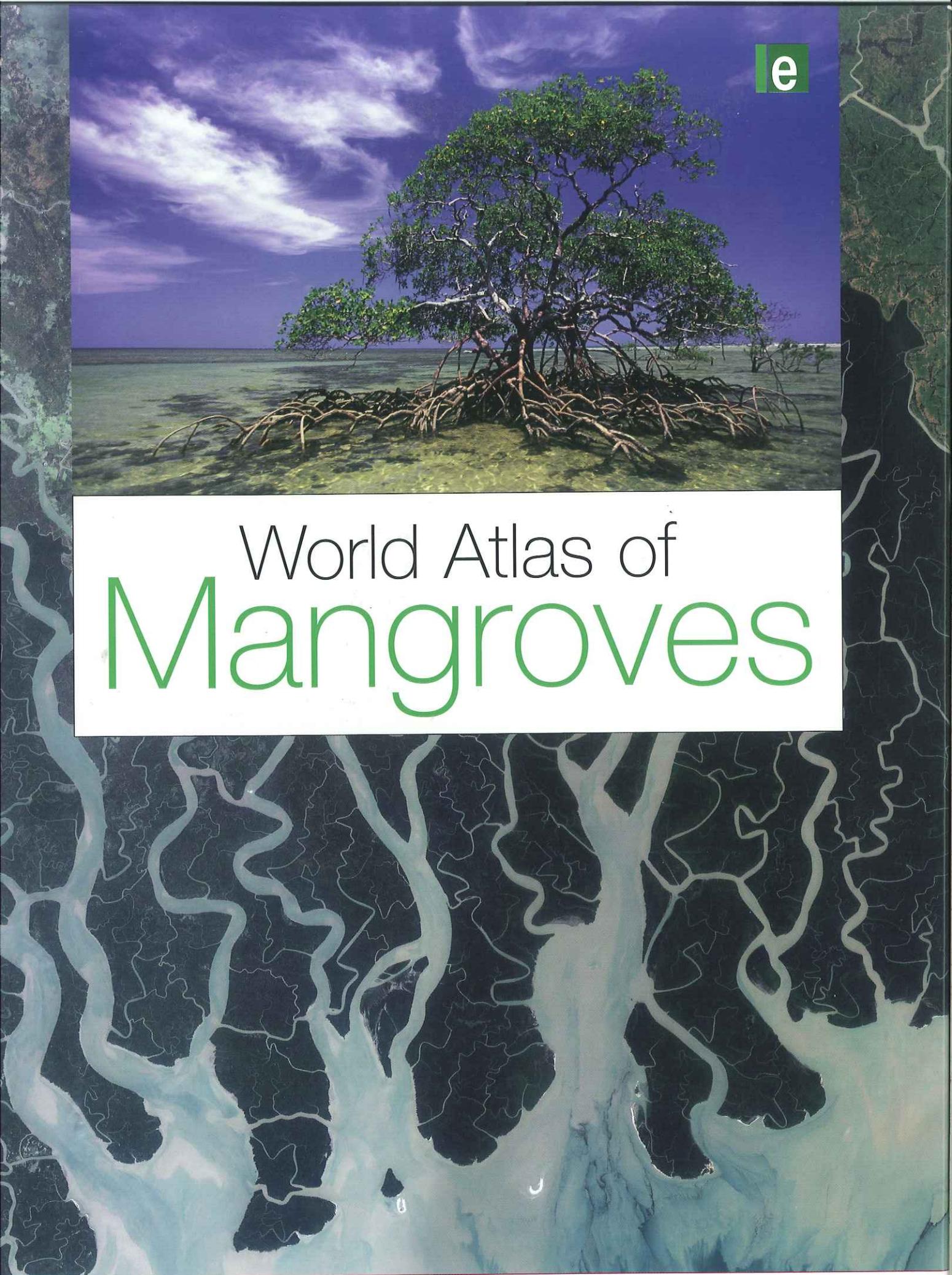


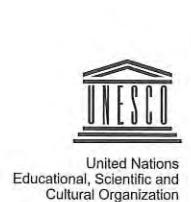
e

World Atlas of Mangroves



World Atlas of Mangroves

Mark Spalding, Mami Kainuma
and Lorna Collins



earthscan
publishing for a sustainable future

London • Washington, DC

First published by Earthscan in the UK and USA in 2010

Copyright © 2010 jointly vested by ITTO, ISME, FAO, UNEP-WCMC, UNESCO-MAB and UNU-INWEH.
This publication may not be reproduced, in whole or in part, by any method or process, without written permission from ISME, the focal copyright holder. Applications for such permission with a statement of the purpose and extent of the reproduction desired should be made through and addressed to International Society for Mangrove Ecosystems (ISME), c/o Faculty of Agriculture, University of the Ryukyus, Okinawa 903-0129, Japan (email: isme@mangtove.or.jp). ISME would appreciate receiving a copy of any publication that uses this publication as a source.

All rights reserved

This publication was primarily funded by the International Tropical Timber Organization (ITTO) through ITTO Project PD 276/04 Rev.2 (F). The project was implemented by the International Society for Mangrove Ecosystems (ISME). In addition to ITTO, project partners included FAO Forestry Department, UNEP-World Conservation Monitoring Centre (WCMC), UNESCO-Man and the Biosphere Programme (MAB), and UNU-Institute for Water, Environment and Health (INWEH) and substantial collaboration by The Nature Conservancy (TNC) all of who provided materials or in-kind inputs. The Japanese Government financially supported this project through ITTO.

The designations of geographical entities in this atlas, and the presentation of the material, do not imply the expression of any opinion whatsoever on the part of the participating organizations concerning the legal status of any country, territory or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Earthscan Ltd, Dunstan House, 14a St Cross Street, London EC1N 8XA, UK

Earthscan LLC, 1616 P Street, NW, Washington, DC 20036, USA

Earthscan publishes in association with the International Institute for Environment and Development

For more information on Earthscan publications, see www.earthscan.co.uk or write to earthinfo@earthscan.co.uk

ISBN: 978-1-84407-657-4

Typeset by FiSH Books

Cover design by Andrew Corbett

Background picture © Earth Observatory/NASA; mangrove picture © Luiz C. Marigo/Peter Arnold/Still Pictures.

A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data

Spalding, Mark.

World atlas of mangroves / Mark Spalding, Mami Kainuma and Lorna Collins.

p. cm.

Includes bibliographical references and index.

ISBN 978-1-84407-657-4

1. Mangrove forests—Maps. 2. Mangrove swamps—Maps. 3. Mangrove plants—Maps. I. Kainuma, Mami, II. Collins, Lorna. III. Title.

G1046D2. S6 2010

333.75—dc22

2009031020

At Earthscan we strive to minimize our environmental impacts and carbon footprint through reducing waste, recycling and offsetting our CO₂ emissions, including those created through publication of this book. For more details of our environmental policy, see www.earthscan.co.uk.

This book was printed in Malta by Gutenberg Press.

The paper used is FSC certified and the inks are vegetable based.



Partner organizations



The International Tropical Timber Organization (ITTO) is an intergovernmental organization promoting the conservation and sustainable management, use and trade of tropical forest resources. Its 60 members represent about 80 per cent of the world's tropical forests and 90 per cent of the global tropical timber trade. ITTO develops internationally agreed policy documents to promote sustainable forest management and forest conservation and assists tropical member countries to adapt such policies to local circumstances to implement them in the field through projects. In addition, ITTO collects, analyses and disseminates data on the production and trade of tropical timber and funds projects and other actions aimed at developing industries at both community and industrial scales. All projects are funded by voluntary contributions, mostly from consumer member countries. Since it became operational in 1987, ITTO has funded 900 projects, pre-projects and activities valued at more than US\$330 million. The major donors are the governments of Japan, Switzerland and the United States. www.itto.int



The International Society for Mangrove Ecosystems (ISME) was established in August 1990 with its headquarters in Okinawa, Japan. The society was registered as a non-profit organization. The statutes stipulate that ISME shall collect, evaluate and disseminate information on mangrove ecosystems, and promote international cooperation. ISME has been conducting its activities at the global level through knowledge application; training and education; and information exchange. As of 2009, ISME's membership includes 38 institutional and over 1000 individual members from 90 countries. www.mangrove.or.jp



The Food and Agriculture Organization of the United Nations (FAO) is one of the largest specialized agencies in the United Nations system and the lead agency for agriculture, forestry, fisheries and rural development. The Forestry Department helps nations manage forests in a sustainable way. The Organization's approach balances social, economic and environmental objectives so that present generations can reap the benefits of the Earth's forest resources while conserving them to meet the needs of future generations. www.fao.org



The United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) is the biodiversity assessment and biodiversity policy support arm of UNEP. The Centre has operated for over 25 years, providing objective, scientifically rigorous products and services to help decision-makers

recognize the value of biodiversity and apply this knowledge to all they do. The Centre's core business is locating data about biodiversity and its conservation, interpreting and analysing that data to provide assessments and policy analysis, and making the results available to both national and international decision-makers and businesses. www.unep-wcmc.org



United Nations Educational, Scientific and Cultural Organization (UNESCO) functions as a laboratory of ideas and a standard-setter to forge universal agreements on emerging ethical issues. The Organization also serves as a clearing house for the dissemination and sharing of information and knowledge while helping Member States to build their human and institutional capacities in diverse fields. The Man and the Biosphere Programme (MAB), proposes an interdisciplinary research agenda and capacity-building aiming to improve the relationship of people with their environment globally. It uses its World Network of Biosphere Reserves as vehicles for knowledge-sharing, research and monitoring, education and training, and participatory decision-making. www.unesco.org/mab



United Nations University Institute for Water, Environment and Health (UNU-INWEH) is the UN think tank on water and contributes to resolving the global water challenges through applied research, capacity-building and policy advice. It is a member of the United Nations University family of organizations, and is supported by the Government of Canada. A dedicated programme focuses on the integration of coastal science and management. It aims to foster sound decision-making, especially in developing countries, through scientific research, and human and institutional capacity-building. Activities particularly focus on coral reef and mangrove habitats. www.inweh.unu.edu



The Nature Conservancy is a leading conservation organization working around the world to protect ecologically important lands and waters for nature and people. The Conservancy has more than 700 staff scientists, and uses science to guide its work and to build effective conservation actions. With more than one million members the Conservancy works in more than 30 countries. With partners it has helped protect more than 480,000 square kilometres of land and more than 8000 kilometres of rivers, while it operates more than 100 marine conservation projects. www.nature.org

Supporting countries/ organizations



JAPAN
Official Development Assistance

The objectives of Japan's Official Development Assistance (ODA) are to contribute to the peace and development of the international community. Japan has utilized its ODA to actively support a number of activities/issues including human resource development as well as global issues such as those related to the environment and water, which are important issues that need to be addressed in order for the international community as a whole to achieve sustainable development. This Atlas project was made possible by an ODA grant provided by the Government of Japan through ITTO. www.mofa.go.jp



สถาบันสิ่งแวดล้อมไทย
Thailand Environment Institute

Founded in May 1993 on the belief that partnership is the most effective approach achieving a more sustainable way of life, the Thailand Environment Institute (TEI) advocates a participatory approach to shared environmental responsibility. Only through harnessing our collective strengths can we hope to achieve a better life for all. www.tei.or.th



TOKIO MARINE
NICHIDO

Tokio Marine & Nichido Fire Insurance is a leading company in Japan's nonlife insurance industry. It was established as the first Japanese nonlife insurance company in August 1879, and this year is the 130th anniversary of the foundation. In 1999, we launched the mangrove reforestation project in areas centred on South-east Asian countries as one of our 120th Anniversary Commemorative Projects. ISME has been supporting our project from the technical side. We have declared our intention to continue this mangrove reforestation project for 100 years. During the last decade, we have planted over 5000 hectares of forests. www.tokiomarine-nichido.co.jp/en/index.html



The University of the Ryukyus was established in 1950 with the support of the United States Military Government of the Ryukyu islands and it became a national university of Japan in 1972. The university has conducted distinctive research and education based on unique geological and historical characteristics of Okinawa, such as marine sciences, tropical agriculture and Okinawan studies, and has promoted academic exchanges with countries/areas in the Asia-Pacific regions. The university consists of seven faculties (Law & Letters, Tourism Sciences & Industrial Management, Education, Science, Medicine, Engineering and Agriculture) and eight graduate schools. www.u-ryukyu.ac.jp/en



The Tropical Biosphere Research Center (TBRC) of the University of the Ryukyus was established in 1994 through the unification of the Sesoko Marine Science Center and the Iriomote Research Institute of Tropical Agriculture. In 2009, TBRC was merged with the Center of Molecular Biosciences. The main objective of the center is to promote broad-based research on the diversity of tropical and subtropical biota and to promote research at molecular level in the fields of natural and biomedical sciences and biotechnology. The TBRC has been hosting more than ten thousand scientists per year to promote research collaborations. www.u-ryukyu.ac.jp/tbrc



Wetlands International is an independent, not-for-profit, global organization that works to sustain and restore wetlands and their resources. Based mostly in the developing world, we have 20 offices on all continents and projects in over 100 countries. Our head office is in Ede, the Netherlands. We work from coastal regions up to high mountain wetlands, at river basin scale and in global flyways to address biodiversity and poverty-environment issues. This involves research, capacity building, community-based projects, advocacy and local to international policy influencing. www.wetlands.org

Contents

Tables, Boxes and Maps.....	vii
Acknowledgements.....	ix
Foreword	xii
Preface.....	xiii
Acronyms and Abbreviations.....	xiv
Introduction	xv
1 Mangrove Ecosystems	1
Mangrove plants.....	1
The mangrove environment	5
Mangrove distribution.....	6
Biogeographic patterns	7
Mangrove ecology	11
2 Mangroves and People	23
Ecosystem services.....	24
Human impacts	31
Managing mangroves.....	37
Summary	43
3 Mapping Mangroves	47
The current work	47
UNEP –World Conservation	
Monitoring Centre mangrove maps	48
Food and Agriculture Organization of the United Nations (FAO) mangrove maps.....	49
Other sources	49
Mangrove area statistics	50
Output maps.....	51
Map key	52
4 Eastern and Southern Africa.....	57
The Comoros Archipelago:	
Comoros and Mayotte	57
Kenya.....	58
Madagascar	61
The Mascarene Islands: Mauritius and Réunion	61
Mozambique	62
The Seychelles.....	64
Somalia	64
South Africa	65
Tanzania.....	67
5 The Middle East	71
Bahrain	71
Djibouti	71
Egypt	72
Eritrea	74
Iran	75
Kuwait	75
Oman	77
Qatar	77
Saudi Arabia.....	79
Sudan.....	80
United Arab Emirates.....	80
Yemen	82
6 South Asia	85
Bangladesh	85
India	88
The Maldives and the British Indian Ocean Territory	94
Pakistan.....	94
Sri Lanka.....	96
7 South-East Asia.....	103
Brunei Darussalam.....	103
Cambodia	104
Indonesia	105
Malaysia	114
Myanmar	118
The Philippines.....	121
Singapore	125
Thailand	125
Timor-Leste	128
Vietnam	129
8 East Asia	135
China.....	135
Taiwan	137
Japan.....	139
9 Australia and New Zealand.....	143
Australia.....	143
New Zealand.....	155
10 Pacific Islands.....	161
Melanesia	161
Fiji.....	161
New Caledonia.....	163
Papua New Guinea	164
Solomon Islands	166
Vanuatu	169
Micronesia	169
Federated States of Micronesia.....	169

Guam	172
Kiribati.....	172
Marshall Islands.....	173
Nauru.....	173
Northern Mariana Islands.....	173
Palau.....	173
Polynesia	174
American Samoa.....	174
French Polynesia.....	174
Hawaii.....	174
Niue	175
Samoa.....	175
Tokelau.....	175
Tonga	175
Tuvalu.....	175
Wallis and Futuna.....	176
11 North and Central America and the Caribbean	181
The Bahamas	181
Belize	183
Bermuda	183
Cayman Islands.....	185
Costa Rica.....	185
Cuba	186
The Dominican Republic.....	189
El Salvador.....	191
Guatemala.....	191
Haiti	192
Honduras.....	192
Jamaica.....	193
Lesser Antilles	194
Anguilla (UK).....	194
Antigua and Barbuda.....	194
Barbados.....	196
British Virgin Islands (UK)	196
Dominica	196
Grenada and the Grenadines.....	196
Guadeloupe (France)	196
Martinique (France).....	197
Montserrat (UK)	197
Netherlands Antilles and Aruba (Netherlands)	197
St Kitts and Nevis.....	197
St Lucia	198
St Vincent and the Grenadines	198
US Virgin Islands (USA)	198
Mexico	198
Nicaragua.....	204
Panama	206
Puerto Rico	207
Trinidad and Tobago	207
Turks and Caicos.....	208
United States of America.....	208
12 South America	215
Brazil.....	215
Colombia.....	222
Ecuador.....	225
French Guiana	229
Guyana	232
Peru	232
Suriname.....	234
Venezuela.....	234
13 West and Central Africa.....	241
Angola	241
Benin	242
Cameroon	243
Congo	243
Democratic Republic of the Congo	245
Equatorial Guinea	246
Gabon	246
The Gambia	247
Ghana	249
Guinea	250
Guinea-Bissau	252
Liberia.....	253
Mauritania	253
Nigeria	255
São Tomé and Príncipe	257
Senegal	258
Sierra Leone	260
Togo	261
Annex 1 Species Descriptions and Range Maps.....	263
Annex 2 National Species Lists.....	277
Annex 3 National Statistics	287
Index	305

Tables, Boxes and Maps

Tables

1.1	The world's 73 mangrove species and hybrids	2
1.2	Regional summaries of mangrove area	6
1.3	The world's largest near-unbroken mangrove tracts	7
1.4	The 12 countries with the largest mangrove areas in the world	8
1.5	Mangrove biomass statistics	13
1.6	Productivity statistics for tropical mangrove systems	14
2.1	Selected examples of economic valuation	30
2.2	Estimated declines in mangrove area by region since 1980	36
2.3	Selected examples of mangrove declines	37
2.4	Examples of mangrove restoration projects	39
3.1	List of acronyms and abbreviations used for protected areas	52
6.1	Impact of the 2004 tsunami upon loss of human lives and wealth in 18 different fishing villages along the south-east coast of India	91

BOXES

2.1	Mangroves and climate change	34
5.1	The unique mangroves of the United Arab Emirates	82
6.1	Coastal protection against tsunamis by mangroves and other vegetation along the south-east coast of India	90
6.2	Post-tsunami mangroves of Andaman and Nicobar Islands	93
7.1	Firefly ecotourism in Malaysia	115
7.2	Primate herbivores of the mangroves of Borneo	119
11.1	Mangrove restoration encouraged by plant-microbe interaction in the arid environment of Baja California Sur, Mexico	203
12.1	Experiences in sustainable management and restoration of mangrove forests in Colombia	226
12.2	Coastal dynamics and their consequences for mangrove structure and functioning in French Guiana	230
13.1	Conserving mangroves in Cameroon	244

Maps

1.1	The global distribution of mangroves	8
1.2	The diversity of mangrove species worldwide	10
2.1	Protected areas with mangroves	40
	Regional map 1 Western Indo-Pacific	55
4.1	Kenya and Tanzania	59
4.2	Madagascar	60
4.3	Mozambique	63
4.4	South Africa	66
5.1	Red Sea	73
5.2	Arabian Gulf and Gulf of Oman	76
5.3	Gulf of Aden	78
6.1	Northern Bay of Bengal	86
6.2	Southern India, Sri Lanka and the Maldives	89
6.3	Pakistan and north-west India	95
	Regional map 2 Central Indo-Pacific	101
7.1	South Sumatra and Java	106
7.2	Borneo	109
7.3	Sulawesi	110
7.4	Nusa Tenggara	111
7.5	Papua (Indonesia)	113
7.6	Peninsula Malaysia and Sumatra	116
7.7	Myanmar	120
7.8	Northern Philippines	122
7.9	Southern Philippines	123
7.10	Thailand	127
7.11	Cambodia and southern Vietnam	130
8.1	Northern Vietnam and southern China	136
8.2	Eastern China and Taiwan	138
8.3	Japan	140
9.1	Northern Australia	144
9.2	North-eastern Australia	146
9.3	Eastern Australia	149
9.4	South-eastern Australia	150
9.5	South Australia	152
9.6	Western Australia	153
9.7	North-western Australia	154
9.8	New Zealand	156
	Regional map 3 Eastern Indo-Pacific	159
10.1	Fiji	162
10.2	Papua New Guinea	165
10.3	Solomon Islands	167
10.4	Vanuatu and New Caledonia	168
10.5	Western Micronesia	170
10.6	Kiribati and Tuvalu	171

Regional map 4 The Americas	179	Regional map 5 West and Central Africa	239
11.1 Yucatan, Belize and northern Honduras	184	13.1 North-west Africa	248
11.2 Cuba and Jamaica	187	13.2 Guinea Bissau to Sierra Leone	251
11.3 Eastern Greater Antilles	190	13.3 Liberia, Côte d'Ivoire and Ghana	254
11.4 Lesser Antilles	195	13.4 Gulf of Guinea	256
11.5 Gulf of California	200	13.5 Gabon to Angola	259
11.6 Gulf of Mexico	201		
11.7 Central America	205		
11.8 Florida and the Bahamas	209		
12.1 Northern Brazil	216		
12.2 North-eastern Brazil	219		
12.3 Southern Brazil	221		
12.4 Northern Colombia and western Venezuela	223		
12.5 Pacific South America	228		
12.6 Eastern Venezuela and the Guianas	233		