Living in a Dynamic Tropical Forest Landscape

Living in a Dynamic Tropical Forest Landscape

Edited by

Nigel E. Stork and Stephen M. Turton

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FOREWORD

The world's tropical rainforests, which occupy no more than 7% of the Earth's land mass, sequester within them about 40% of all carbon that is not held in the oceans. Importantly, they are home to a large part of global biodiversity, with perhaps as many as half of the world's total species found nowhere else. In addition, they play a key role in the Earth's atmospheric circulation and in the determination of climate, including precipitation, at a local and regional scale. Located almost entirely within developing countries, these forests are heavily impacted by legal and illegal logging, destructive mining, clearing for agriculture and plantations and shifting cultivation. A majority of Indigenous people living in rainforest areas have been removed from their traditional lands, and the megafauna in these forests, essential to their regular functioning, is being devastated by hunting.

Despite strong efforts for more than three decades, it has proved extraordinarily difficult to develop sustainable land-use systems in the moist tropics. Their resources have proved attractive for exploitation by corporations and individuals within their own countries, and the speed of their destruction has been increased by the demands of an emerging global economy. Industrialized countries have, as a whole, exhibited insufficient will to secure the protection of resources outside of their boundaries, despite continued lamentation about the situation.

Tropical rainforests are found on the mainland of only one industrialized nation, Australia, and it is in the so-called 'Wet Tropics' of that nation that major progress has been made in achieving sustainable systems for these forest ecosystems. The local scientific community has played a major, long-term role, particularly in driving the creation of the Wet Tropics of Queensland World Heritage Area in the 1980s. Impressive advances have been made in the past 10–15 years through the creation of a multidisciplinary science-based partnership – the Cooperative Research Centre for Tropical Rainforest Ecology and Management – that unites universities, the Commonwealth Scientific Industrial Research Organisation (CSIRO), other research organizations, local communities and local people, the Indigenous community, governments at all levels, industry, particularly the tourism industry, and non-governmental organizations in an effort to manage these ecosystems sustainably. This book provides an in-depth analysis of how this progress has been achieved.

It is fitting that we should pay respect to the research pioneers of the Wet Tropics and in particular to Len Webb, whose botanical studies in the 1960s and 1970s and later, often with Geoff Tracey, laid out the path for others to follow. Len was passionate about Indigenous people, and would be pleased to see the recent strength of engagement with Rainforest Aboriginal peoples, evidenced by numerous chapters in this book. It is also good to see a few of those pioneers as authors in this book – Jiro Kikkawa, Mike Bonell, and many more. Also included as authors are some of those who made the conservation and protection of rainforests in North Queensland happen, including Aila Keto, Rosemary Hill and Mike Berwick. The battles to preserve Australia's rainforests up and down the east coast and in south-west Tasmania have been fierce and have received much international attention.

In the final chapter, editors Nigel Stork and Steve Turton ask whether there are lessons from the Australian Wet Tropics that can be applied elsewhere. There certainly are! It is essential in pursuing sustainability anywhere to engage all the stakeholders in debates about the way rainforests can be managed, to make science-based decisions and to work across disciplines and ecosystems. The ways in which our landscapes are managed directly affect the health of waterways, estuaries, wetlands, coral reefs and oceans. This book takes a uniquely comprehensive and therefore exemplary holistic approach to landscape science and sustainable management, and is a valuable contribution that will certainly attract interest throughout the world.

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ACRONYMS AND ABBREVIATIONS

AATSE	Australian Academy of Technological Sciences and Engineering
ABA	additive basal area
ACF	Australian Conservation Foundation
ACIUCN	Australian Committee for the World Conservation Union
AGB	above-ground biomass
AHC	Australian Heritage Commission
AIMS	Australian Institute of Marine Science
ALP	Australian Labour Party
ANN	artificial neural network
ATSIC	Aboriginal and Torres Strait Islander Commission
AWS	automatic weather station
BA	basal area
BK	Bellenden Ker
BMB	Black Mountain Barrier
BMC	Black Mountain Corridor
BP	before present
BRDF	bidirectional reflectance distribution function
CAFNEC	Cairns and Far North Environment Centre
cal. yr BP	calculated year before present
CAPE	convective available potential energy
CCA	Community Conserved Areas
CDM	clean development mechanism
CEO	chief executive officer
CMA	Catchment Management Authorities
CNVF	complex notophyll vine forest
CRC	Cooperative Research Centre
CRRP	Community Rainforest Revegetation Program
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTCC	Cape Tribulation Community Council
CVM	contingent valuation method
Cwlth	Commonwealth
CYCC	Cape York Conservation Council
D	Recharge
DASETT	Department of Arts, Sports, the Environment, Tourism and Territories
DBH	diameter at breast height
DEC	Department of Environment and Conservation
DEM	digital elevation model
DFG	disperser functional groups
DN	digital numbers
DNRM	Department of Natural Resources and Mines
DNRMW	Department of Natural Resources, Mines and Water
DOGIT	deed of grant in trust
DPI	Queensland Department of Primary Industries
DPIF	Department of Primary Industries and Fisheries
EIA	environmental impact assessment
EMS	environmental management systems
ENSO	El Niño Southern Oscillation
EOS	experience opportunity spectrum
EPA	Environmental Protection Agency
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ERS	European Remote Sensing satellite
E_s	forest floor evaporation
ET	evapotranspiration
EVI	enhanced vegetation index
FANN	forest artificial neural network
FFG	fruit functional groups
FIS	forest inventory survey
FLR	forest landscape restoration
FNQ NRM	Far North Queensland Natural Resource Management Ltd.
FNQEB	Far North Queensland Electricity Board
FPQ	Forestry Plantations Queensland
FWPRDC	Forest and Wood Products Research and Development Corporation
GAM	generalized additive models
GBR	Great Barrier Reef
GBRMPA	Great Barrier Reef Marine Park Authority
GCM	global climate models
GCP	ground control points
GDR	Great Dividing Range

GIS	geographical information systems
GLM	generalized linear models
GPS	global positioning systems
HCO	Holocene climatic optimum
HoA	heads of agreement
I	canopy interception
IBRA	Interim Biogeographic Regionalisation for Australia
IFOV	instantaneous field of view
ILUA	Indigenous land use agreement
IPA	Indigenous Protected Areas
IPCC	Intergovernmental Panel on Climate Change
IPCC TAR	International Panel for Climate Change Third Assessment Report
IPM	integrated pest management
ITSG	Indigenous technical support group
IUCN	International Union for Conservation of Nature and Natural Resources (World Conservation Union)
IWG	Indigenous working group
JCU	James Cook University
JERS	Japanese Earth Resource Satellite
JI	joint implementation
K^*	satiated (saturated) hydraulic conductivity
LAI	leaf area index
LGM	Last Glacial Maximum
MDI	mean daily intensity
MEA	millennium ecosystem assessment
MHR	Member of the House of Representatives
MIS	managed investment schemes
MJO	Madden–Julian Oscillation
ML1	Mount Lewis
MP	Member of Parliament
MSL	mean sea level
MVF	mesophyll vine forest
NAP	National Action Plan
NAPSWQ	National Action Plan for Salinity and Water Quality
NCAR	National Centre for Atmospheric Research
NCEP	National Centre for Environmental Prediction
NDVI	normalized difference vegetation index
NGO	non-government organization
NHT	Natural Heritage Trust
NIR	near infra-red
NORMA	Northern Rainforest Management Agency
NPP	net primary production
NQAA	North Queensland Afforestation Association
NQTC	North Queensland Timber Cooperative
NRM	natural resource management
NRM & E	natural resources, mines and energy
NSW	New South Wales
NT	Northern Territory
OC	Oliver Creek
OECD	Organisation for Economic Co-operation and Development
P	total precipitation
PAR	photosynthetically active radiation
P_c	cloud interception
PFANN	palaeo-forest artificial neural network
P_g	rainfall
P_{ga}	rainfall corrected for slope effects and wind losses
PHT	Pleistocene/Holocene transition
PJVS	plantation joint venture scheme
PSG	programme support groups
PSIA	psychosocial impact assessment
PV	potential vorticity
QBVR	quantifying the biodiversity values of reforestation
QCC	Queensland Conservation Council
QDMR	Queensland Department of Main Roads
QF	quickflow
QFD	Queensland Forestry Department
QPWS	Queensland Parks and Wildlife Service
QRR	quickflow response ratios
R	runoff
RAAF	Royal Australian Air Force
RAIN	Rainforest Information and Action Network
RCSQ	Rainforest Conservation Society of Queensland
RE	regional ecosystem
RF	return flow
RFID	Rainfall intensity–frequency–duration
RIS	regional investment strategy
ROS	recreation opportunity spectrum
RPAC	Regional Planning Advisory Committee
SAP	structural adjustment package
SAR	Synthetic Aperture Radar

SCP	Smithfield Conservation Park
S_f	stemflow
SIA	social impact assessment
SLATS	Statewide Landcover and Trees Study
SNSM	simple notophyll and simple microphyll forests and thickets
SoE	state of the environment
SOF	saturation overland flow
SoWT	State of the Wet Tropics
SPOT	Systeme Pour l'Observation de la Terre
spp.	species (plural)
SSF	subsurface stormflow
SVI	spectral vegetation indices
T	transpiration
TEK	traditional ecological knowledge
T_f	throughfall
TIN	triangulated irregular network
TOAC	Traditional Owner Advisory Committee
TOFTW	tall open forests and tall woodlands
TREAT	Trees for the Evelyn and Atherton Tablelands
TRS	Tropical Rainforest Society
TWS	The Wilderness Society
UB	Upper Barron
UNESCO	United Nations Educational, Scientific and Cultural Organisation
VIM	visitor impact management
VMS	visitor monitoring system
VP	vertical percolation
VPD	vapour pressure deficit
WA	Western Australia
WAG	Douglas Shire Wilderness Action Group
WHA	World Heritage Area
WHC	World Heritage Committee
WMC	Western Mining Corporation
WTAPPT	Wet Tropics Aboriginal Plan Project Team
WTMA	Wet Tropics Management Authority
WTP	willingness to pay
WTQWHA	Wet Tropics of Queensland World Heritage Area
WTTPS	Wet Tropics Tree Planting Scheme
WTVPRAS	Wet Tropics Vertebrate Pest Risk Assessment Scheme
WTWHA	Wet Tropics World Heritage Area
WTWHPM Act	Wet Tropics World Heritage Protection and Management Act 1993
$\delta\theta$	soil water storage

EDITORS

Nigel Stork holds the Chair of Resource Management and is Head of School of Resource Management and Geography, Head of the Burnley Campus and Associate Dean for Knowledge Transfer at the University of Melbourne. Formerly the CEO of the Cooperative Research Centre for Tropical Rainforest Ecology and Management, he has studied tropical forest ecology with particular interest in insect diversity in many tropical regions of the world. He has edited or co-edited ten books and written more than 150 scientific papers. Nigel is a Director of Earthwatch Australia, Member of Council for Association for Tropical Biology and Conservation and was the former Chair of the Wet Tropics Management Authority Community Consultative Committee.

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INTRODUCTION

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This book is a compendium of what we have learnt about the so-called 'Wet Tropics' landscapes of north-east Australia and brings together a wealth of scientific findings and traditional ecological knowledge. These forested landscapes, although only a very small part of Australia in geographical terms, are home to a high proportion of the continent's species and ecosystems, and have a special significance both nationally and internationally. These tropical forest landscapes have also been the home for Indigenous Australians for thousands of years. In recognition of the global significance of the natural history of the region the Wet Tropics was World Heritage listed by UNESCO in 1988.

Like other regions of eastern Australia (and the humid tropics in general), the Wet Tropics has experienced widespread clearing for agriculture, notably along the coastal plain between Mossman and Ingham and on the Atherton Tablelands inland from Cairns (Figures I.1 and I.2). Despite these major land use impacts, the region still contains large tracts of intact forest and wetlands that, elsewhere in eastern Australia, have been severely fragmented. In recent decades there has been increasing pressure for further agricultural, urban, peri-urban and tourism development in the Wet Tropics and these and other uses compete with nature conservation in what is a highly contested landscape. This has provided regional planners with both challenges and opportunities for sustainable use of Australia's most biologically complex landscape. Many of these impacting forces are discussed in this volume.

Although a few scientists had worked for many years on various aspects of the natural history of the Wet Tropics, until quite recently our understanding of the region was patchy. This changed with the significant funding of the Cooperative Research Centre for Tropical Rainforest Ecology and Management (the Rainforest CRC) from 1993 to 2006. The Rainforest CRC, driven by the wide-ranging needs of its stakeholders, encouraged long-term foundational research and supported multidisciplinary projects often emphasizing the importance of linking social and ecological systems. It is doubtful that such an integrated, concerted and broad-scale research effort has ever been achieved before for a tropical forest landscape anywhere in the world. All those involved in the Rainforest CRC were keen to acknowledge that the important lessons gained from this living research laboratory should be used to guide future research efforts in tropical and sub-tropical Australia and elsewhere in the world. We therefore felt compelled to bring together this knowledge and the lessons learnt in a single comprehensive volume of work. In doing this we were well aware of the paucity

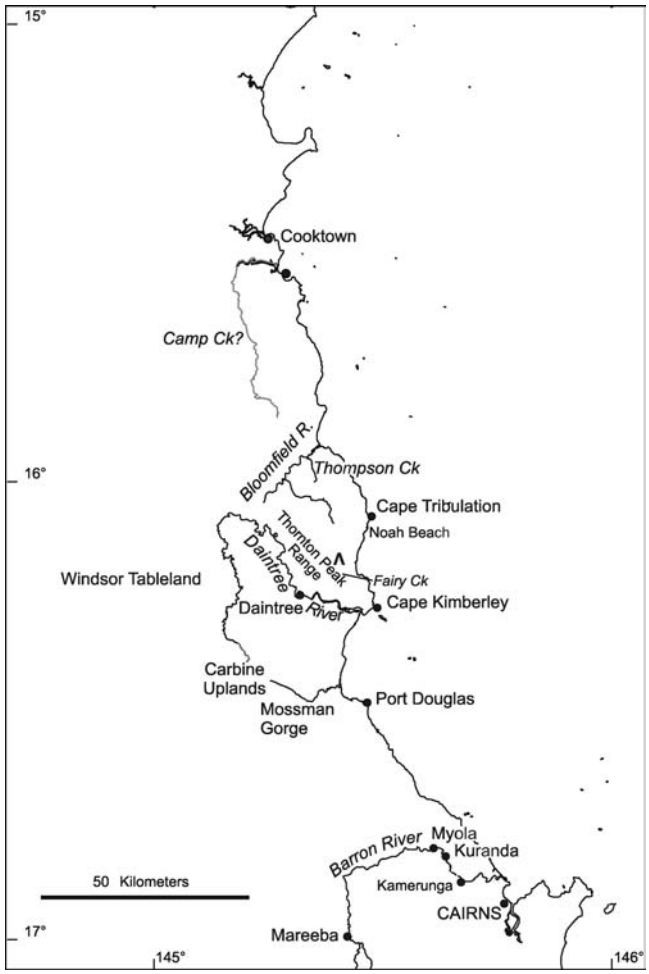

Figure I.1 Wet Tropics region of Australia – northern costal section.

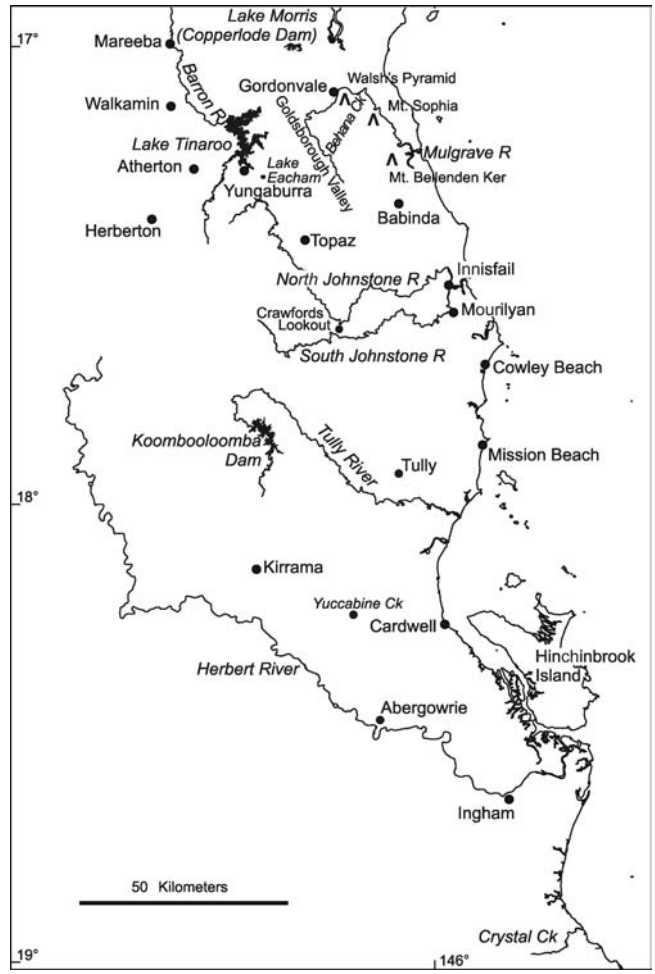

Figure I.2 Wet Tropics region of Australia – southern costal section and Atherton Tablelands.

of information for other tropical forest landscapes around the world. Internationally there are no texts that provide such a holistic view of any tropical forest landscape, including the social, cultural and economic dimensions. Furthermore, no other texts provide such a breadth of understanding and linkages among different fields of study. Other texts focusing on individual tropical forests really only take a biological view and usually lack an Indigenous and management focus (e.g. Gentry 1990; McDade *et al*. 1994; Leigh *et al*. 1996; Laurance & Bierregaard 1997). Recent books by Bermingham *et al*. (2005) examining the history and ecology of tropical forests and by Laurance and Peres (2006) on the threats to tropical forests draw heavily on examples from the Wet Tropics.

Australia has a reputation for its environmental science and its application to improve natural resource management, conservation and sustainability at the landscape scale. It is also the only developed country with tropical rainforest on its mainland. The rainforest science carried out in many fields of study over the past 10–15 years has been world class and there have been many internationally significant scientific breakthroughs, such as those in conservation genetics, vegetation modelling, agroforestry and revegetation techniques, biodiversity assessment and modelling of the impacts of climate change on tropical biodiversity, and the integration of science with natural resource management, to name but a few. In this book authors have been encouraged to place their chapters in an international context.

Since the Australian Wet Tropics rainforests and their adjacent agricultural and urban landscapes are now as well understood as or better understood than any other tropical forest landscapes in the world, we hope that this book also will be of interest to a wide range of readers, including students, scientists, policy-makers and natural resource managers, especially in the humid tropics. The book is presented in six parts, with part summaries being written by international luminaries who have tried to place the chapters in a global context. Part I looks at the history and biodiversity of the Wet Tropics region and includes chapters on Indigenous cultures and European settlement as well as the establishment of the World Heritage Area. Part II examines ecological processes and other ecosystem services and includes chapters on seed dispersal, pollination and economic valuation of the region. Part III looks at the threats to the environmental values of the region, including biological and human-induced threats, such as climate and land-use change. Part IV examines the social and cultural dimensions of living in a World Heritage Area, including reference to the Indigenous People and their ancient links with this landscape. Part V tackles various approaches to restoring tropical forest landscapes, including production versus biodiversity trade-offs. Part VI is concerned with how science can inform policy, conservation and management of tropical forest landscapes. Most authors have included a summary at the end of their chapters and many have also included text boxes highlighting significant issues or case studies.

In writing and editing this book we have been influenced and assisted by a large number of people. We are grateful for the inspirational leadership and encouragement provided by Ralph Slatyer and Sydney Schubert, who chaired the Rainforest CRC from 1993 to 2002 and 2002 to 2006, respectively, the inaugural CEO of the CRC, Jiro Kikkawa, and many Directors of the CRC, including Mike Berwick, David Butcher, Guy Chester, John Courtenay, Josh Gibson, Daniel Gschwind, Brian Keating, John Mullins, Norman Palmer, Julia Playford, David Siddle, Vicki Pattemore and Russell Watkinson. Working in government-funded research programmes means that your research is often subjected to endless reviews! However, we found these to be very useful in guiding our research, with an increased likelihood of useful outcomes for our stakeholders. Here we would like to acknowledge the wise advice provided by some of those reviewers, which often led to significant changes in direction and scientific advances. In particular, we thank Keith Boardman, Henry Nix, Andrew Beattie and Graham Kelleher, all of whom particularly influenced our thinking.

Our editorial assistant, Annette Bryan, performed miracles transforming draft chapters into ready to go text and working with the authors. Adella Edwards similarly transformed the figures provided by authors into a uniform and polished style. We also acknowledge and thank Shannon Hogan, David Knobel and Trish O'Reilly of the Rainforest CRC for their support in the production of the book. Our thanks are also extended to Ward Cooper, Delia Sandford and Rosie Hayden from Blackwell Publishing for their assistance and guidance.

Finally, we wish to acknowledge the remarkable contribution that the late Geoff McDonald made to our own understanding of tropical landscapes and the involvement of indigenous and non-indigenous communities in sustainable management. He was a true visionary.

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1 AUSTRALIAN RAINFORESTS IN A GLOBAL CONTEXT

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Introduction

Moist tropical rainforests cover approximately 6–7% of the surface of the globe and occur in a band about 15–20° either side of the equator. Typically they receive more than 2000 mm precipitation a year and although they may frequently experience a dry season, this is often punctuated by periods of heavy rainfall. These forests are typified by their evergreen nature, although some species of trees can be deciduous. Longer and drier dry seasons inevitably produce tropical dry forests, with most tree species being deciduous. Throughout this book when authors refer to rainforests they are referring to moist tropical rainforests (Figure 1.1).

Rainforests are renowned for their immense biodiversity. It is often said that tropical rainforests house more than half of the world's biodiversity. At least 44% of the world's vascular plants and 35% of the world's vertebrates (Sechrest *et al*. 2002) are endemic to 25 'global biodiversity hotspots' (Myers *et al*. 2000) more than half of which are tropical rainforest sites. Much less is known about the diversity of non-vertebrate animals in tropical rainforests, although some would consider that there are possibly tens of millions of species in these ecosystems.

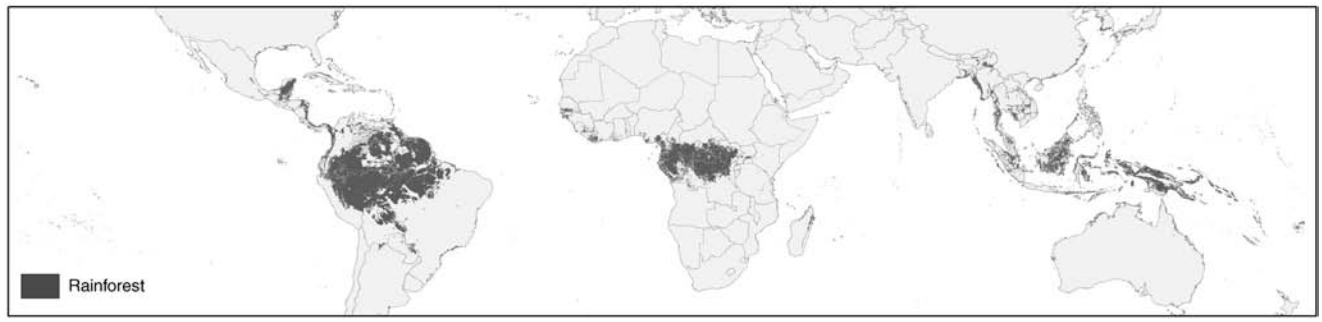

Figure 1.1 The global distribution of tropical rainforest. *Source*: from Primack and Corlett (2005), original figure provided by UNEP-WCMC.

Australia's rainforests comprise only a minuscule proportion of the global total but are vitally important for their unique biodiversity, for the unique ecosystem they represent in what is a very dry continent and because they are the last vestiges of what was an ancient and extensive ecosystem once covering perhaps as much as a third of Australia (Bowman 2000).

Rainforests as contested landscapes

Rainforests throughout the world are highly contested landscapes as governments and the commercial sector seek to increase economic benefits from what are seen as largely unproductive forests. Major threats include logging, both legal and illegal, fire and general encroachment through increased road and rail access (Laurance & Peres 2006). Laurance *et al*. (2001) highlighted the fate of tropical rainforests when they showed how the Amazonian rainforest might be reduced to 40% of its current coverage if proposed infrastructure projects were to come to fruition in Brazil. Earlier Myers (1993) brought to the attention of the world the decline in rainforests (and tropical dry forests) due to the actions of growing numbers of shifting cultivators who were taking advantage of new access roads into previously inaccessible areas. Population growth is seen by many as a major threat to tropical forests, leading to the extinction of tropical forest species (but see Wright & Muller-Landau 2006a, b). In many parts of the world, and in particular in African rainforests, the bushmeat trade is devastating the mega-fauna of rainforests (Bennett & Robinson 2000). The loss of these large vertebrates will result in many changes to the structure and composition of tropical rainforests. These changes may well be exacerbated by the impact of climate change.

Australian rainforests and their significance

With the exception of Antarctica, Australia is the driest continent on Earth. However, northern Australia receives monsoonal rains in north Queensland, the Northern Territory and the Kimberley region of Western Australia, with patches of rainforest occurring there (McKenzie *et al.* 1991; Bowman 2000). Most rainfall occurs along the east coast in places where the Great Dividing Range meets the coast. Although much of the east coastline is or was forested, rainforest now only occurs where the rainfall is high and where there is sufficient rain during the dry season to maintain this forest type. As a result, rainforests are scattered throughout tropical, subtropical, warm temperate and cool temperate areas of Queensland, New South Wales, Victoria and Tasmania, with small patches also found in north coastal Northern Territory and Western Australia. Rainforests occur from sea level to high altitudes, usually within 100 km of the coast in areas receiving more than 1200 mm of rainfall that are climatic and fireproof refuges. Drier, semi-deciduous vine thickets are also found in the Brigalow Belt and monsoonal vine thickets are scattered over parts of the seasonal tropics of northern Australia. Figure 1.2 (after Bowman 2000) shows the distribution of rainforests in Australia and demonstrates how fragmented these forests are. Not surprisingly, these forests have been the focus of much research on forest fragmentation (Laurance & Bierregaard 1997; and see Laurance & Goosem, Chapter 23, this volume). Only about 20% or 156 million hectares of Australia has a native forest cover of which just over 3.0 million hectares is rainforest (Table 1.1). Rainforests are located in 31 of Australia's 80 Interim Biogeographic Regionalisation for Australia (IBRA) biogeographical regions (Thackway & Cresswell 1995). The largest area of remaining rainforest in Australia is located in the so-called Wet Tropics region (27.6%), where most of the larger blocks are contained within the boundaries of the Wet Tropics of Queensland World Heritage Area (WHA) (Table 1.2).

It is estimated that about 30% (~13 000 km^2) of the pre-European extent of rainforests has been cleared (National Land and Water Resources Audit 2001). Most accessible lowland and tableland rainforests have been cleared and/or have become highly fragmented, while most remaining larger blocks of rainforest inhabit steep or rugged terrains. Historically, rainforests were among the earliest Australian native vegetation communities to be exploited for timber and agriculture. Examples of extensive past rainforest clearing include the decimation of the 'Big Scrub' rainforests in northern New South Wales (Floyd 1987), the Illawarra rainforests, the hoop pine scrubs of south-east Queensland (Young & McDonald 1987), the rainforests of the Atherton and Eungella Tablelands, the coastal floodplain rainforests of the Daintree, Barron, Johnstone, Tully–Murray, Herbert, Proserpine and Pioneer rivers in north-east

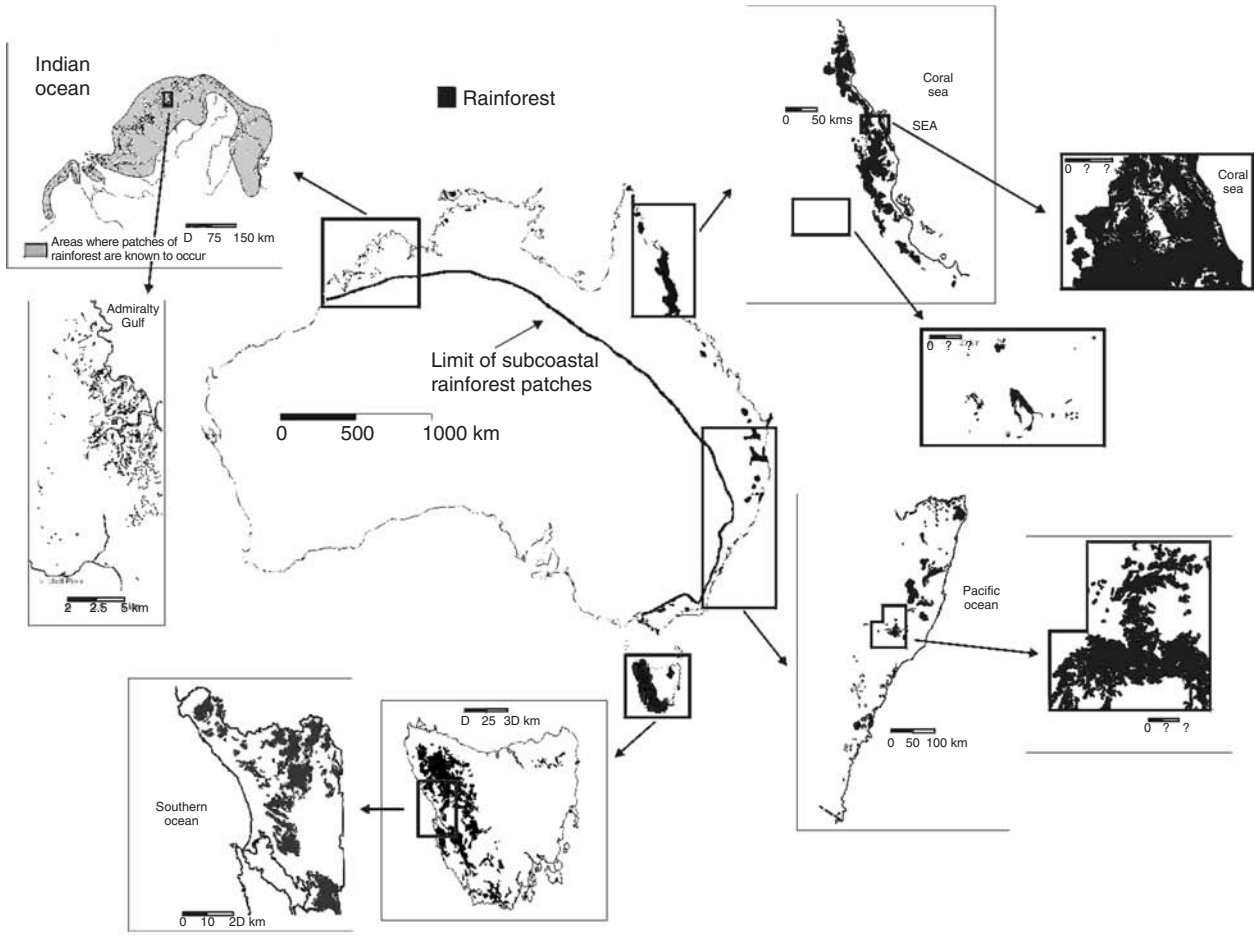

Figure 1.2 Map of extent of rainforests in Australia. *Source*: after Bowman (2000).

Table 1.1 Area of pre-European and present-day rainforest in Australia (km^2)

	State						*Continent*	*Region*
	Vic	*WA*	*NSW*	*NT*	*Tas*	*Qld*	*Australia*	*Wet Tropics*
Present area	407	16	2218	977	7055	19558	30231	8340
Pre-European estimate	445	18	4836	978	7161	30055	43493	10974
Per cent remaining	91.5	88.9	45.9	99.9	98.5	65.1	69.5	76

Source: National Land and Water Resources Audit (2001), WTMA (2002).

Table 1.2 Percentage contribution to Australia's present-day extent of rainforest

State								*Continent*	*Region*	*Subregion*
ACT	*SA*	*Vic*	*WA*	*NSW*	*NT*	*Tas*	*Qld*	*Australia*	*Wet Tropics*	*WHA*
0	0	13	0.1	7.3	3.2	23.3	64.7	100	27.6	22.1

Source: National Land and Water Resources Audit (2001), WTMA (2002).

Queensland and extensive areas of Brigalow Belt vine thickets in Queensland and New South Wales (Sattler & Williams 1999). In recent years there has been strong opposition to such clearing from the conservation sector and the battles have featured prominently in the media. Recent Regional Forest Agreements in various key locations in Australia have resulted in the protection of large areas of rainforest. Valentine and Hill (Chapter 6, this volume) discuss further the conflict that resulted in the World Heritage listing of much of the Wet Tropics.

The broad range of ecological community types classified under the umbrella term 'rainforest' masks the level of regional depletion of some rainforest and vine thicket types. In the Wet Tropics, for example, the escarpment and highland rainforest communities remain largely intact, whereas the coastal lowland and tableland rainforest communities have been severely depleted. Of 24 endangered Wet Tropics regional ecosystems 18 occur on the coastal lowlands as fragmented remnants, while a further five are from basalt landscapes on the Atherton Tableland. The status of endangered, in general, refers to those regional ecosystems that have been reduced to less than 10% of their pre-European extent (Sattler & Williams 1999).

Studies have shown that rainforests are remnants of the oldest types of vegetation in Australia. Many species have ancestors dating back to the Cretaceous or early Tertiary Period, over 65 million years ago (Keto & Scott 1986; DASETT 1987; BRS 2003). For this reason, Australian rainforests have major historical and scientific significance. Australian rainforests are more important for the maintenance of biodiversity than their small area would imply (e.g. Table 1.1). Five of the 13 centres of plant diversity identified in Australia are dominated by rainforest, while a further three have rainforest components (BRS 2003).

The total Australian rainforest area might be small in global terms but the forests are unique in a number of important ways: their variety is unusual; the range of climates in which they have survived is exceptionally wide; and the number of plants and animals that are endemic to them and are still identifiable as being of very primitive stocks is scientifically exciting.

The Wet Tropics rainforests

The largest fragment of rainforest in Australia occurs as a narrow strip along the east coast from 15° 30' S to almost 19° 25' S and covers approximately 2 million hectares. Such is the biological significance of the region that a large part of this was inscribed on the World Heritage List on 9 December 1988 as the Wet Tropics of Queensland World Heritage Area. The listing was the direct consequence of the accumulated scientific research and understanding of the region's rainforests up to that time (see McDonald & Lane 2000). The tenure of the land within the World Heritage Area is complex and changing (Table 1.3). Although the rainforests of Queensland's Wet Tropics are small in size when compared to the rainforests of other parts of the world, the World Heritage Area covers such a

Table 1.3 Size comparisons of World Heritage tropical rainforest properties

Major rainforest type	*Country*	*Size (ha)*
Lowland rainforest		
Salonga National Park	Zaire	3600000
Lorentz	Indonesia	2500000
Okapi Faunal Reserve	Zaire	1372625
Wet Tropics of Queensland	Australia	894420
Virunga National Park	Zaire	790000
Thungyai-Huai Kha Khaeng	Thailand	622200
Kahuzi-Biega National Park	Zaire	600000
Sian Ka'an	Mexico	528000
Dja Faunal Reserve	Cameroon	526000
Rio Platano Biosphere Reserve	Honduras	500000
Tai National Park	Côte d'Ivoire	330000
Ujung Kulon National Park	Indonesia	78359
Los Katios National Park	Colombia	72000
Tikai National Park	Guatemala	57600
Sinharaja Forest Reserve	Sri Lanka	8864
Montane rainforest		
Canaima National Park	Venezuela	3000000
Talamanca/Amistad	Costa Rica/Panama	791592
Sangay National Park	Equador	271925
Machu Picchu	Peru	32592
Mount Nimba Reserves	Côte d'Ivoire	18000
Mome Trois Pitons	Dominica	6857
Sub-montane rainforest		
Manu National Park	Peru	1532806

Table 1.4 The changing nature of land tenure in the Wet Tropics of Queensland World Heritage Area (WHA)

	Percentage of WHA							
Tenure	*1992*	*1995*	*1997*	*1998*	*1999*	*2000*	*2002*	*2003*
National parks	28	28	30	30	30	32	32	32
Forest reserves	—	—	—	—	—	—	29	38.9
State forests	36	38	38	38	38	39	10	0.1
Timber reserves	9	8	8	8	8	8	7	7
Various reserves and dams	1	1	1	1	1	1	1	1
Unallocated state land	7	7	8	8	8	7	7	7
Leasehold	16	15	12	12	12	10	11	11
Freehold and similar	2	2	2	2	2	2	2	2
Rivers, roads, railways and esplanades	1	1	1	1	1	1	1	1

high proportion of the total rainforested area that it ranks highly in size among other rainforest World Heritage Areas (Table 1.4).

The Wet Tropics contains the richest variety of animals and plants in the country, including two-thirds of the butterfly species, half of the birds and a third of the mammals. A very high proportion of the fauna and flora is endemic to the Wet Tropics (Commonwealth of Australia 1986), including 70 vertebrate species (Williams & Hilbert 2006). More than 400 plant and 76 animal species are officially listed as rare, vulnerable or endangered (WTMA 1999). The Wet Tropics also provides an unparalleled living record of the ecological and evolutionary processes that shaped the flora and fauna of Australia over the past 400 million years when it was first part of the Pangaean landmass and then of the ancient Gondwana continent. For example, the rainforests of the Wet Tropics have more plant taxa with primitive characteristics than any other area on Earth. Of the 19 angiosperm families described as the most primitive (Walker 1976), 12 occur in the Wet Tropics, giving it the highest concentration of such families on Earth. These families are: Annonaceae, Austrobaileyaceae, Eupomatiaceae, Himantandraceae, Myristicaceae and Winteraceae of the order Magnoliales; Atherospermataceae, Gyrocarpaceae, Hernandiaceae, Idiospermaceae, Lauraceae and Monimiaceae of the order Laurales (DASETT 1987). The cool temperate rainforests of Tasmania contain several primitive conifers and flowering plants (Adam 1994; BRS 2003).

Until the 1970s, it was thought that rainforests were 'alien' to the Australian landscape, while sclerophyll types of vegetation, such as eucalypts and acacias, were considered the quintessential Australian vegetation. Rainforests were considered to be recent invaders across the land bridge that, in fairly recent geological times, connected Australia with New Guinea. Ecological and taxonomic research, however, gradually provided evidence that radically changed this view (Webb 1959; Webb *et al*. 1976, 1984; Webb & Tracey 1981). It was not just that rainforests had evidently adapted themselves to various climatic conditions (tropical, monsoonal, subtropical, temperate) that bore witness to longer local habitation than was commonly believed. It was other irrefutable evidence, such as the discovery of many families of primitive ancient angiosperms in the Wet Tropics, that confirmed these rainforest ecosystems as among the oldest rainforests on Earth. Although many of these elements also occur in New Caledonia and to a smaller extent in New Guinea, the Wet Tropics also displays a co-evolution with related sclerophyll floras and faunas. The setting of extensive tropical rainforests adjacent to the world's largest fringing reef, the Great Barrier Reef, is another unusual feature, with rainforest meeting the reef found

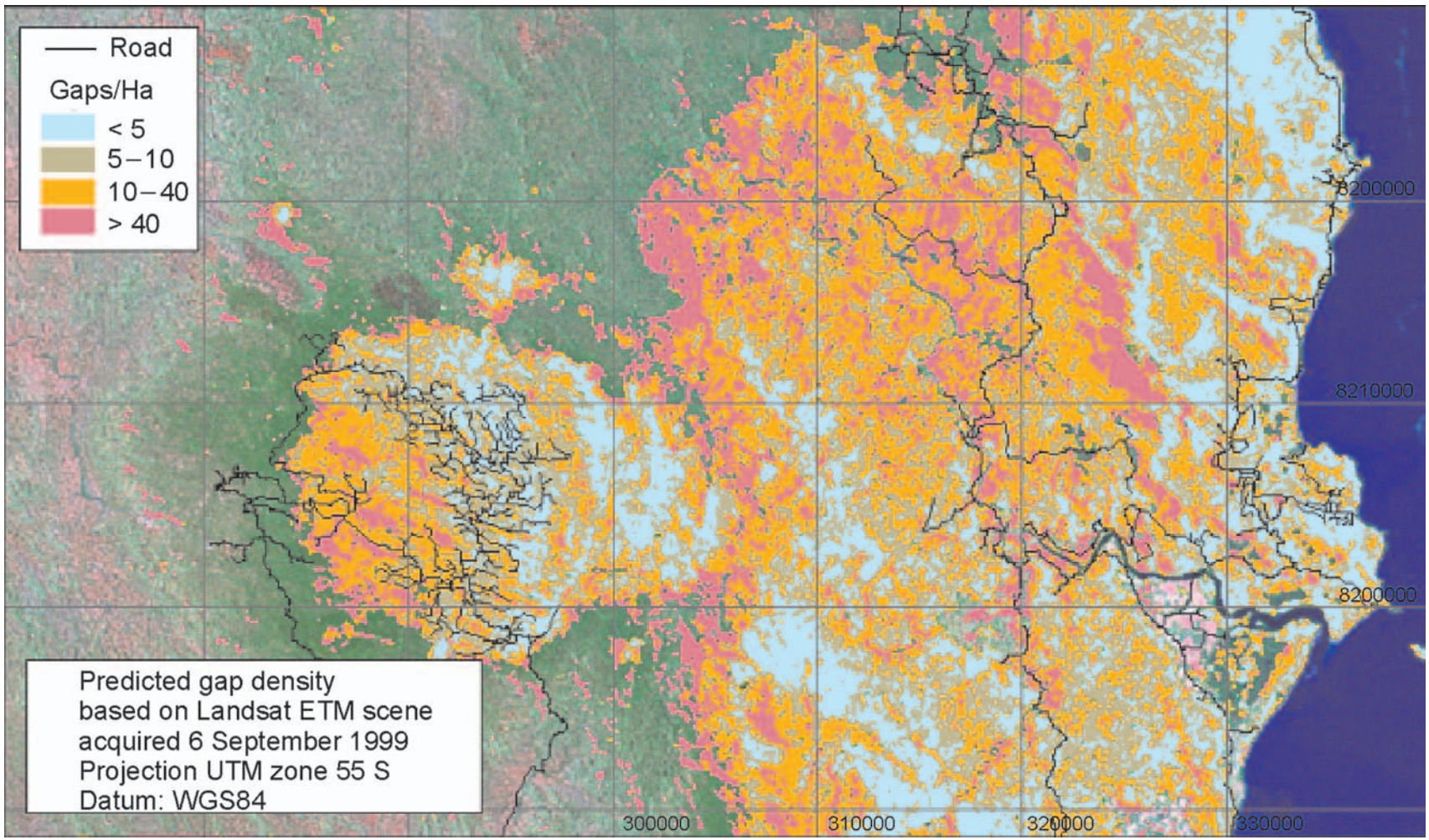

Plate 47.4 Original Landsat 7 ETM image for the Daintree–Cape Tribulation section of the Wet Tropics overlaid with estimated gap fraction.

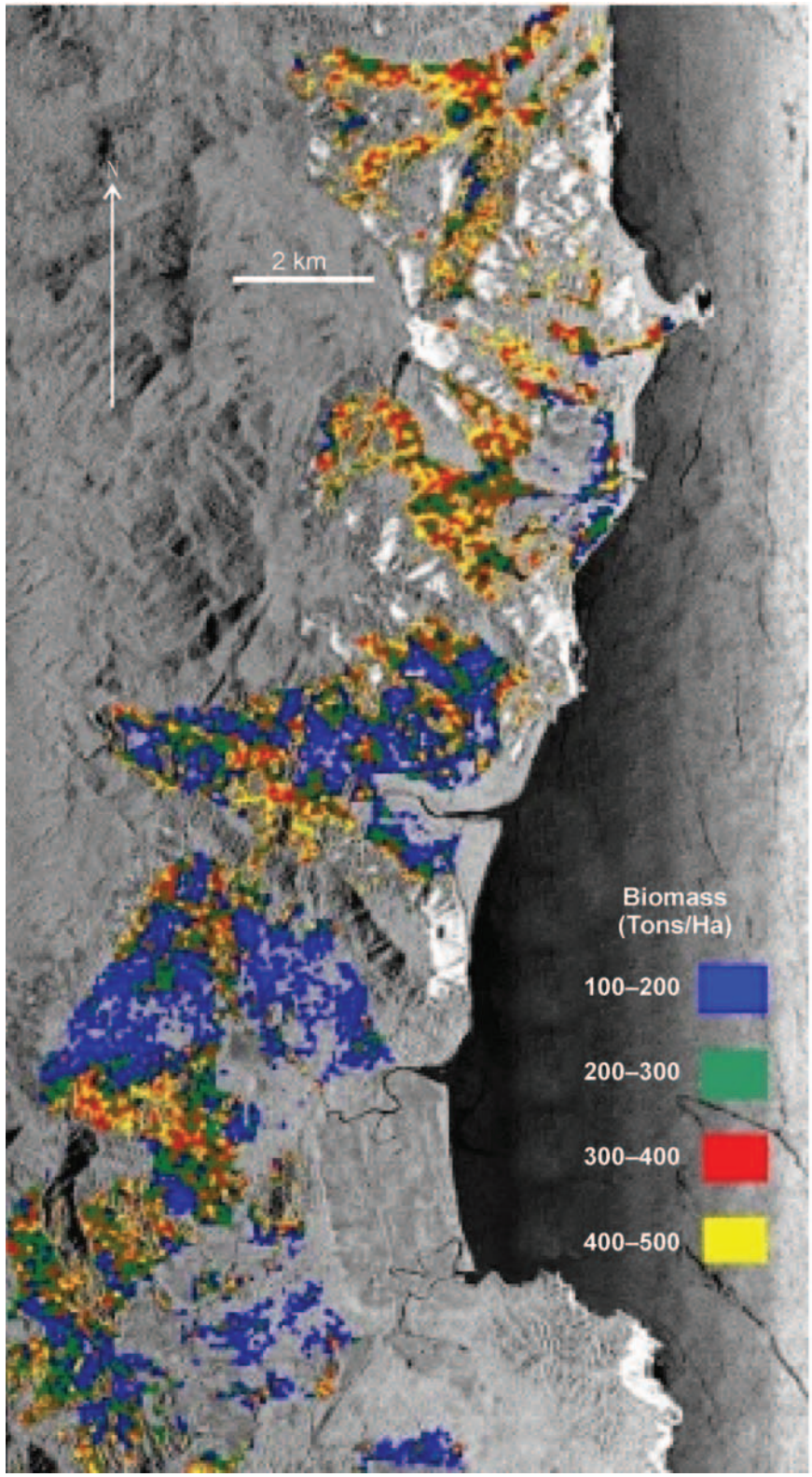

Plate 47.5 Example of preliminary biomass estimation product derived from radar interferometry based on the Wet Tropics AIRSAR data.

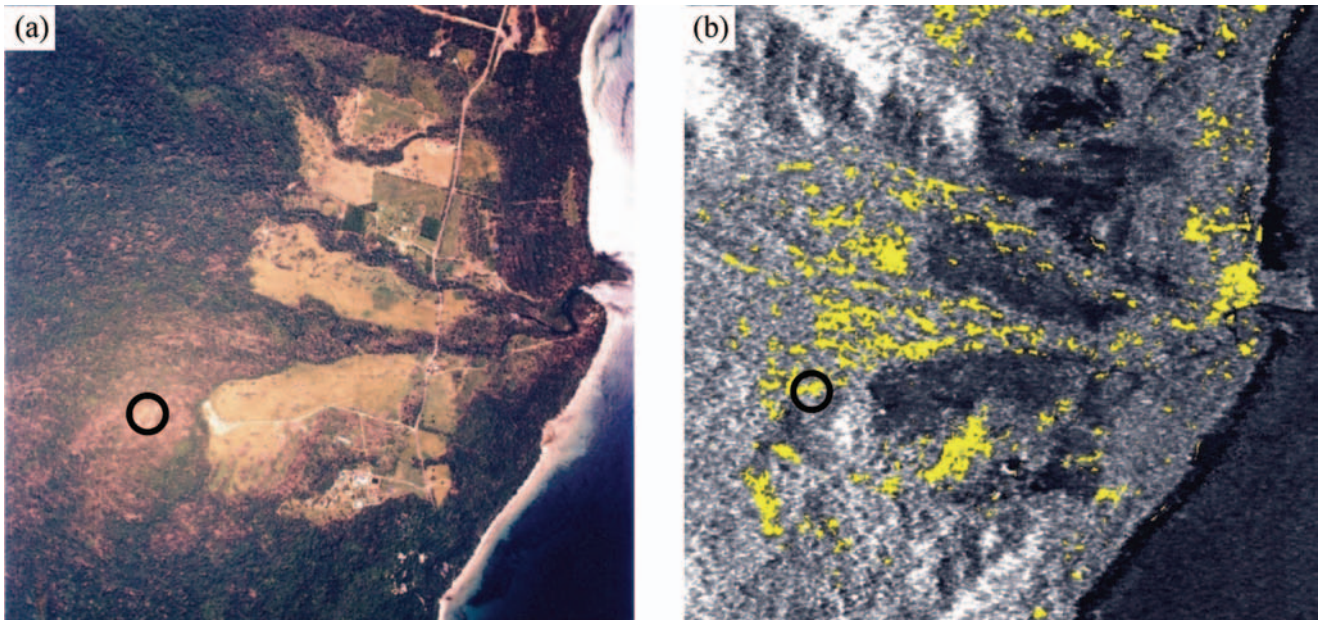

Plate 47.6 (a) Aerial photography (courtesy of Wet Tropics Management Authority) and (b) canopy height difference map produced by subtracting pre-cyclone from post-tropical cyclone Rona canopy heights derived from imaging radar data. Area shown is centred on the canopy crane site (black circle), Coconut Beach Resort, Cape Tribulation.

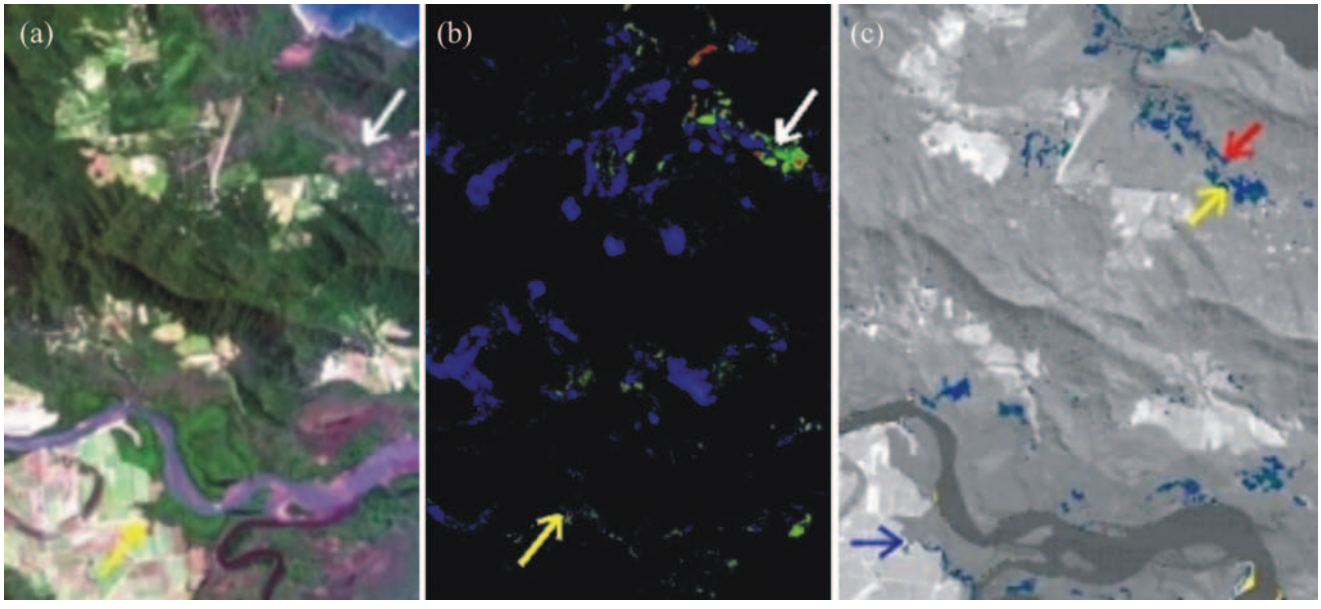

Plate 47.7 (a) Hyperion image in true colour of an area containing pond apple (arrows). Example of pond apple detection maps generated from processing (b) Hyperion image data and (c) Landsat 7 ETM image data and a constraining model. The coloured areas indicate where there is a spectral match with field measurements of pond apple.

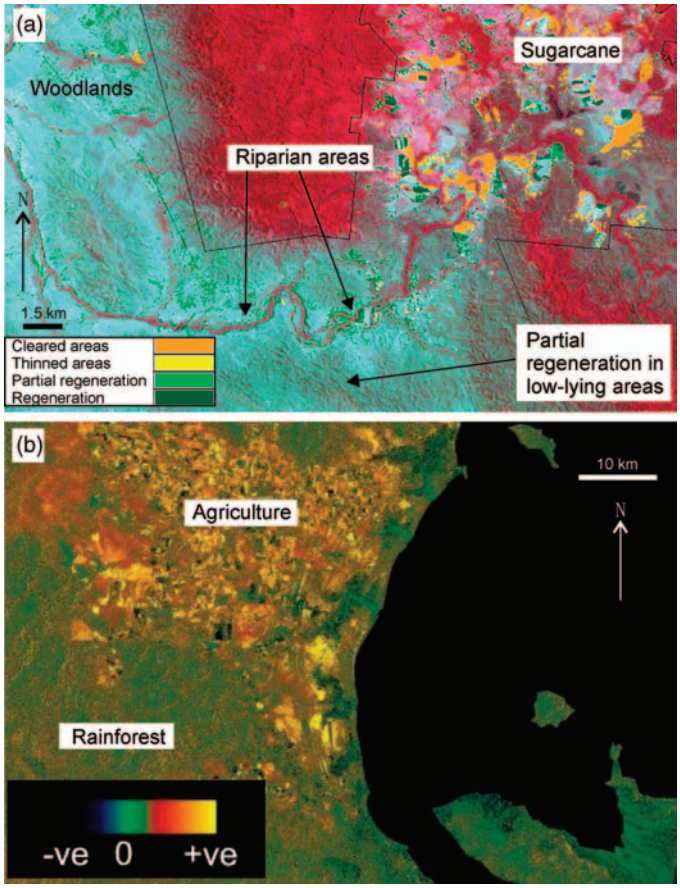

Plate 47.8 An example of changes in vegetation cover in the Wet Tropics mapped from (a) Landsat 7 ETM Enhanced Vegetation Index difference image 1988–90 and (b) JERS-1difference image of January 1994 to July 1996.

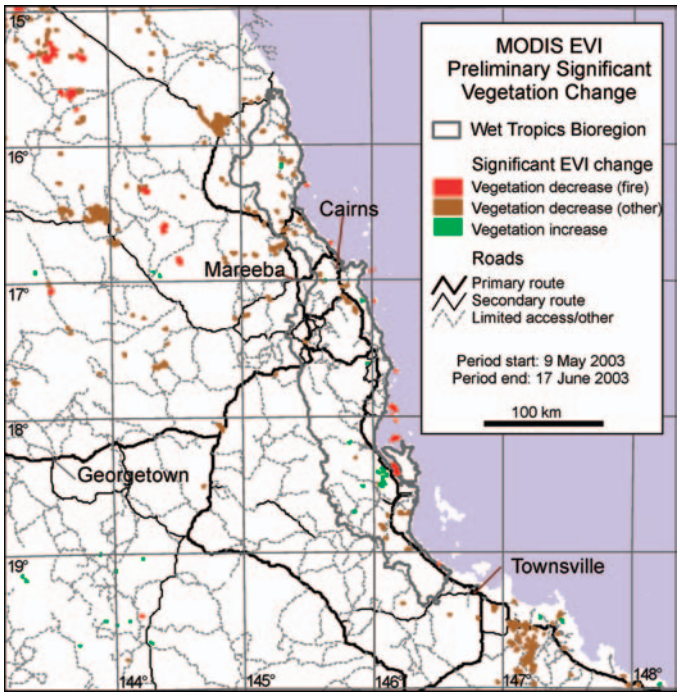

Plate 47.9 Example of a vegetation cover trend image produced from an integration of 48 daily enhanced vegetation index images and fire images for the period 19 May to 17 July 2003.