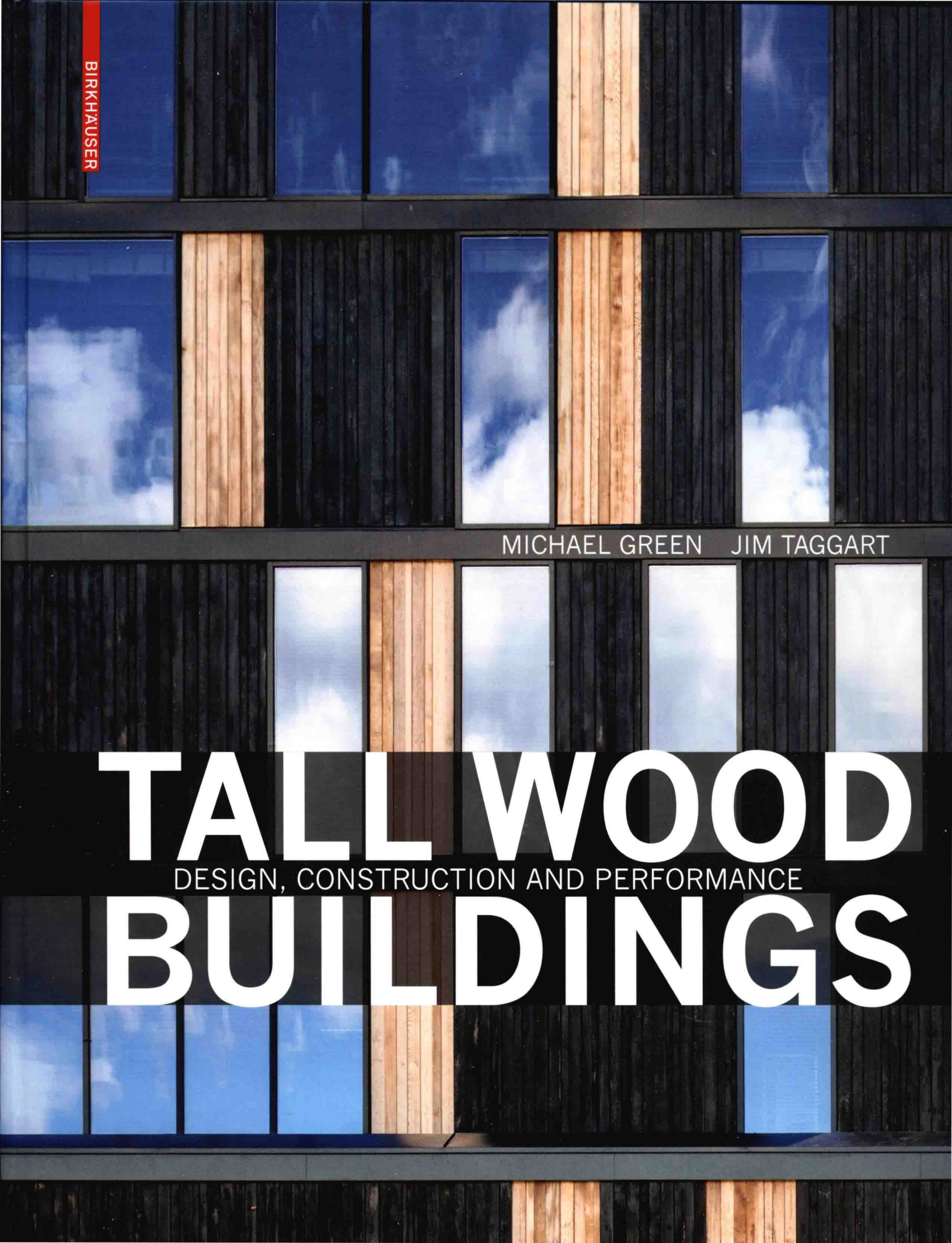
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MICHAEL GREEN JIM TAGGART
TALL WOOD BUILDINGS
DESIGN, CONSTRUCTION AND PERFORMANCE

Over the last decade, Tall Wood buildings have been at the forefront of innovative building practice in urban contexts. In many cities around the globe, these timber high-rises have emerged as a new urban element. Structures of up to 18 storeys have been built or are under construction while others of up to 40 storeys are being considered. This dynamic shift has been enabled by the emergence of new engineered wood products, prefabrication and more flexibility in fire regulations. The low CO_2 footprint of wood – often regionally sourced – make it a responsible choice for today's buildings.

This publication provides a systematic introduction to the technology and explains typical Tall Wood constructions such as panel systems, frame and hybrid systems. An international selection of 13 best-practice case studies is documented in detail with many specially prepared construction drawings, demonstrating the range of the technology.

Both authors are experienced specialists for timber construction:

Michael Green, MGA | Michael Green Architecture, Director of DBR | Design Build Research Institute, Vancouver, is a researcher and practitioner in the field of timber structures. His 2013 TED talk made a large audience aware of Tall Wood buildings.

Jim Taggart, Vancouver, is an architect, publicist and editor of *Sustainable Architecture and Building Magazine*. He teaches at the British Columbia Institute of Technology.

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JIM TAGGART

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TALL WOOD BUILDINGS

DESIGN, CONSTRUCTION AND PERFORMANCE

MICHAEL GREEN
JIM TAGGART

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FOREWORD

We are living in an age which will come to be dominated by our relationship with the planet. As the changes to our climate become ever more apparent, the way we live and inhabit the earth will, by necessity, be transformed.

A fundamental change in the way in which we build our cities is imperative, re-learning how to build in timber and how to build tall with the new engineered timbers that the 21st century technologies allow will be fundamental to our future. This new age of architecture takes us beyond the notions of modernism and concrete construction to a new timber age.

Timber is the only construction material that can be grown and as it grows it consumes carbon. Using timber not only reduces our impact on the planet but will also help to reverse some of the effects of 20th century industrialization. Timber construction is not only healthy for our planet but is also healthy for humans. Living and working in timber buildings is good for the soul and good for health. The time has come again to leave behind inhospitable concrete caves and embrace the timber age.

A new architecture will emerge as we learn how to build in timber. We are the very beginning of this new and exciting era, this book marks the beginning of this new age and will help to provide the inspiration and momentum for the exciting new architecture to come.

Andrew Waugh
Waugh Thistleton Architects, London
August 2016

WOOD, A MATERIAL FOR OUR TIME

As the 21st century unfolds, architecture stands at a crossroads. Until now there has been no reason to challenge the supremacy of concrete and steel as the materials of choice for high-rise buildings, but in the past decade our evaluation criteria have become more complex. The core tenets of 'commodity, firmness and delight', first proposed by the Roman architect Vitruvius 2000 years ago as the prerequisites for a fine building, now fall within a framework of pressing global imperatives that are daunting in both scale and scope. The practice of architecture must now encompass the issues of climate change, population growth, and a global housing shortage.

In the spring of 2015, the National Oceanic and Atmospheric Administration (NOAA), a scientific agency based in Washington, DC, announced that changes in the Earth's climate system had reached a significant and disturbing milestone. For the first time since the NOAA began measuring the concentration of carbon dioxide in the atmosphere at 40 sites around the globe, the average of those monthly measurements exceeded 400 parts per million (ppm).

According to the NOAA, this represents an increase of approximately 120ppm since industrialization began about 200 years ago. As we know, the rapid rise in CO_2 emissions has been driven by technological development, population growth and the commensurate increase in fossil fuel consumption. However, the accumulation of CO_2 and other greenhouse gases in the atmosphere has not been linear, as 60ppm of the increase has occurred in the last 50 years, and 7.5ppm in the last three years alone.

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At 400ppm, the atmospheric concentration of CO_2 is at a level not seen on Earth for millions of years and the implications are significant. In the words of Dr. Erika Podest, carbon and water cycle research scientist with NASA: 'This milestone is a wakeup call that our actions in response to climate change need to match the persistent rise in CO_2. Climate change is a threat to life on Earth and we can no longer afford to be spectators.'[1]

Implicit in Dr. Podest's statement is the assertion that we cannot manifest the changes that are necessary to stabilize the climate system simply by fine-tuning our current way of doing things – rather we must completely transform our commercial and industrial practices to radically reduce, and ultimately eliminate, their carbon footprint.

Also in the spring of 2015, two devastating earthquakes in Nepal, resulting in the collapse of hundreds of buildings and the loss of more than 8000 lives, came as a tragic reminder of the substandard conditions in which far too many people in the developing world live and work. As with climate change, the statistics are alarming. UN Habitat has estimated that 1 billion people (one in seven of the world's population) currently live in slums, and a further 100 million are homeless.[2]

As the world population continues to increase, it is projected that we will need to construct 3 billion units of affordable housing over the next 20 years. The vast majority of these will be required in the cities of the developing world, where population growth is taking place most rapidly.

At first glance the challenges of climate change and world housing might appear to be unrelated. Of the two, climate change receives more attention in the developed world, as its environmental and economic effects are felt directly in the wake of increasingly frequent hurricanes and floods, droughts and forest fires. By contrast, while access to adequate and secure housing is recognized by the United Nations as a universal human right, it is not a daily concern for most people in the West.

The reverse is true in the developing world, where vast numbers of people live at or below the poverty line, and for whom the overriding concern is the day to day search for enough food to eat and a safe place to sleep. Understandably, for those living in such circumstances, the mitigation of climate change may be so far beyond their control that it is nothing more than an abstract concept.

However, leaders in the sustainability movement increasingly believe that the solution to the environmental crisis is inextricably intertwined with issues of equity, democracy and social justice – not just within national boundaries, but across the world. This position was eloquently summarized by Andrew Ross in his 2011 book *Bird on Fire*, when he wrote: 'The task of averting drastic climate change might be described as an experiment – a vast social experiment in decision-making and democratic action. Success in that endeavour will not be determined primarily by large technological fixes, though many will be needed along the way. Just as decisive to the outcome is whether our social relationships, cultural beliefs, and political customs will allow for the kind of changes that are necessary. That is why the climate crisis is as much a social as a biophysical challenge, and why the solutions will have to be driven by a fuller quest for global justice than has hitherto been tolerated or imagined.'[3]

To frame the challenge in architectural terms, approximately one third of global greenhouse gas (GHG) emissions are attributable to the construction and operation of buildings. The Intergovernmental Panel on Climate Change (IPCC) has estimated that these emissions increased at an annual average of more than 2% between 1971 and 2004. Historically the majority of GHG emissions were generated by the highly developed countries of North America, Europe and Central Asia. However by 2030, it is projected that these emissions will be surpassed by those from developing countries, and overall emissions will be almost twice the 2004 levels.[4]

The production of our most widely used construction material, namely concrete, is already responsible for

between 5% and 8% of global GHG Greenhouse emissions. We produce approximately 3 tonnes of concrete per year for every person on the planet. Although this figure also includes concrete used in a variety of infrastructure applications, it nonetheless represents a significant proportion of the emissions attributable to the construction and operation of buildings. As for steel, while it is less carbon-intensive than concrete, and is relatively efficient to recycle, the production of steel accounts for about 4% of global energy use.[5]

To address the housing shortage, construction activity in the developing world will have to increase exponentially, yet our current materials and technologies cannot deliver this increased volume of construction without grave negative consequences for the environment. If we were to proceed with 'business as usual', the increase in construction activity would generate incalculable quantities of greenhouse gases, and a potentially catastrophic acceleration of climate change.

While reducing the operating energy required to heat and cool buildings is dependent on regionally based solutions that respond to the particularities of local climate, reducing the energy intensity of building construction can be achieved using a universal approach. The typologies of mid- and high-rise urban housing are essentially the same everywhere, and currently realized using a combination of load-bearing concrete masonry and concrete or steel frame systems. The only material we have available to us that could deliver housing solutions on the scale required – and at the same time reduce the GHG emissions associated with construction – is wood.

New massive wood products such as cross-laminated timber (CLT), together with computerized design and fabrication techniques, have accelerated the development of new approaches to building with wood. Calculations have indicated that some of these approaches may be applied to structures in excess of 40 storeys. Although research and development of these new approaches is concentrated in Europe and North America, the implications for the global construction industry are profound.

The expansion of wood construction at this scale must be predicated on the exclusive use of material harvested from independently certified, sustainably managed forests. Only third-party certification provides the necessary guarantee that the rate of wood harvest does not exceed the rate of forest regeneration, and will therefore not result in deforestation and further contribute to climate change.

The purpose of this book is to present the arguments in favour of 'Tall Wood' buildings and to showcase completed projects that demonstrate the applicability of this technology to construction across a wide range of building types, and in a variety of physical and cultural contexts.

While Tall Wood construction can only ever be part of the solution to the social and environmental challenges we face, its adoption around the world would represent the kind of transformational thinking and cooperative action that will be essential if we are to restore equilibrium to the world's climate system, and eliminate the inequities that have contributed to our current problems.

Michael Green and Jim Taggart
Vancouver, Canada
May 2016

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WOOD, SUSTAINABILITY AND CLIMATE CHANGE

At least in theory, wood is the ultimate sustainable building material. It is strong, durable, renewable and, above all, manufactured by the sun. In practice, however, what remains at issue, is whether we can manage our forest resources in a way that meets our needs without reducing their area, or compromising the ecological services they provide as reservoirs of carbon, purifiers of air and water, sanctuaries of biodiversity and providers of animal habitat.

These concerns are legitimate, as deforestation and its negative effects remain a significant problem in some regions of the developing world. While forest certification organizations continue to work with governments and industry in these areas to establish sustainable forest management (SFM) practices and protocols, these are already in place throughout the major wood-producing countries of the developed world. Thus the focus of this book is on those regions; continental Europe, Scandinavia, North America and Australasia.

FORESTS TODAY

As long ago as 2001, the United Nations Food and Agriculture Organization (UNFAO) determined that, in these regions 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 eucalypts 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 properly 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.

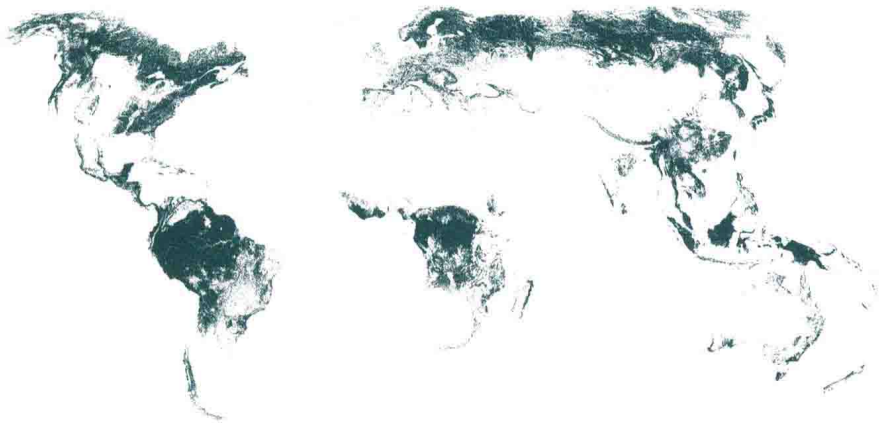
Some countries, such as Estonia and Scotland, are actively reforesting unproductive grassland, recognizing both the economic and environmental benefits this can bring. Overall, the regions that are the primary focus of this book have either stable or increasing areas of forest cover [ill. p. 14 bottom].

SUSTAINABLE FOREST MANAGEMENT

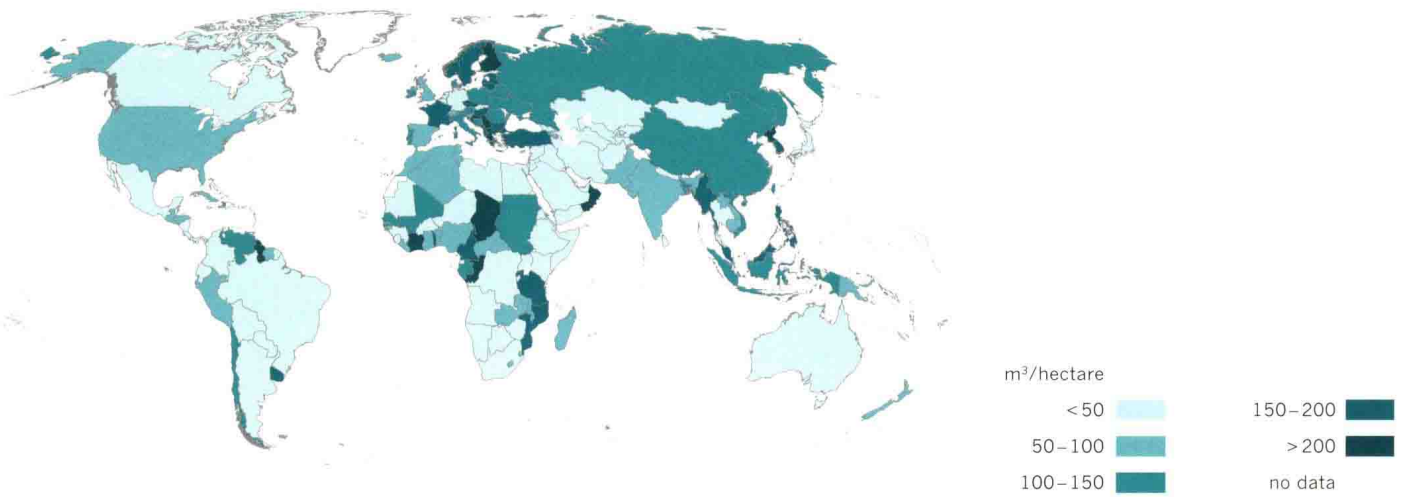
Despite the great variety of natural, semi-natural and plantation forest types, there are third-party administered, internationally recognized sustainable forest management (SFM) protocols applicable to each. These protocols provide assurance to governments, industry, architects and the public alike 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].

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

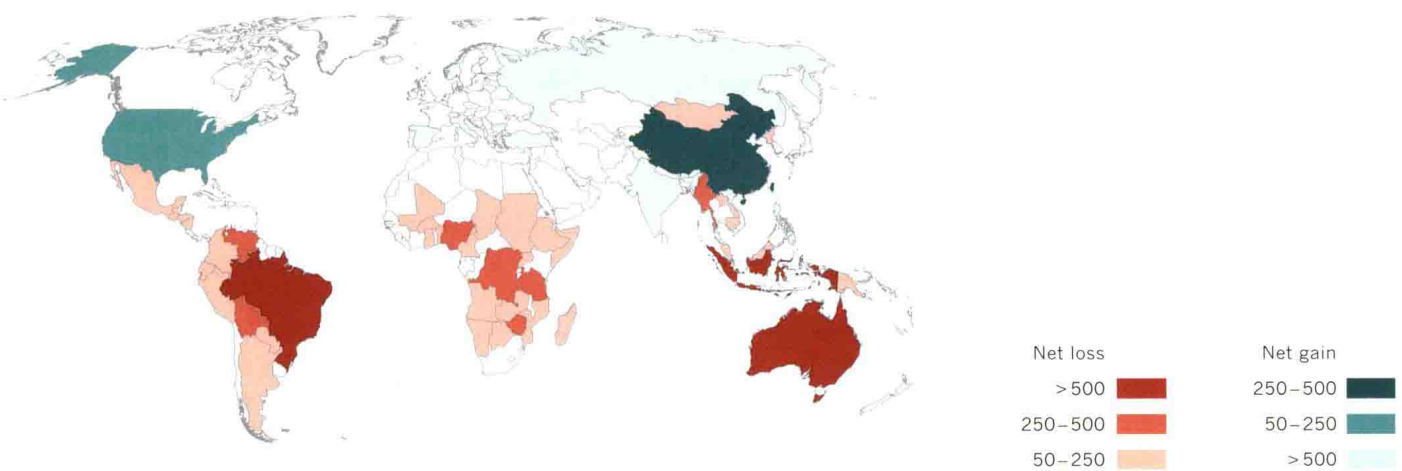
- Conserve biodiversity;
- Maintain the productive capacity of forest ecosystems;
- Maintain the vitality and health of forest ecosystems;
- Conserve and maintain soil and water resources;
- Maintain the forest contribution to global carbon cycles;
- Maintain and enhance long-term, multiple socio-economic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



World map depicting overall forest cover



World map depicting percentage of land area dedicated to commercial forestry



World map depicting annual decrease and increase in forest cover

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