

VERTEBRATES OF THE WET TROPICS RAINFORESTS OF AUSTRALIA

SPECIES DISTRIBUTIONS AND BIODIVERSITY

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Rainforest CRC



Established and supported under the
Australian Cooperative Research Centres Program

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for Tropical Rainforest Ecology
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ISBN 0 86443 762 5

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Published by the Cooperative Research Centre for Tropical Rainforest Ecology and Management. Further copies may be requested from the Cooperative Research Centre for Tropical Rainforest Ecology and Management, James Cook University, PO Box 6811, Cairns QLD Australia 4870.

This publication should be cited as: Williams, S. E. (2006) Vertebrates of the Wet Tropics Rainforests of Australia: Species Distributions and Biodiversity. Cooperative Research Centre for Tropical Rainforest Ecology and Management. Rainforest CRC, Cairns, Australia (282 pp.)

May 2006

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Top: Amethystine Python, *Morelia kinghorn* (Photo: Stephen E. Williams)
Centre: Superb Fruit-Dove, *Ptilinopus superb* (Photo: Michael Cermak)
Bottom: White-lipped Treefrog, *Litoria infrafrenata* (Photo: Stephen E. Williams)

Colour Plates ©

Plate 1: Wompoo Fruit-Dove, *Ptilinopus magnificus* (Photo: Michael Cermak)
Plate 2: Southern Cassowary, *Casuarius casuarius* (Photo: Michael Cermak)
Plate 3: Boyd's Forest Dragon, *Hypsilurus boydii* (Photo: Stephen E. Williams)
Plate 4: Green-eyed Treefrog, *Litoria genimaculata* (Photo: Stephen E. Williams)

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Layout by Shannon Hogan and Annette Bryan.
The Rainforest CRC extends thanks to Michael Cermak for use of photographs.

CONTENTS

List of Tables	ii
List of Figures	ii
Colour Plates	iii
Foreword	vii
Acknowledgements	vii
Index to Maps	viii
1. Introduction.....	1
1.1. Global Climate Change in the Wet Tropics.....	6
2. Methods.....	9
2.1. Distribution Data	9
2.2. Distribution Maps	9
2.2.1. Bioclimatic Models of Species Distribution	9
2.2.2. Biogeographic Limits.....	10
2.2.3. Habitat Preference	10
2.2.4. Prediction of Climate Change Impacts.....	11
2.2.5. Species Richness Maps.....	11
3. Results, Discussion and Maps.....	13
3.1. Species Distribution Maps	13
3.2. Species Richness	14
4. References	17
5. Appendices	23
A. Full Species List of Vertebrates that Occur in the Wet Tropics Biogeographic Region (Including Mount Elliot, a Wet Tropics Outlier)	23
B. Species Richness Maps and Species Distribution Maps.....	57
C. Electronic Version of <i>Vertebrates of the Wet Tropics Rainforests of Australia: Distributions and Biodiversity</i> (CD-ROM)	Enclosed

LIST OF TABLES

Table 1: Summary of terrestrial vertebrate species richness in the Wet Tropics by taxonomic class	14
Table 2: Summary of the number of species by conservation status	15
Table 3: Number of species that utilise rainforest to varying degrees in the Wet Tropics.....	15
Table 4: Full species list of vertebrates that occur in the Wet Tropics biogeographic region (including Mount Elliot, a Wet Tropics outlier)	27

LIST OF FIGURES

Figure 1: The distribution of rainforests within the Wet Tropics bioregion	3
Figure 2: Subregions of the Wet Tropics bioregion. Upland subregions more than three hundred metres above sea level are indicated in blue in the legend.....	4
Figure 3: Changes across the elevational gradient in bird species richness and abundance	6

COLOUR PLATES

Plate 1: Wompoo Fruit-Dove, <i>Ptilinopus magnificus</i> (Map 49)	iii
Plate 2: Southern Cassowary, <i>Casuarius casuarius</i> (Map 39)	iv
Plate 3: Boyd's Forest Dragon, <i>Hypsilurus boydii</i> (Map 130)	v
Plate 4: Green-eyed Treefrog, <i>Litoria genimaculata</i> (Map 162).....	vi



Plate 1: Wompoo Fruit-Dove, *Ptilinopus magnificentus* (Map 49).



Plate 2: Southern Cassowary, *Casuarus casuarius* (Map 39).



Plate 3: Boyd's Forest Dragon, *Hypsilurus boydii* (Map 130).



Plate 4: Green-eyed Treefrog, *Litoria genimaculata* (Map 162).

FOREWORD

One of the most basic elements of ecology and conservation biology is knowing what species occur in what places. As conceptually simple as this may sound, it is an incredibly difficult and complex undertaking, although probably the single most important fact underpinning all of ecology.

It is impossible to make informed decisions about conservation management without some knowledge on the general geographic distributions of species. The aim of this report is to provide readers with my best estimate of the distribution of as many species of rainforest vertebrates as possible at this time within the Wet Tropics bioregion. Understanding biodiversity necessitates understanding the factors that determine the distribution of each constituent species.

Approximately 350 species of vertebrates occur in the rainforests of the Wet Tropics bioregion, however, only about 153 species have their core distributions in the rainforest. In this report, I present distribution maps for the 177 species of Wet Tropics vertebrates where there was sufficient data to produce a useful map (the vast majority of true rainforest species), and twelve species richness maps based on overlaid distribution maps (Appendix B). The distribution maps represent a combination of bioclimatic modeling, habitat preferences, biogeographic distributions and expert knowledge. Also included is a comprehensive species list of all vertebrates in the Wet Tropics bioregion (Appendix A), with information on the conservation status, range size (of the mapped species), habitat specialisation and summaries of species richness by taxa both in spatially continuous maps and in tabulated form.

The CD-ROM enclosed in the back cover (Appendix C) provides a PDF version of this report, which is embedded with hyperlinks to enable easy viewing of any species maps from the Index to Maps and those mapped species listed in Appendix A.

ACKNOWLEDGMENTS

I would like to thank the following people and organisations for helping to make this report possible either by their personal efforts or through financial support:

Emily Bolitho, Sam Fox, Sara Townsend, Joanne Isaac, Ant Backer, Luke Shoo, Yvette Williams, Jeff Middleton, Richard Pearson, Jo Weineke, Earthwatch volunteers, the Australian Research Council, the Rainforest CRC, James Cook University, National Geographic, the National Science Foundation, field volunteers too numerous to name and data contributors (see appendix in Williams *et al.* 1996).

INDEX TO MAPS

SPECIES RICHNESS MAPS

Map 1:	Species Richness of Rainforest Vertebrates	59
Map 2:	Species Richness of Endemic Rainforest Vertebrates	60
Map 3:	Species Richness of Listed Rainforest Species	61
Map 4:	Species Richness of Rainforest Mammals	62
Map 5:	Species Richness of Endemic Rainforest Mammals	63
Map 6:	Species Richness of Rainforest Birds.....	64
Map 7:	Species Richness of Endemic Rainforest Birds.....	65
Map 8:	Species Richness of Rainforest Reptiles.....	66
Map 9:	Species Richness of Endemic Rainforest Reptiles	67
Map 10:	Species Richness of Rainforest Frogs.....	68
Map 11:	Species Richness of Endemic Non-Microhylid Frogs	69
Map 12:	Species Richness of Endemic Microhylid Frogs	70

SPECIES DISTRIBUTION MAPS

Monotremes

Map 13:	Platypus	<i>Ornithorhynchus anatinus</i>	73
----------------	----------------	---------------------------------------	----

Mammals

Map 14:	Rusty Antechinus.....	<i>Antechinus adustus</i>	77
Map 15:	Yellow-footed Antechinus	<i>Antechinus flavipes</i>	78
Map 16:	Atherton Antechinus	<i>Antechinus godmani</i>	79
Map 17:	Spotted-tailed Quoll	<i>Dasyurus maculates</i>	80
Map 18:	Long-nosed Bandicoot.....	<i>Perameles nasuta</i>	81
Map 19:	Striped Possum	<i>Dactylopsila trivirgata</i>	82
Map 20:	Yellow-bellied Glider	<i>Petaurus australis</i>	83
Map 21:	Mahogany Glider	<i>Petaurus gracilis</i>	84
Map 22:	Lemuroid Ringtail Possum.....	<i>Hemibelideus lemuroids</i>	85
Map 23:	Green Ringtail Possum.....	<i>Pseudochirops archeri</i>	86
Map 24:	Daintree River Ringtail Possum.....	<i>Pseudochirulus cinereus</i>	87
Map 25:	Herbert River Ringtail Possum	<i>Pseudochirulus herbertensis</i>	88
Map 26:	Coppery Brushtail Possum	<i>Trichosurus vulpecula</i>	89
Map 27:	Long-tailed Pygmy Possum	<i>Cercartetus caudatus</i>	90
Map 28:	Northern Bettong	<i>Bettongia tropica</i>	91
Map 29:	Musky Rat-kangaroo.....	<i>Hypsiprymnodon moschatus</i>	92
Map 30:	Bennett's Tree-kangaroo	<i>Dendrolagus bennettianus</i>	93
Map 31:	Lumholtz's Tree-kangaroo	<i>Dendrolagus lumholtzi</i>	94
Map 32:	Red-legged Pademelon	<i>Thylogale stigmatica</i>	95
Map 33:	Fawn-footed Melomys	<i>Melomys cervinipes</i>	96
Map 34:	Prehensile-tailed Rat	<i>Pogonomys mollipilosus</i>	97
Map 35:	Bush Rat.....	<i>Rattus fuscipes</i>	98

Map 36:	Cape York Rat	<i>Rattus leucopus</i>	99
Map 37:	Giant White-tailed Rat.....	<i>Uromys caudimaculatus</i>	100
Map 38:	Masked White-tailed Rat.....	<i>Uromys hadrourus</i>	101

Birds

Map 39:	Southern Cassowary	<i>Casuarius casuarius</i>	105
Map 40:	Australian Brush Turkey	<i>Alectura lathamii</i>	106
Map 41:	Orange-footed Scrubfowl.....	<i>Megapodius reinwardt</i>	107
Map 42:	Grey Goshawk	<i>Accipiter novaehollandiae</i>	108
Map 43:	Red-necked Crake	<i>Rallina tricolor</i>	109
Map 44:	Emerald Dove	<i>Chalcophaps indica</i>	110
Map 45:	White-headed Pigeon	<i>Columba leucomela</i>	111
Map 46:	Pied Imperial Pigeon.....	<i>Ducula bicolor</i>	112
Map 47:	Topknot Pigeon.....	<i>Lopholaimus antarcticus</i>	113
Map 48:	Brown Cuckoo-Dove.....	<i>Macropygia amboinensis</i>	114
Map 49:	Wompoo Fruit-Dove.....	<i>Ptilinopus magnificus</i>	115
Map 50:	Rose-crowned Fruit-Dove.....	<i>Ptilinopus regina</i>	116
Map 51:	Superb Fruit-Dove	<i>Ptilinopus superbus</i>	117
Map 52:	Sulphur-crested Cockatoo	<i>Cacatua galerita</i>	118
Map 53:	Australian King Parrot.....	<i>Alisterus scapularis</i>	119
Map 54:	Double-eyed Fig-Parrot	<i>Cyclopsitta diophthalma</i>	120
Map 55:	Crimson Rosella	<i>Platycercus elegans</i>	121
Map 56:	Scaly-breasted Lorikeet.....	<i>Trichoglossus chlorolepidotus</i>	122
Map 57:	Rainbow Lorikeet.....	<i>Trichoglossus haematodus</i>	123
Map 58:	Chestnut-breasted Cuckoo	<i>Cacomantis castaneiventris</i>	124
Map 59:	Fan-tailed Cuckoo.....	<i>Cacomantis flabelliformis</i>	125
Map 60:	Brush Cuckoo	<i>Cacomantis variolosus</i>	126
Map 61:	Shining Bronze-Cuckoo (Golden)	<i>Chrysococcyx lucidus</i>	127
Map 62:	Gould's Bronze-Cuckoo	<i>Chrysococcyx russatus</i>	128
Map 63:	Oriental Cuckoo	<i>Cuculus saturatus</i>	129
Map 64:	Common Koel.....	<i>Eudynamis scolopacea</i>	130
Map 65:	Southern Boobook	<i>Ninox novaeseelandiae</i>	131
Map 66:	Rufous Owl	<i>Ninox rufa</i>	132
Map 67:	Lesser Sooty Owl.....	<i>Tyto multipunctata</i>	133
Map 68:	Papuan Frogmouth	<i>Podargus papuensis</i>	134
Map 69:	White-rumped Swiftlet.....	<i>Collocalia spodiopygius</i>	135
Map 70:	Azure Kingfisher	<i>Alcedo azurea</i>	136
Map 71:	Little Kingfisher	<i>Alcedo pusilla</i>	137
Map 72:	Laughing Kookaburra	<i>Dacelo novaeguineae</i>	138
Map 73:	Buff-breasted Paradise-Kingfisher ...	<i>Tanysiptera sylvia</i>	139
Map 74:	Rainbow Bee-eater	<i>Merops ornatus</i>	140
Map 75:	Noisy Pitta.....	<i>Pitta versicolor</i>	141
Map 76:	White-throated Treecreeper.....	<i>Cormobates leucophaeus</i>	142
Map 77:	Mountain Thornbill	<i>Acanthiza katherina</i>	143
Map 78:	Large-billed Gerygone	<i>Gerygone magnirostris</i>	144
Map 79:	Brown Gerygone.....	<i>Gerygone mouki</i>	145
Map 80:	Fernwren.....	<i>Oreoscopus gutturalis</i>	146

Map 81:	Yellow-throated Scrubwren.....	<i>Sericornis citreogularis</i>	147
Map 82:	White-browed Scrubwren	<i>Sericornis frontalis</i>	148
Map 83:	Atherton Scrubwren	<i>Sericornis kerri</i>	149
Map 84:	Large-billed Scrubwren.....	<i>Sericornis magnirostris</i>	150
Map 85:	Eastern Spinebill.....	<i>Acanthorhynchus tenuirostris</i>	151
Map 86:	Bridled Honeyeater.....	<i>Lichenostomus frenatus</i>	152
Map 87:	Graceful Honeyeater.....	<i>Meliphaga gracilis</i>	153
Map 88:	Lewin's Honeyeater	<i>Meliphaga lewinii</i>	154
Map 89:	Yellow-spotted Honeyeater.....	<i>Meliphaga notata</i>	155
Map 90:	Dusky Honeyeater	<i>Myzomela obscura</i>	156
Map 91:	Scarlet Honeyeater	<i>Myzomela sanguinolenta</i>	157
Map 92:	Helmeted Friarbird	<i>Philemon buceroides</i>	158
Map 93:	Macleay's Honeyeater	<i>Xanthotis macleayana</i>	159
Map 94:	Grey-headed Robin	<i>Heteromyias albispecularis</i>	160
Map 95:	Pale-yellow Robin	<i>Tregellasia capito</i>	161
Map 96:	Chowchilla	<i>Orthonyx spaldingii</i>	162
Map 97:	Eastern Whipbird	<i>Psophodes olivaceus</i>	163
Map 98:	Bowers Shrike-Thrush	<i>Colluricincla boweri</i>	164
Map 99:	Little Shrike-Thrush.....	<i>Colluricincla megarhyncha</i>	165
Map 100:	Golden Whistler	<i>Pachycephala pectoralis</i>	166
Map 101:	Pied Monarch.....	<i>Arses kaupi</i>	167
Map 102:	Spangled Drongo.....	<i>Dicrurus bracteatus</i>	168
Map 103:	Yellow-breasted Boatbill	<i>Machaerirhynchus flaviventer</i>	169
Map 104:	White-eared Monarch	<i>Monarcha leucotis</i>	170
Map 105:	Black-faced Monarch	<i>Monarcha melanopsis</i>	171
Map 106:	Spectacled Monarch	<i>Monarcha trivirgatus</i>	172
Map 107:	Grey Fantail	<i>Rhipidura fuliginosa</i>	173
Map 108:	Rufous Fantail.....	<i>Rhipidura rufifrons</i>	174
Map 109:	Barred Cuckoo-Shrike	<i>Coracina lineate</i>	175
Map 110:	Varied Triller	<i>Lalage leucomela</i>	176
Map 111:	Yellow Oriole.....	<i>Oriolus flavocinctus</i>	177
Map 112:	Olive-backed Oriole	<i>Oriolus sagittatus</i>	178
Map 113:	White-breasted Woodswallow	<i>Artamus leucorhynchus</i>	179
Map 114:	Black Butcherbird.....	<i>Cracticus quoyi</i>	180
Map 115:	Pied Currawong	<i>Strepera graculina</i>	181
Map 116:	Victoria's Riflebird	<i>Ptiloris victoriae</i>	182
Map 117:	Spotted Catbird.....	<i>Ailuroedus melanotis</i>	183
Map 118:	Golden Bowerbird	<i>Prionodura newtoniana</i>	184
Map 119:	Satin Bowerbird	<i>Ptilonorhynchus violaceus</i>	185
Map 120:	Tooth-billed Bowerbird.....	<i>Scenopoeetes dentirostris</i>	186
Map 121:	Mistletoebird	<i>Dicaeum hirundinaceum</i>	187
Map 122:	Silvereye	<i>Zosterops lateralis</i>	188
Map 123:	Bassian Thrush.....	<i>Zoothera lunulata</i>	189
Map 124:	Metallic Starling	<i>Aplonis metallica</i>	190
Map 125:	Blue-faced Parrot-Finch.....	<i>Erythrura trichroa</i>	191

Reptiles

Map 126:	Chameleon Gecko	<i>Carphodactylus laevis</i>	195
Map 127:	(No common name)	<i>Nactus cheverti</i>	196
Map 128:	Black Mountain gecko	<i>Nactus galgajuga</i>	197
Map 129:	Northern Leaf-tailed Gecko	<i>Saltuarius cornutus</i>	198
Map 130:	Boyd's Forest Dragon	<i>Hypsilurus boydii</i>	199
Map 131:	Eastern Water Dragon	<i>Physignathus lesueurii</i>	200
Map 132:	Spotted Tree Monitor	<i>Varanus scalaris</i>	201
Map 133:	Thornton Peak Skink	<i>Calyptotis thorntonensis</i>	202
Map 134:	Northern Red-throated Skink	<i>Carlia rubrigularis</i>	203
Map 135:	(No common name)	<i>Coeranoscincus frontalis</i>	204
Map 136:	(No common name)	<i>Eulamprus frerei</i>	205
Map 137:	(No common name)	<i>Eulamprus tigrinus</i>	206
Map 138:	Grey-tailed Skink	<i>Glaphyromorphus fuscicaudis</i>	207
Map 139:	(No common name)	<i>Glaphyromorphus mjobergi</i>	208
Map 140:	Prickly Forest Skink	<i>Gnypetoscincus queenslandiae</i>	209
Map 141:	(No common name)	<i>Lampropholis coggeri</i>	210
Map 142:	(No common name)	<i>Lampropholis robertsi</i>	211
Map 143:	(No common name)	<i>Saproscincus basiliscus</i>	212
Map 144:	Czechura's Litter Skink	<i>Saproscincus czechurai</i>	213
Map 145:	(No common name)	<i>Saproscincus lewisi</i>	214
Map 146:	Four-toed Litter Skink	<i>Saproscincus tetradactylus</i>	215
Map 147:	Bartle Frere Skink	<i>Techmarscincus jigurru</i>	216
Map 148:	Amethystine Python	<i>Morelia kinghorn</i>	217
Map 149:	Carpet Python	<i>Morelia spilota</i>	218
Map 150:	Brown Tree Snake	<i>Boiga irregularis</i>	219
Map 151:	Northern Tree Snake	<i>Dendrelaphis calligastra</i>	220
Map 152:	Common Tree Snake	<i>Dendrelaphis punctulata</i>	221
Map 153:	Slaty-grey Snake	<i>Stegonotus cucullatus</i>	222
Map 154:	Keelback	<i>Tropidonophis mairii</i>	223
Map 155:	Northern Dwarf Crowned Snake	<i>Cacophis churchilli</i>	224
Map 156:	Eastern Small-Eyed Snake	<i>Cryptophis nigrescens</i>	225
Map 157:	Yellow-faced Whipsnake	<i>Demansia psammophis</i>	226
Map 158:	Black-bellied Swamp Snake	<i>Hemiaspis signata</i>	227
Map 159:	Red-bellied Black Snake	<i>Pseudechis porphyriacus</i>	228
Map 160:	Rough-scaled Snake	<i>Tropidechis carinatus</i>	229

Frogs

Map 161:	Eastern Sedgefrog	<i>Litoria fallax</i>	233
Map 162:	Green-eyed Treefrog	<i>Litoria genimaculata</i>	234
Map 163:	White-lipped Treefrog	<i>Litoria infrafrenata</i>	235
Map 164:	Stony-creek Frog	<i>Litoria lesueurii</i>	236
Map 165:	Armoured Mistfrog	<i>Litoria lorica</i>	237
Map 166(a):	Waterfall Frog	<i>Litoria nannotis</i>	(All Records) ... 238
Map 166(b):	Waterfall Frog	<i>Litoria nannotis</i>	(Post-Decline) ... 239
Map 167:	Striped Rocketfrog	<i>Litoria nasuta</i>	240

Map 168:	Mountain Mistfrog	<i>Litoria nyakalensis</i>	241
Map 169 (a):	Common Mistfrog	<i>Litoria rheocola</i> (All Records) ...	242
Map 169(b):	Common Mistfrog	<i>Litoria rheocola</i> (Post-Divine) ...	243
Map 170:	Northern Orange-eyed Treefrog	<i>Litoria xanthomera</i>	244
Map 171(a):	Australian Lace-lid	<i>Nyctimystes dayi</i> (All Records) ...	245
Map 171(b):	Australian Lace-lid	<i>Nyctimystes dayi</i> (Post-Divine) ...	246
Map 172:	Striped Marshfrog	<i>Limnodynastes peronii</i>	247
Map 173:	Northern Barred Frog.....	<i>Mixophyes schevilli</i>	248
Map 174:	Northern Barred Frog spp. A	<i>Mixophyes species A</i>	249
Map 175:	Magnificent Broodfrog.....	<i>Pseudophryne covacevichae</i>	250
Map 176:	Sharp-snouted Dayfrog.....	<i>Taudactylus acutirostris</i>	251
Map 177:	Northern Tinkerfrog.....	<i>Taudactylus rheophilus</i>	252
Map 178:	Tableland Gungan	<i>Uperoleia altissima</i>	253
Map 179:	Cricket Chirper.....	<i>Austrochaperina fryi</i>	254
Map 180:	White-browed Chirper.....	<i>Austrochaperina pluvialis</i>	255
Map 181:	Peeling Chirper	<i>Austrochaperina robusta</i>	256
Map 182:	Tapping Nursery	<i>Cophixalus aenigma</i>	257
Map 183:	Windsor Nursery-Frog	<i>Cophixalus bombiens</i>	258
Map 184:	Beautiful Nursery-Frog.....	<i>Cophixalus concinnus</i>	259
Map 185:	Bloomfield Nursery-Frog.....	<i>Cophixalus exiguous</i>	260
Map 186:	Pipping Nursery-Frog.....	<i>Cophixalus hosmeri</i>	261
Map 187:	Buzzing Nursery-Frog.....	<i>Cophixalus infacetus</i>	262
Map 188:	Mountain Top Nursery-Frog.....	<i>Cophixalus monticola</i>	263
Map 189:	Tangerine Nursery-Frog	<i>Cophixalus neglectus</i>	264
Map 190:	Common Nursery-Frog	<i>Cophixalus ornatus</i>	265
Map 191:	Boulder Nursery-Frog	<i>Cophixalus saxatilis</i>	266
Map 192:	Australian Bullfrog.....	<i>Rana daemeli</i>	267

1. INTRODUCTION

I have been trying to understand the ecology of the rainforests in the Wet Tropics bioregion of north Queensland since 1986 when I started first year biology at James Cook University. I remember, as a child, driving past places like Mount Elliot, looking up into the mysterious, cloud-draped rainforests and wondering what was up there. I have been fortunate enough to not only find out what is up there but to have made a career out of it. I have now been to many mountaintops and steamy lowland forests and the contents of this report describe some aspects of the things I have found.

During the past fifteen years, I have been attempting to understand the patterns and processes of rainforest biodiversity in the Wet Tropics and, more recently, how global climate change is likely to affect these rainforests. The Wet Tropics bioregion lies along the tropical northeastern coast of Queensland, between Cooktown in the north and Townsville in the south (Figure 1). It covers an area of approximately 1.8 million hectares, of which about one million hectares is rainforest. The Wet Tropics World Heritage Area (WTWHA) protects nearly 900,000 hectares of the region, primarily rainforest. The region is characterised by a series of disjunct mountain ranges running roughly parallel to the coast, with most of the mountains being covered in tropical rainforest.

Rainfall within the rainforest areas varies from about 1,500 millimetres up to as much as 9,000 millimetres annually, although this is highly variable from year to year. Rainfall is strongly seasonal with most of the annual rainfall falling between December and February.

When the Rainforest Cooperative Research Centre (CRC) first commenced in 1995, I conducted a review of what was known about the distribution and biodiversity of vertebrates in the region (Williams *et al.* 1996). At that stage, our distributional knowledge was surprisingly limited even for the better-known groups of vertebrates. We analysed the available data at the best resolution possible at the time, which was the presence/absence of species in each mountain range or subregion (Figure 2). These data and analyses were surprisingly informative considering the low resolution of the data, which led me to include regional analyses of biodiversity in my PhD research and a number of publications on various aspects of ecology in the Wet Tropics (Williams 1997; Williams and Pearson 1997; Williams and Hero 1998, 2001; Graham *et al.* 2006). However, it was always recognised that we needed to move beyond subregional species richness and compile/collate/collect point locality data on species distributions and abundance.

It was always considered important but too costly and time consuming to conduct systematic surveys across the region that would include the most important gradients. The contents of this report are based on systematic, standardised surveys that were funded and conducted under a variety of research projects. Standardising the techniques has meant that the samples from the different studies that I have conducted could be combined to finally have reasonable coverage of the region, albeit more than ten years later. It is now possible to move to continuous spatial analyses rather than simple subregional comparisons.

In this report I present one step in this direction, that is, my best estimate of the distribution of most species of terrestrial rainforest vertebrate in the Wet Tropics, excluding bats. The backbone of this report is the maps of species richness and species distributions. They are not yet complete; many species do not yet have sufficient data to allow a realistic or reliable map and thus the maps presented here vary in their reliability, dependent on the amount and quality of the data input. However, I hope that these maps are useful at many levels. Biodiversity at its simplest level is the number of species in a place and this is what the combination of these maps is trying to estimate – which species are in which places.

The Wet Tropics bioregion presents a unique opportunity to examine ecology and biogeography because the rainforests have been protected under World Heritage listing since 1988 and there is an extensive ecological and biophysical research base. Webb (1987) stated that the Australian Wet Tropics is one of the “most significant regional ecosystems in the world” as a key to understanding the origins of angiosperms, past climatic sifting and to understanding links with temperate Australia, Asia and South America.

Considerable knowledge has become available on regional climate (Nix 1991), vegetation distribution (Tracey and Webb 1975; Goosem *et al.* 1995; Stanton and Stanton 2005), distribution of rainforest fauna (Winter *et al.* 1984; Winter 1988; Nix and Switzer 1991; McDonald 1992; Williams *et al.* 1996), patterns of phylogeography (Joseph *et al.* 1995; Schneider *et al.* 1998; Moritz *et al.* 2000; Hugall *et al.* 2002; Bell *et al.* 2004; Schneider and Williams 2005) and historical paleodistribution of vegetation and climate (Nix 1991; Kershaw 1994; Hilbert *et al.* 2001; Graham *et al.* 2006). Broad distributions and habitat preferences of many rainforest animals of the Wet Tropics have been well documented (Kikkawa 1976, 1982, 1991; Kikkawa and Pearse 1969; Kikkawa and Williams 1971; Kikkawa *et al.* 1981; Schodde and Calaby 1972; Driscoll and Kikkawa 1989; Crome and Nix 1991; Ingram 1991; Williams *et al.* 1996).

The regionally endemic upland species are considered to be relicts of either an older connection with the upland fauna of New Guinea or from an older, cool temperate Australian fauna (Kikkawa *et al.* 1981). In contrast, the lowland rainforest of the Wet Tropics has a higher affinity with the rainforests of Cape York and New Guinea, with dispersal from the north over the paleohistory of the region being an important process (Kikkawa *et al.* 1981). Phylogeographic patterns based on molecular population genetics suggest that vicariant evolution in historical rainforest refugia has been an important influence on the fauna (Schneider and Williams 2005). However, the species are old (at least several million years) and the influence of the more recent Quaternary climate/habitat fluctuations has been via processes of non-random extinction and recolonisation rather than recent allopatric speciation (Schneider and Williams 2005).

Data describing the detailed distributions of individual species within the region has been very patchy. While earlier studies have provided valuable basic information on species distributions, analyses of macro-ecological patterns of species richness and assemblage structure have been hampered by coarse resolution in the datasets with distribution data being limited to the scale of subregions (mountain ranges) (Winter *et al.* 1984; Winter 1988; McDonald 1992; Williams *et al.* 1996; Williams and Pearson 1997; Moritz *et al.* 2000; Williams and Hero 2001). Williams *et al.* (1996) suggested that in order to move beyond analyses based on coarse distribution data, it would be necessary to (a) compile point locality data rather than subregional (mountain range) species lists; (b) collect abundance data rather than presence/absence data; and (c) explicitly examine the elevational gradient in more detail.

The elevational gradient is the primary ecological gradient driving patterns of species richness and composition in the Wet Tropics biogeographic region (Williams and Pearson 1997). Attempts have been made to expand knowledge on the elevational distribution and relative abundance of bird species; however, data has previously been restricted to a small number of species (Crome and Nix 1991; Wieneke 1992) or incompletely sampled mountain ranges within the region (Gill 1970; Kikkawa 1982; Boles and Longmore 1989). The comprehensive dataset used to produce these maps has been and is continuing to be used in a number of recent studies.

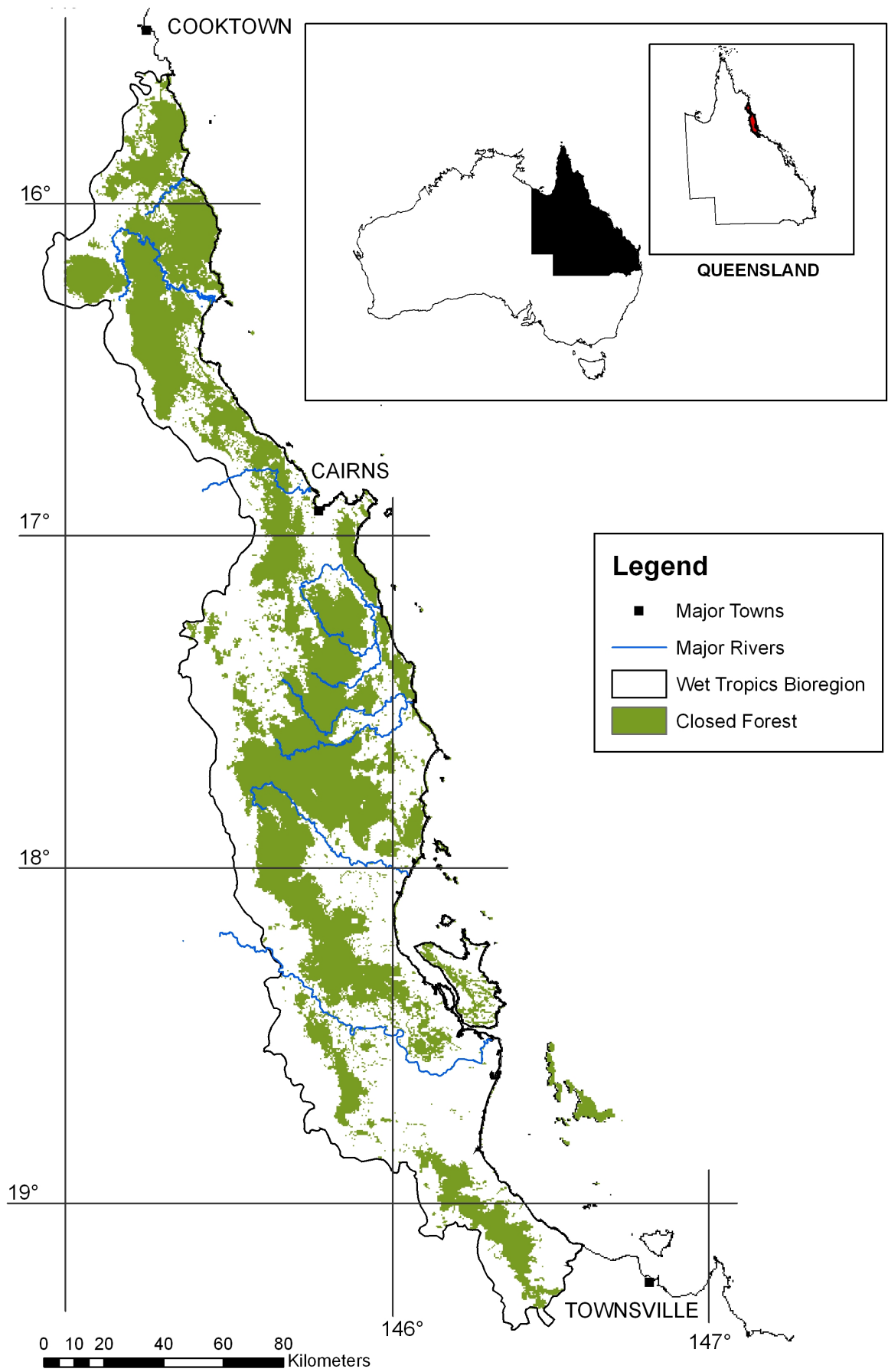


Figure 1: The distribution of rainforests within the Wet Tropics bioregion.

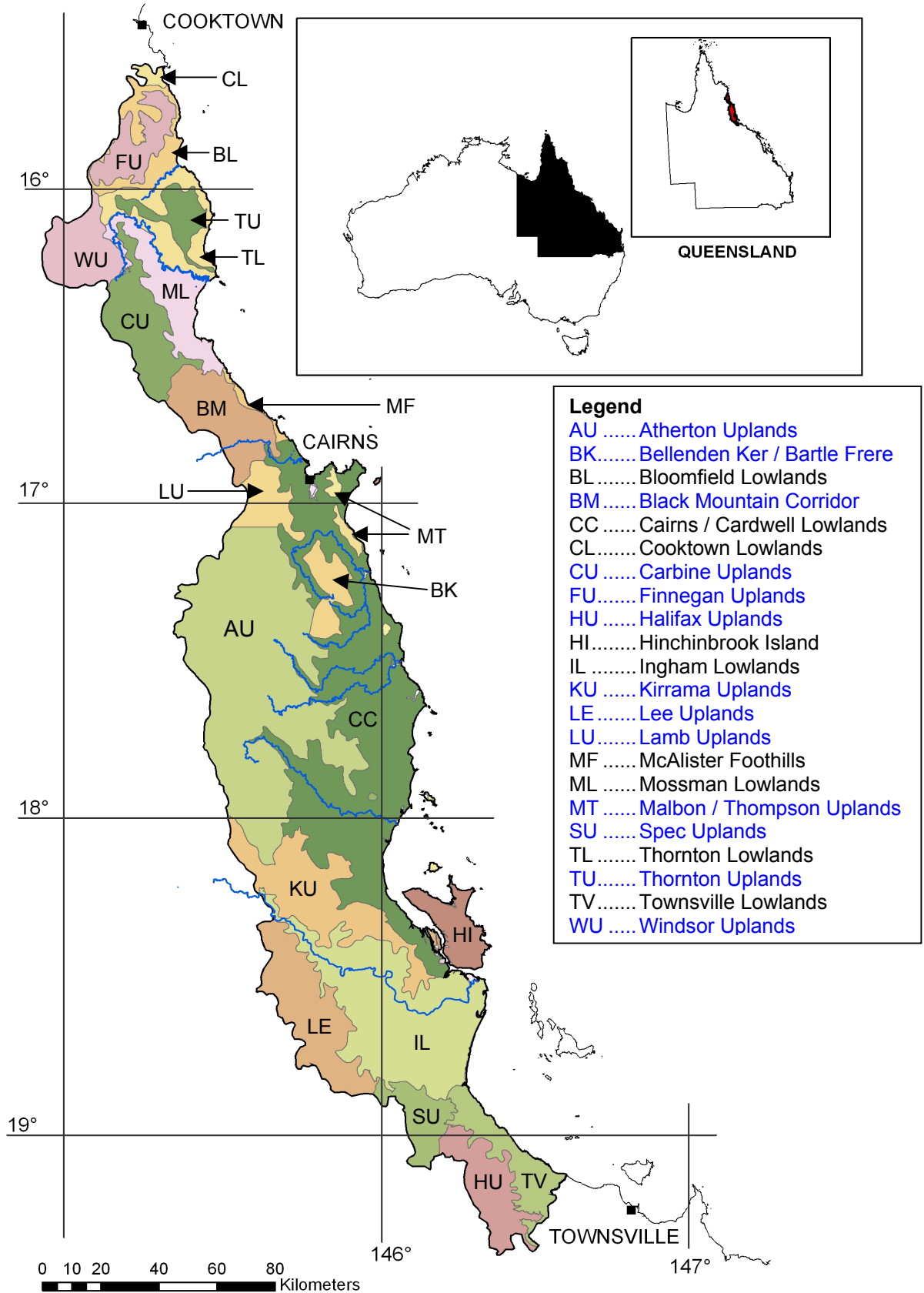


Figure 2: Subregions of the Wet Tropics bioregion. Upland subregions more than three hundred metres above sea level are indicated in blue in the legend.

Regionally endemic birds are known to exhibit complex variability in abundance within current elevation ranges (Shoo *et al.* 2005a) and the same has also been demonstrated for other vertebrate taxa in the region, including arboreal mammals (Trenerry and Werren 1993; Kanowski *et al.* 2001) and microhylid frogs (Shoo and Williams 2004). Species richness was previously considered to be highest in the lowlands (Kikkawa 1991), declining toward the uplands where a very different assemblage of species is apparent (Kikkawa 1982; Boles and Longmore 1989; Crome and Nix 1991). However, analyses based on subregional species richness suggested that species richness of rainforest birds in the upland and lowland forests were not significantly different and species richness and endemism were positively correlated with rainforest area and habitat diversity (Williams *et al.* 1996).

With the recent availability of systematic standardised surveys of vertebrates across the region, detailed altitudinal patterns of species richness are now available (Williams *et al.* in press) (Figure 3). Historical contraction of rainforest to small refugia, followed by non-random species extinctions, may explain the general paucity of specialised species and low endemism in the lowlands (Williams and Pearson 1997). Molecular data provides additional support for the hypothesis that there were local extinctions during periods of rainforest contraction and subsequent expansion (Joseph *et al.* 1995; Schneider and Williams 2005).

Protecting the biota and ecosystem functions of the Wet Tropics bioregion is only possible if we have some understanding of current patterns of biodiversity and the factors that maintain ecosystem processes and determine the distributions of species, assemblages and habitats. Therefore, it is imperative that we gain an understanding of the factors determining the distribution of species. The distribution and abundance of a species is determined by a number of complex and often interacting factors within four general categories (Brown and Lomolino 1998):

1. Biogeographic history (e.g. extinction episodes due to habitat contraction);
2. Physiological preferences and tolerances of species and habitats to the abiotic environment (e.g. temperature, rainfall and climatic stability);
3. Biotic interactions (e.g. competition and predation); and
4. Disturbance (e.g. fire and cyclones).

The maps included in this report are a step forward in the ongoing research to improve our knowledge of species distributions in the Wet Tropics region and the processes that determine these distributions. This knowledge is crucial if we are to maintain this unique ecosystem into the future, particularly in the face of global climate change. Until recently, the major threats to the biodiversity values of the Wet Tropics were habitat clearing, fragmentation, pests and diseases. It is now apparent that climate change and the interactions between a changing climate and other pressures are the key challenges we now face in protecting our tropical rainforests.

The bioclimatic models that provided significant input into these maps largely influenced my decision to redirect my research efforts. Initially, my research was focused on understanding spatial patterns of biodiversity. I smugly thought that we had one of the best systems in the world for this research because we had a high-biodiversity area that was accessible, well studied and well protected. The realisation that climate change induced by anthropogenic greenhouse gas emissions could cause catastrophic impacts on the Wet Tropics was a shock. Since the early analyses predicting these impacts, the impacts of climate change on biodiversity in the Wet Tropics has been the primary focus of my research.

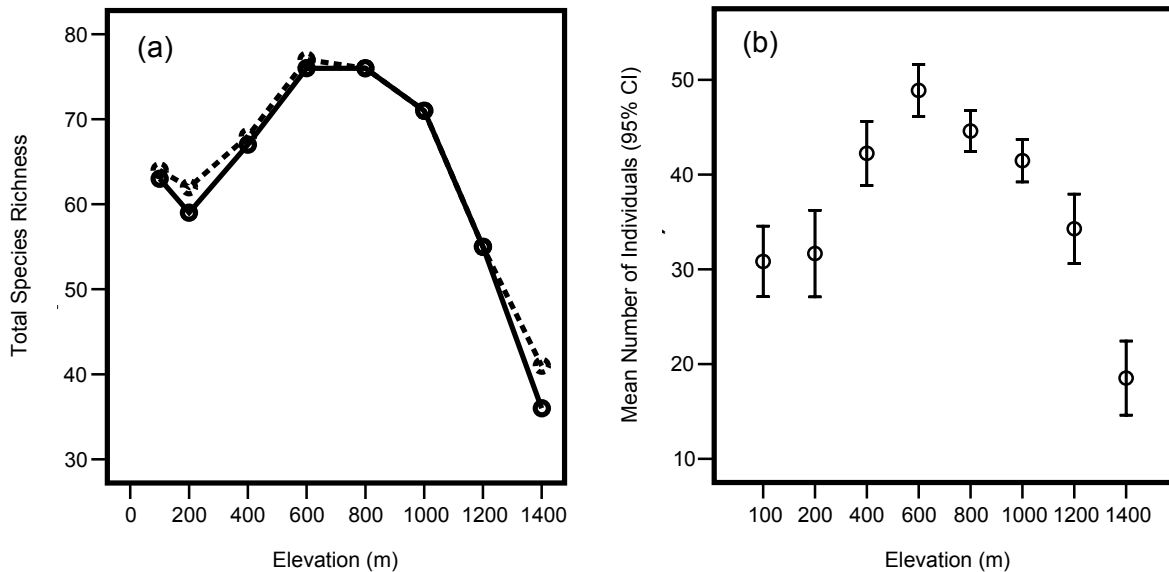


Figure 3: Changes across the elevational gradient in bird species richness and abundance, (a) observed (S_{obs} – solid line) and estimated total species richness (Michaelis-Menton Means, S_{mmm} – dashed line); and (b) bird density (mean number of individuals recorded in a survey) (after Williams *et al.* in review).

1.1 GLOBAL CLIMATE CHANGE IN THE WET TROPICS

There is no doubt that the global climate is changing due to anthropogenic greenhouse gas emissions. Average temperatures have already risen approximately 0.6°C and are continuing to increase (Houghton *et al.* 2001). The Australian Bureau of Meteorology has announced that 2005 was the hottest year on record. Regional climate modeling in Australia suggests that during the remainder of this century we will experience an increase in average temperatures of 1.4 to 5.8°C , combined with increases in atmospheric CO_2 concentrations.

Changes in rainfall patterns are also predicted with rainfall becoming more variable, longer dry spells and increased frequency of disturbance events such as flooding rains and cyclones (Easterling *et al.* 2000; Walsh and Ryan 2000; Milly *et al.* 2002; Palmer and Raianen 2002). Additionally, a rise in the average basal altitude of the orographic cloud layer is expected (Pounds *et al.* 1999), which will likely exacerbate the effects of longer and more variable dry seasons due to a reduction in cloud capture by the canopy in mountain rainforests (Still *et al.* 1999).

It is now widely accepted that climate change is probably the most significant threat to global biodiversity and human well-being (Hughes 2000; Parmesan and Yohe 2003; Root *et al.* 2003; Thomas *et al.* 2004a,b; Root *et al.* 2005; Pounds *et al.* 2006). There is a common, though incorrect, perception that the impacts of climate change will be worse in temperate regions than in the tropics although it is generally accepted that all mountain biota are extremely vulnerable. Global biodiversity is concentrated in the tropics, where there are also often high levels of vulnerable species and restricted endemics. Mountain systems represent hotspots of biodiversity and endemism due to the compression of climatic zones over the elevational gradient (Körner 2002). It is this dependence on elevational gradients that makes these systems vulnerable to climate change.

Many studies have demonstrated, or predicted, that climate change will result in shifts in the latitudinal and altitudinal range of affected species, with concomitant complex changes in assemblage structure and ecosystem function (Parmesan 1996; Hill *et al.* 2002; Peterson *et*

al. 2002; Parmesan and Yohe 2003; Root *et al.* 2003). However, the rainforests of the Wet Tropics, Cape York and Eungella are each isolated habitats with no potential for rainforest endemics to move beyond their current bioregion. Furthermore, the biogeography of the region predisposes the fauna to being vulnerable to climate change for two reasons:

1. Endemic fauna are adapted to cool, wet and relatively aseasonal environments; and
2. The impacts of increasing temperatures should be most noticeable across altitudinal gradients and, in this region, the altitudinal gradient and the associated complex topography dominate the biogeography of the region (Nix and Switzer 1991; Williams *et al.* 1996).

Predictive modeling of impacts on species distributions and population size suggested the potential for catastrophic extinctions in the Wet Tropics (Williams *et al.* 2003; Shoo *et al.* 2005a,b; Williams and Hilbert 2006). Bioclimatic models of the spatial distribution for endemic rainforests vertebrates predict that many species will lose the majority of their core habitat under relatively small increases in temperature, resulting in an amplification of extinction rates and a significant reduction in overall biodiversity in the region (Williams *et al.* 2003).

In a recent study using population size and density rather than distributions (based on standardised abundance surveys) of Wet Tropics birds, Shoo *et al.* (2005a) predict that 74% of rainforest species will become threatened as a result of projected mid-range warming in the next one hundred years. However, extinction risk in rainforest birds varied according to where a species is currently most abundant along the altitudinal gradient. Upland birds are expected to be most affected and are likely to be immediately threatened by small increases in temperature. However, there is a capacity for the population size of lowland species to increase, at least in the short term. Many microhylid frog species are also predicted to suffer large declines in population size as climates that currently support high density populations of species on mountaintops are likely to disappear under moderate levels of climate warming (Williams *et al.* in review). It has also been predicted that for regionally endemic birds and frogs, as temperature increases, population size is likely to decline more rapidly than distribution area. This indicates that for these species, extinction risk associated with climate change will be more severe than expected from decline in distribution area alone (Shoo *et al.* 2005; Shoo 2005).

Finally, Williams *et al.* (in revision) found that species richness and density of Wet Tropics rainforest birds is highest at elevations of six to eight hundred metres (Figure 3) and is positively related to net primary productivity and energy input. The authors suggest that an increase in temperature due to global warming may result in an increase in net primary productivity that could ameliorate some of the predicted negative effects of climate change on upland rainforest birds (Williams *et al.* in revision).

It is not only the vertebrates that are expected to suffer from climate change. Studies on invertebrate fauna have found many species restricted to high altitudes, including low vagility arthropods (Monteith 1985,1995; Monteith and Davies 1991), schizophoran flies (Wilson *et al.* in review) and ants (Yek unpublished data). These results suggest that the impacts in the invertebrate assemblages will be similar to those previously predicted for regionally endemic vertebrates by Williams *et al.* (2003).

Ultimately, the impacts of global climate change will depend on two factors; firstly, the final, realised degree of change, and secondly, the resilience of the species and ecosystem in question. The relative resilience of a species will depend on its ability to adapt via ecological or evolutionary plasticity within biogeographic constraints such as habitat connectivity. The imperative now is to understand the patterns and processes of the rainforest ecosystem in

Stephen E. Williams

order to allow effective conservation management. Knowing which species occur in any given area is a basic, but vitally important, piece of information for almost all aspects of ecology, conservation, natural resource management, impact assessment and general natural history. I hope these maps and summaries will be useful in all of these areas of interest.