

Managing Forest Ecosystems

Volume 34

Series Editors

Klaus von Gadow, *Georg-August-University, Göttingen, Germany*

Timo Pukkala, *University of Joensuu, Joensuu, Finland*

Margarida Tomé, *Instituto Superior de Agronomia, Lisbon, Portugal*

Aims & Scope

Well-managed forests and woodlands are a renewable resource, producing essential raw material with minimum waste and energy use. Rich in habitat and species diversity, forests may contribute to increased ecosystem stability. They can absorb the effects of unwanted deposition and other disturbances and protect neighbouring ecosystems by maintaining stable nutrient and energy cycles and by preventing soil degradation and erosion. They provide much-needed recreation and their continued existence contributes to stabilizing rural communities.

Forests are managed for timber production and species, habitat and process conservation. A subtle shift from multiple-use management to ecosystems management is being observed and the new ecological perspective of multi-functional forest management is based on the principles of ecosystem diversity, stability and elasticity, and the dynamic equilibrium of primary and secondary production.

Making full use of new technology is one of the challenges facing forest management today. Resource information must be obtained with a limited budget. This requires better timing of resource assessment activities and improved use of multiple data sources. Sound ecosystems management, like any other management activity, relies on effective forecasting and operational control.

The aim of the book series *Managing Forest Ecosystems* is to present state-of-the-art research results relating to the practice of forest management. Contributions are solicited from prominent authors. Each reference book, monograph or proceedings volume will be focused to deal with a specific context. Typical issues of the series are: resource assessment techniques, evaluating sustainability for even-aged and uneven-aged forests, multi-objective management, predicting forest development, optimizing forest management, biodiversity management and monitoring, risk assessment and economic analysis.

More information about this series at <http://www.springer.com/series/6247>

Felipe Bravo • Valerie LeMay • Robert Jandl
Editors

Managing Forest Ecosystems: The Challenge of Climate Change

Second Edition

 Springer

Editors

Felipe Bravo
ETS de Ingenierías Agrarias - Universidad
de Valladolid & iuFOR - Sustainable
Forest Management Research Institute
Universidad de Valladolid - INIA
Palencia, Spain

Valerie LeMay
Forest Resources Management Department
University of British Columbia
Vancouver, BC, Canada

Robert Jandl
Austrian Research Centre for Forests (BFW)
Vienna, Austria

ISSN 1568-1319 ISSN 2352-3956 (electronic)
Managing Forest Ecosystems
ISBN 978-3-319-28248-0 ISBN 978-3-319-28250-3 (eBook)
DOI 10.1007/978-3-319-28250-3

Library of Congress Control Number: 2017937885

1st edition: © Springer Science + Business Media B.V. 2008
© Springer International Publishing Switzerland 2017

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland



Foreword

During the last decades, climate changes, particularly warming trends, have been recorded around the globe. For many countries, these changes in climate have become evident through insect epidemics (e.g., mountain pine beetle epidemic in Western Canada or bark beetle in secondary spruce forests in Central Europe), drought episodes and intense forest fires in the Mediterranean countries and SW United States, and unusual storm activities in SE Asia. Climate changes are expected to impact vegetation manifesting as changes in vegetation extents, tree species compositions, growth rates, and mortality rates and also as species migrations. Over a number of sessions, the International Panel on Climate Change (IPCC) has discussed how forests may be impacted and also how forests and forest management practices may be used to mitigate the impacts of changes in climate, particularly to possibly reduce the rate of change. The second edition of this volume, which forms part of Springer's book series *Managing Forest Ecosystems*, presents an update on state-of-the-art research results, visions, and theories, as well as specific methods for sustainable forest management under changing climatic conditions. The book contains a wealth of information which may be useful to foresters and forest managers, politicians, and the legal and policy environment and forestry administrators. Case studies from a wide geographic range are presented on the impacts of climate changes on forest environments and economic activities and, also, possible mechanisms for ameliorating climate changes through forest management activities. As in the first edition, the volume is subdivided into five sections.

The first section presents an introduction which clarifies the context and sets the scene, in particular focusing on climatic change and its impact on forest management, the mitigation potential of sustainable forestry, and the role of adaptive management and research. The second section titled "Overview of Climate Change and Forest Responses" provides a general overview, including information about greenhouse gas emissions from mountain forests, the capacity of forests to cope with climate change, and the role of dead trees in carbon sequestration. The third section presents monitoring and modeling approaches. This includes methods to estimate carbon stocks and stock changes in forests at different scales of resolution, methods to estimate climate change impacts on forest health, an overview of forest

ecophysiological models, and recent advancements in techniques for assessing and monitoring carbon stocks. In the fourth section, several approaches for economic analyses of different management scenarios are presented, including optimizing carbon sequestration in coppice rotations, estimating carbon in forests and wood products, and examining climatic impacts on forest economies, including changes in harvest cycles and uses of wood. Finally, a range of case studies on climate change impacts and mitigation activities in different ecosystems across Africa, Asia, Europe, and America is presented in the fifth section. The case studies include both natural and planted forests in temperate and tropical biomes.

We wish to acknowledge the valuable contributions made by our referees, for their constructive criticism and improvement. Finally, we appreciate the diligent proofreading and editing assistance provided by Celia Redondo of the University of Valladolid at Palencia and Ria Kanters of Springer in the first edition and by Valeria Rinaudo and Ineke Ravesloot in the second edition.

Palencia, Spain
Vienna, Austria
Vancouver, BC, Canada

Felipe Bravo
Robert Jandl
Valerie LeMay

Contents

Part I Introduction

- 1 Introduction**..... 3
Felipe Bravo, Robert Jandl, Valerie LeMay, and Klaus von Gadow

Part II Overview of Climate Change and Forest Responses

- 2 A Mechanistic View of the Capacity of Forests to Cope with Climate Change** 15
Fernando Valladares
- 3 Greenhouse Gas Emissions from Temperate European Mountain Forests**..... 41
Robert Jandl, Mirco Rodeghiero, Andreas Schindlbacher, and Frank Hagedorn

Part III Monitoring and Modeling

- 4 Estimating Carbon Stocks and Stock Changes in Forests: Linking Models and Data Across Scales** 61
V. LeMay and W.A. Kurz
- 5 Forest Eco-Physiological Models: Water Use and Carbon Sequestration** 81
D. Nadal-Sala, T.F. Keenan, S. Sabaté, and C. Gracia
- 6 Influence of Climatic Variables on Crown Condition in Pine Forests of Northern Spain** 103
A.V. Sanz-Ros, J.A. Pajares, and J.J. Díez
- 7 Changing Trends of Biomass and Carbon Pools in Mediterranean Pine Forests**..... 119
Cristina Gómez, Joanne C. White, and Michael A. Wulder

- 8 REDD+ and Carbon Markets: The Ethiopian Process** 151
Julian Gonzalo, Solomon Zewdie, Eyob Tenkir,
and Yitebitu Moges

Part IV Economic and Management Impacts

- 9 Influence of Carbon Sequestration in an Optimal Set of Coppice Rotations for Eucalyptus Plantations** 187
Luis Diaz-Balteiro and Luiz C.E. Rodríguez
- 10 Use of Forests and Wood Products to Mitigate Climate Change** 205
L. Valsta, B. Lippke, J. Perez-Garcia, K. Pingoud, J. Pohjola,
and B. Solberg
- 11 Biomass Forest in Sweden and Carbon Emissions Balance** 219
Tord Johansson
- 12 Innovation in the Value Chain of Wood Products: Data, Equations and Life-Cycle Analysis** 235
I. Lizarralde, F. Rodríguez, and F. Bravo
- 13 Forest Carbon Sequestration: The Impact of Forest Management**.... 251
Felipe Bravo, Miren del Río, Andrés Bravo-Oviedo,
Ricardo Ruiz-Peinado, Carlos del Peso, and Gregorio Montero
- 14 Effects of Forest Age Structure, Management and Gradual Climate Change on Carbon Sequestration and Timber Production in Finnish Boreal Forests** 277
Jordi Garcia-Gonzalo, Ane Zubizarreta-Gerendiain,
Seppo Kellomäki, and Heli Peltola

Part V Case Studies

- 15 Mediterranean Pine Forests: Management Effects on Carbon Stocks** 301
Miren del Río, Ignacio Barbeito, Andrés Bravo-Oviedo,
Rafael Calama, Isabel Cañellas, Celia Herrero, Gregorio
Montero, Dianel Moreno-Fernández, Ricardo Ruiz-Peinado,
and Felipe Bravo
- 16 Carbon Sequestration of Ponderosa Pine Plantations in Northwestern Patagonia** 329
P. Laclau, E. Andenmatten, F.J. Letourneau, and G. Loguercio
- 17 Assessing Pine Wilt Disease Risk Under a Climate Change Scenario in Northwestern Spain** 351
G. Pérez, J.J. Díez, F. Ibeas, and J.A. Pajares

18 Soil Organic Carbon Sequestration Under Different Tropical Cover Types in Colombia..... 367
 Flavio Moreno, Steven F. Oberbauer, and Wilson Lara

19 Modelling of Carbon Sequestration in Rubber (*Hevea brasiliensis*) Plantations 385
 Engku Azlin Rahayu Engku Ariff, Mohd Nazip Suratman, and Shamsiah Abdullah

20 Carbon Sequestration in Mediterranean Oak Forests 403
 Isabel Cañellas, Mariola Sánchez-González, Stella M. Bogino, Patricia Adame, Daniel Moreno-Fernández, Celia Herrero, Sonia Roig, Margarida Tomé, Joana A. Paulo, and Felipe Bravo

21 Forest Management in the Sahel and Ethiopian Highlands and Impacts on Climate Change..... 429
 Wubalem Tadesse, Mulugeta Lemenih, and Shiferaw Alem

Index..... 447