Forests and Global Change

Forests hold a significant proportion of global biodiversity and terrestrial carbon stocks, and are at the forefront of human-induced global change. The dynamics and distribution of forest vegetation determine the habitat for other organisms, and regulate the delivery of ecosystem services, including carbon storage. Presenting recent research across temperate and tropical ecosystems, this volume synthesises the numerous ways that forests are responding to global change and includes perspectives on:

- the role of forests in the global carbon and energy budgets;
- historical patterns of forest change and diversification;
- contemporary mechanisms of community assembly and implications of underlying drivers of global change;
- the ways in which forests supply ecosystem services that support human lives.

The chapters represent case studies drawn from the authors' expertise, highlighting exciting new research and providing information that will be valuable to academics, students, researchers and practitioners with an interest in this field.

David A. Coomes is a forest ecologist and conservation biologist working with the forest ecology and conservation group at the University of Cambridge. He is Associate Editor of the *Journal of Ecology* and *Biological Reviews* and has authored more than 90 papers, including many from his group's work in New Zealand.

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Ecological Reviews

Ecological Reviews publishes books at the cutting edge of modern ecology, providing a forum for volumes that discuss topics that are focal points of current activity and likely long-term importance to the progress of the field. The series is an invaluable source of ideas and inspiration for ecologists at all levels from graduate students to more-established researchers and professionals. The series has been developed jointly by the British Ecological Society and Cambridge University Press and encompasses the Society's Symposia as appropriate.

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Forests and Global Change

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Preface

Forests house a significant proportion of global biodiversity and terrestrial carbon, as well as providing livelihoods for millions of people, yet they are changing at an unprecedented rate. They are disappearing rapidly in many parts of the tropics, but are increasing in cover and biomass in many higher-latitude regions. They are responding to industrial pollution and introduced organisms. The dynamics and distribution of forest vegetation are important because they determine the amount of habitat for numerous other organisms, and regulate the delivery of ecosystem services such as carbon storage, and water and soil quality. It is increasingly recognised that forests influence the energy budget of the planet, making an understanding of forest dynamics an essential aspect of climate change modelling.

Despite the importance of forests to biodiversity conservation and the provision of ecosystem services such as erosion control and carbon storage, the community of forest ecologists is strongly differentiated by biome, which constrains conceptual integration at a global scale. In the tropics, there is a concentration of effort and expertise around the networks of large plots coordinated by the Center for Tropical Forest Science on the one hand, and the alliance of smaller plots forming the RAINFOR, AfriTRON and GEM networks on the other, with many others working outside these networks. In temperate and boreal forest regions, there are long-term ecological monitoring sites (e.g. the Long-Term Ecological Research Network, LTER) and impressive national inventory systems that were originally established for monitoring timber stocks but increasingly available to ecologists. In this volume we draw together perspectives from across these diverse communities of forest ecologists to attempt a global synthesis of forest responses to global change.

This volume consists of 15 invited contributions, providing a global synthesis of recent scientific developments concerning the interactions of forests with the drivers of global change. Similarly to other volumes in the *Ecological Reviews* series, this one has arisen from plenary talks given at a British Ecological Society Symposium. The meeting, entitled *Forests and Global Change*, was held at the University of Cambridge in 2011, attracting over 300 researchers from at least 30 countries. Chapters are organised into three

overarching themes which form subsections of the book: (Part I), forest dynamics and global change; (Part II), species traits and responses to changing resource availability; and (Part III), detecting and modelling global change. Within those themes, there are perspectives on the role of forests in the global carbon and energy budgets; historical patterns of forest change and diversification; contemporary mechanisms of community assembly and implications of underlying drivers of global change; and the multiple ways in which forests supply ecosystem services that support human lives and livelihoods. This volume seeks to target ecologists across the spectrum, from postgraduate students to senior scientists seeking state-of-the-art reviews on specific topics, but it is not an elementary textbook covering all aspects of global change. Rather, our focus is on promising areas of research where new ideas are under development and exciting discoveries are being made.

Technological advances mean that ecologists are better than ever at monitoring how forests are changing, understanding the knock-on consequence of change and making predictions about future responses. The book integrates across different methodologies and biomes to derive a global synthesis based on the following methodologies: statistical analyses of decadal-scale inventory data, ecophysiological approaches, remote sensing and modelling, and historical analyses using phylogenetic information.

Decadal-scale inventory data: Traditionally, information on changes in forests has been obtained from permanent plots that sample the local tree flora. In northern temperate regions, distributed networks containing many thousands of plots have been established for forestry purposes, and these are now being used to answer ecological questions. Sampling is less systematic in tropical regions; many plots have been established that are 100 × 100 m (1 ha) in size, although often smaller (0.1 ha) plots and occasionally much larger ones (25 and 50 ha) have also been established. These plots may then be integrated into national or regional networks to address questions of importance at these larger spatial scales. The value of census plot data increases with the length of the records available, and there are now robust analyses of forest change based on decadal-scale censuses of multiple plots within regions. Thus it may be possible, for the first time, to derive a truly global picture of forest change based on multi-year time series.

Ecophysiological approaches: A network of distributed plots has the potential to capture stand-level data on species composition and dynamics, but understanding the mechanisms of underlying forest–canopy interactions requires instrumentation and manipulative experiments, and measurements over short (diurnal to annual) time scales. Insights into the physiological mechanisms that drive forest responses to changing environments have been obtained from networks of canopy flux towers and experimental sites that now extend across all forest ecosystems. These point-source data provide time series of

physiological processes that help to calibrate and interpret the inventory data obtained from plots, but in order to maximise the potential to achieve these aims it is necessary to move across scales using modelling techniques.

Modelling: More recently, forest ecologists have begun to use census plot and ecophysiological data to develop and test models that simulate changes on mapped stands. These forest simulators are then applied to topics ranging from theoretical models of tree species coexistence through to scenario-testing for forest management. There is an important synergistic relationship between forest plots and simulation models: plots are required to generate realistic parameters for most types of forest simulation model, while models add value to plot networks by projecting over longer time scales and multiple alternative scenarios. In order to realise the added value of these approaches, it is important for ecologists who hold plot data and those with expertise in modelling to communicate effectively in the same fora.

Remote sensing: Remote sensing techniques represent a tool for rapid monitoring of land-use changes over substantial areas, and are likely to increase in importance as the resolution of image analysis improves. Satellite images have a long history for monitoring land-use. For instance, the LANDSAT satellites provide unparalleled evidence of the changes of cover and seasonality of forests. Emerging technologies include the use of LiDAR (light detection and ranging) sensors to provide detailed information about canopy structure, and hyperspectral imagery provides, for the first time, methods to identify the positions of species and functional groups over entire landscapes based on the chemical signatures of individual tree crowns.

Molecular phylogenies: Rapid advances in high-throughput sequencing and new bioinformatics tools are allowing ecologists to construct dated community-level phylogenies that permit inference of patterns of diversification in response to historical phases of global change. These data are providing new perspectives into the processes that influence contemporary patterns of plant distribution, and represent an important resource for researchers attempting to forecast the impacts of contemporary global change.

We are indebted to all the authors who contributed chapters, and to everybody who helped make the symposium a memorable success. We are especially grateful to the anonymous reviewers of chapters, the Editorial Board of *Ecological Reviews*, and Cambridge University Press. The future of forests depends on how humans decide to manage them in the decades to come. It is our hope that after reading this volume you will have a greater appreciation of the multiple drivers of forest change, and feel inspired to become involved in conservation of these unique and vulnerable ecosystems.

David Burslem
David Coomes and William Simonson