

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

**LATE HOLOCENE ENVIRONMENTAL
HISTORY OF
NORTHLAND, NEW ZEALAND**

A thesis presented in partial
fulfilment of the requirements for the degree of
Doctor of Philosophy
in Geography
at
Massey University, New Zealand

by

Bernd Striewski

1999

**LATE HOLOCENE ENVIRONMENTAL
HISTORY OF
NORTHLAND, NEW ZEALAND**

Errata

Please note typographical errors have occurred on the following pages:

- p. 96 line 3; for regions read region's
- p. 122 line 6; should read
individual anticyclones than the rest of the country. As a result the prevailing
wind
- p. 122 line 12; for amount read amounts
- p. 122 line 14; for trough read troughs
- p. 125 last line; for (rainfall ³0.1 mm) read (rainfall \geq 0.1 mm)
- p. 137 last line; for (*Typha latifolia* sp.) read (*Typha latifolia* sp.)
- p. 172 line 20; for (Westland *quintinia*) read (Westland quintinia)
- p. 198 line 24; for Polynesian read Polynesians
- p. 199 line 14; should read
Polynesian colonisation history was marked by rapid decline of the forest
cover.
- p. 222 line 14; for Asterace read Asteracea
- p. 236 line 23; for archeology read archaeology
- p. 249 line 20; for investigation read investigations
- p. 327 line 26; for Cores 1-3 read Cores 2-4
- p. 328 line 1; for core 1 read core 2; line 6 for Core 2 read Core 3; line 9 for Core 3
read Core 4; line 11 for core 2 read core 3
- p. 344 lines 4, 8, 12; for meter read metre

ACKNOWLEDGMENTS

I wish to thank my supervisor Professor John Flenley for his supervision of my doctorate studies. Many thanks John for your kind assistance and ready advice.

Funding for this project was supplied by the *Foundation for Research, Science & Technology* under Grant Nos FLE 101, FLE 102 and MAU 305.

Professor Douglas Sutton (Auckland University), Messrs Harley Betts, Matai Power and David Feek (Massey University) and Dr Brigitte Slacek, are gratefully acknowledged for their cheery assistance during the field phases of my research, often under very wet, mucky conditions.

Numerous landowners and the local Maori people of Northland readily granted me access to their property/land.

The following people are gratefully acknowledged for their technical assistance:

Mineralogy and geochemistry: Professor Robert Brooks, Dr Shane Cronin, Messrs Lance Currie, Malcom Boag and Mike Bretherton, Associate Professor John Kirkman (Department of Soil Science, Massey University); Dr Dennis Eden, Mr Joe Whitton (Landcare Research New Zealand Limited, Palmerston North); Dr Julian Lee and Mrs Wilhelmina Martin (AgResearch New Zealand Pastoral Agriculture Research Institute Limited, Palmerston North).

Cartography and draughting: Mrs Karen Puklowski and Mrs Leighanne Empson, (Department of Geography, Massey University).

Radiocarbon dating: Drs Joseph McKee and Rodger Sparks; Ms Nicole Redvers-Higgins (Rafter Radiocarbon Laboratory, Institute of Geological and Nuclear Sciences, Lower Hutt).

Administration: Mrs Olive Harris and Glynis Walsh (Department of Geography, Massey University).

Sediment coring: Mr David Feek (Department of Geography, Massey University).

I also wish to thank my fellow postgraduate students both past and present who have offered me friendship, assistance, advice and who went through the “ups” and “downs” of postgraduate studies with me-“thanks mates”.

Very special thanks go to Dr Andrew Hammond, Karen Puklowski and Miho McCauley for assisting with the draughting, cartography, proof reading and the myriad of other tasks needed in the final compilation of my thesis.

Mr and Mrs Elliot of Kamo are thanked for their generous hospitality during our field trips to Northland.

Mein ganz besonderer Dank geht an meine Eltern, Horst und Gisela Striewski, ohne deren fortlaufende emotionale und großzügige finanzielle Unterstützung diese Doktorarbeit nicht zustande gekommen wäre!

ABSTRACT

This thesis describes the environmental changes inferred from sedimentological investigations of sediment sequences at three lowland swamp and lake sites of Late Holocene age in Northland, northern North Island. The sites investigated are Wharau Road Swamp (coastal Bay of Islands), Lake Tauanui (inland Bay of Islands) and Lake Taumatawhana (central Aupouri Peninsula).

The purpose of this sediment-based study was to reconstruct aspects of the environmental histories at these localities which would reflect the different environmental changes, natural and anthropogenic, that the sites proper and their drainage basins underwent through the passage of time. Particular emphasis was placed on human-induced environmental changes in order to address the on-going debate over the date of arrival of people in New Zealand. To this end the sediment sequences collected from the drainage basins of the above sites were analysed for a number of sedimentary parameters, including texture, sediment chemistry, mineralogy and organic matter content. In order to distinguish between natural and anthropogenic disturbances the results of these analyses were compared against the results of pollen and charcoal counts performed on the same sediment sequences.

Wherever significant breaks in the sedimentological and palynological record of the sediment sequences were encountered, (bulk) samples were submitted for radiocarbon dating to establish a chronology of environmental changes. At Wharau Road Swamp the radiocarbon chronology was enhanced by the occurrence of one macro-tephra layer within the sediment sequence.

The establishment of a radiocarbon chronology finally allowed one to determine the onset of sedimentologically-palynologically-demonstrated anthropogenic catchment disturbance at the respective localities. At Wharau Road earliest human presence was dated to *ca.* 600 (uncalibrated) years B.P. (about A.D. 1350) and at Lake Taumatawhana at *ca.* 900 (uncalibrated) years B.P. (about A.D. 1050). At Lake Tauanui

sedimentological and palynological evidence for the beginning of human activities provide different dates. While sedimentological data only supported a date of *ca.* 350 (uncalibrated) years B.P. (about A.D. 1600) for the onset of human-induced catchment disturbances, the pollen and charcoal record suggested that anthropogenic deforestation began at *ca.* 1100 years B.P. (about A.D. 850).

TABLE OF CONTENTS

Acknowledgments	i
Abstract	iii
Table of Contents.....	v
List of Figures	xv
List of Tables	xviii
List of Plates	ix

CHAPTER 1: INTRODUCTION

1.1 Aim of research and objective	2
1.2 Taxonomy	4
1.3 Structure of thesis	4
REFERENCES	8

CHAPTER 2: POLYNESIAN MIGRATION

2.1 History of colonisation in the Pacific region	12
2.1.1 The Pacific Basin of the Pleistocene.....	13
2.1.2 The earliest human inhabitants	14
2.1.3 The colonisation of Ancient Near Oceania	15
2.1.4 The migration into Remote Oceania	19
2.1.4.1 The Lapita cultural complex.....	21
2.1.4.2 Developments in Fiji and West Polynesia.....	26
2.1.4.3 Mode of exploration of Remote Oceania	28
2.1.4.4 The settlement of East Polynesia and its margins	31
2.1.5 Summary	37
2.2 Polynesian colonisation of New Zealand.....	39

2.2.1	Date of settlement of New Zealand.....	40
2.2.1.1	Orthodox model.....	42
2.2.1.2	Early hypothesis.....	42
2.2.1.3	Short prehistory hypothesis	44
2.2.2	Origin of New Zealand Maoris	45
2.2.3	Multiple settlement of New Zealand and return voyages.....	48
2.2.4	Mode of settlement of New Zealand	50
2.2.5	Summary.....	51
REFERENCES		53

CHAPTER 3: THE NEW ZEALAND PHYSICAL ENVIRONMENT

3.1	Geology and tectonic framework.....	61
3.2	Soils	66
3.3	Climate.....	69
3.3.1	Wind	71
3.3.2	Precipitation	72
3.3.3	Temperature	73
3.4	Hydrology	75
3.5	Summary.....	82
REFERENCES		85

CHAPTER 4: THE PHYSICAL ENVIRONMENT OF NORTHLAND

4.1	Geology and physiography.....	92
4.1.1	Physiographic framework.....	92
4.1.2	Tectonic architecture	94
4.1.3	Geology	96
4.1.3.1	Late Palaeozoic to Mid Cretaceous	96
4.1.3.2	Late Cretaceous to Oligocene.....	98

	4.1.3.3	Oligocene to Miocene.....	98
	4.1.3.4	Pliocene to Late Holocene.....	103
	4.1.3.5	Effects of the Quaternary glaciations.....	105
	4.1.4	Summary.....	107
4.2		Soils.....	107
	4.2.1	Northern rendzinas	111
	4.2.2	Northern yellow-brown earths.....	112
	4.2.3	Northern podzolised yellow-brown earths and podzols	113
	4.2.4	Northern brown granular clays and loams.....	115
	4.2.5	Northern red and brown loams	116
	4.2.6	Northern yellow-brown sands	117
	4.2.7	Northern recent, gley, and organic soils	118
	4.2.8	Steepland soils.....	119
	4.2.9	Summary.....	119
4.3		Climate.....	120
	4.3.1	Weather systems affecting Northland.....	121
	4.3.2	Elements of climate in Northland.....	123
	4.3.2.1	Wind	124
	4.3.2.2	Precipitation.....	125
	4.3.2.3	Temperature.....	128
	4.3.2.4	Frosts	129
	4.3.2.5	Humidity.....	130
	4.3.2.6	Annual sunshine	131
	4.3.2.7	Other elements.....	131
	4.3.3	Summary.....	132
4.4		Hydrology	132
	4.4.1	Rivers of Northland.....	132
	4.4.1.1	Flow regime.....	134
	4.4.1.2	Sediment discharge.....	140
	4.4.2	Lakes of Northland	141
	4.4.2.1	Wind-blown dune lakes.....	141
	4.4.2.2	Volcanic lakes.....	142

4.4.2.3	Riverine lakes	143
4.4.3	Wetlands of Northland	143
4.4.4	Summary.....	144
REFERENCES	146

CHAPTER 5: THE BIOTA AND QUATERNARY RECORD OF NEW ZEALAND

5.1	General aspects of the origins, history and composition of the biota of New Zealand.....	153
5.1.1	The floral record.....	154
5.1.2	Fauna.....	158
5.1.2.1	Marine and freshwater fauna.....	158
5.1.2.2	Terrestrial fauna.....	160
5.1.3	Types of vegetation.....	167
5.1.4	The indigenous forest of New Zealand	169
5.1.4.1	Conifer hardwood forests	171
5.1.4.1.1	<i>Agathis australis</i> -podocarp- hardwood forests.....	174
5.1.4.1.2	Podocarp-hardwood forests	175
5.1.4.1.3	Podocarp-hardwood- <i>Nothofagus</i> forests	177
5.1.4.2	<i>Nothofagus</i> forests.....	178
5.2	General aspects of the Quaternary environment of New Zealand	179
5.2.1	Chronology of the New Zealand Quaternary	180
5.2.2	Palaeoenvironmental conditions and vegetation during the Late Quaternary.....	182
5.2.2.1	The Last Glacial Maximum.....	183
5.2.2.2	The Late Glacial	188
5.2.2.3	The Holocene (Post Glacial-10 ka to present).....	190
5.2.2.3.1	The Early Holocene (9.5 to 7.5 ka).....	192
5.2.2.3.2	The Late Holocene (7.5 ka to present).....	194

5.3	The human era and its impact on the environment	198
5.3.1	Prehistoric anthropogenic forest destruction.....	198
5.3.2	Prehistoric anthropogenic faunal extinctions.....	203
5.4	Summary	204
	REFERENCES	208

CHAPTER 6: LATE QUATERNARY VEGETATION AND CLIMATE OF NORTHLAND

6.1	General aspects of the Last Glacial to present vegetation and climate	219
6.2	Pre-European vegetation.....	223
6.3	Present day vegetation	224
6.4	Summary	225
	REFERENCES	228

CHAPTER 7: RESEARCH STRATEGY AND METHODOLOGY

7.1	Rationale of research.....	231
7.1.1	Historical background.....	232
7.1.2	Concepts of the mode of human colonisation in the Pacific.....	234
7.1.2.1	Short prehistory	235
7.1.2.2	Early hypothesis.....	236
7.1.3	Sediment-based evidence for prehistoric human-induced environmental disturbance	247
7.1.4	Principle research objectives.....	249
7.1.5	Review of previous palaeoenvironmental studies.....	250
7.2	Description of methods used.....	250
7.2.1	Site selection	251
7.2.1.1	Criteria for site selection.....	251
7.2.1.2	Suitability of selected sites	251

7.2.2	Coring methods.....	253
7.2.3	Collection and description of sediment cores	253
7.2.4	X-ray photography	254
7.2.5	Sampling methodology	255
7.2.6	Laboratory methods.....	255
7.2.6.1	Pretreatment of samples.....	256
7.2.6.1.1	Physical disaggregation	256
7.2.6.1.2	Chemical removal of cements and other binding agents.....	257
7.2.6.1.2.1	Removal of organic matter	257
7.2.6.1.2.2	Removal of iron and aluminium oxides and oxyhydroxides	257
7.2.6.1.2.3	Removal of carbonates	258
7.2.6.2	Sediment texture.....	258
7.2.6.2.1	Grain-size scale.....	259
7.2.6.2.2	Grain-size analysis of the clay- and silt-fraction.....	260
7.2.6.2.3	Grain-size analysis of the sand-fraction.....	260
7.2.6.3	Sediment mineralogy.....	260
7.2.6.3.1	X-ray diffraction	261
7.2.6.3.2	Differential thermal analysis.....	262
7.2.6.3.3	Petrological microscopy	262
7.2.6.4	Sediment chemistry	262
7.2.6.4.1	Pretreatment of samples for chemical analysis	263
7.2.6.4.2	Inductively-coupled plasma spectrometry ..	263
7.2.6.4.3	Classification of elements in main groups..	263
7.2.6.5	Sediment constituents.....	264
7.3	Dating of sediments	266
7.3.1	Radiocarbon dating of sediments.....	266
7.3.1.1	Accelerator Mass Spectrometry dating.....	266
7.3.1.2	Sources of error in radiocarbon dating	267

7.3.2	Use of tephra layers for dating	267
REFERENCES		269

CHAPTER 8: WHARAU ROAD SWAMP

8.1	Physical setting of the region.....	286
8.1.1	Geology and physiography	286
8.1.2	Soils.....	290
8.1.3	Climate	294
8.2	Vegetation of the region.....	297
8.2.1	Pre-Polynesian vegetation	299
8.2.2	Pre-European vegetation.....	301
8.2.3	Modern vegetation.....	302
8.3	Description of the Wharau Road Swamp	304
8.3.1	Physiography and vegetation of the site	305
8.3.2	Description of the sediment cores	306
8.3.2.1	Stratigraphy.....	306
8.3.2.2	X-ray radiography.....	307
8.3.3	Radiocarbon dating.....	308
8.4	Sedimentology of core material	309
8.4.1	Sediment texture.....	309
8.4.2	Organic content	310
8.4.3	Sediment mineralogy.....	311
8.4.4	Sediment chemistry	312
8.5	Discussion.....	313
8.5.1	Radiocarbon chronology.....	313
8.5.2	Sedimentology	313
8.6	Conclusions.....	316
REFERENCES		317

CHAPTER 9: LAKE TAUANUI

9.1	Description of Lake Tauanui	324
9.1.1	Physical setting and vegetation of the site	324
9.1.2	Description of sediment cores	326
9.1.2.1	Stratigraphy.....	327
9.1.2.2	X-ray radiography.....	327
9.1.3	Radiocarbon dating.....	328
9.2	Sedimentology of core material	329
9.2.1	Sediment texture.....	329
9.2.2	Organic content	331
9.2.3	Sediment mineralogy.....	331
9.3	Discussion.....	333
9.3.1	Radiocarbon chronology.....	333
9.3.2	Sedimentology	333
9.4	Conclusions.....	335
	REFERENCES	338

CHAPTER 10: LAKE TAUMATAWHANA

10.1	Description of Lake Taumatawhana	341
10.1.1	Physiography and vegetation of the site	341
10.1.2	Description of sediment core.....	343
10.1.2.1	Stratigraphy.....	343
10.1.2.2	X-ray radiography.....	343
10.1.3	Radiocarbon dating.....	344
10.2	Sedimentology of core material	345
10.2.1	Sediment texture.....	345
10.2.2	Organic content	346
10.2.3	Sediment mineralogy.....	346
10.2.4	Sediment chemistry	347

10.3	Discussion.....	349
10.3.1	Radiocarbon chronology.....	349
10.3.2	Sedimentology.....	351
10.4	Conclusions.....	357
	REFERENCES	359

CHAPTER 11: SUMMARY AND CONCLUSIONS

11.1	Summary of results	362
11.2	Discussion.....	364
11.3	Conclusions.....	366
11.4	Recommendations.....	367
	REFERENCES	370

APPENDICES

APPENDIX I:	Location of coring sites in Northland, New Zealand.....	372
-------------	---	-----

APPENDIX II: Wharau Road Swamp

Appendix II.1:	Stratigraphy of sediment cores.....	376
Appendix II.2:	Sediment texture.....	383
Appendix II.3:	Sediment constituents.....	387
Appendix II.4:	Sediment mineralogy.....	391
Appendix II.5:	Sediment chemistry	394

APPENDIX III: Lake Tauanui

Appendix III.1:	Stratigraphy of sediment cores.....	395
Appendix III.2:	Sediment texture	400
Appendix III.3:	Sediment constituents	401
Appendix III.4:	Sediment mineralogy	404

APPENDIX IV: Lake Taumatawhana

Appendix IV.1: Stratigraphy of the sediment core	407
Appendix IV.2: Sediment texture	408
Appendix IV.3: Sediment constituents	409
Appendix IV.4: Sediment chemistry	410

BACKPOCKET:

(Reprint) of Elliot, M B; Striewski, B; Flenley, J R; Sutton, D G (1995). Palynological and sedimentological evidence for a radiocarbon chronology of environmental change and Polynesian deforestation from Lake Taumatawhana, Northland, New Zealand. *Radiocarbon* 37: 899-916.

(Reprint) of Elliot, M B; Striewski, B; Flenley, J R; Kirkman, J H; Sutton, D G (1997). A 4300 year palynological and sedimentological record of environmental change and impact from Wharau Road Swamp, Northland, New Zealand. *Journal of the Royal Society of New Zealand* 27: 401-418.

LIST OF FIGURES

Figure	Short title	Follows page number
2.1	The Pacific Basin.....	12
2.2	Ancient Near Oceania, Sundaland and Sahul.....	13
2.3	Log/log transformation of a Mercator projection map of the Pacific.....	34
2.4	Colonisation of Island Melanesia and Polynesia.....	36
2.5	Polynesian dispersal patterns.....	41
3.1	Geographical position of New Zealand in the South Pacific.....	61
3.2	Mainland New Zealand with its outlying island groups.....	61
3.3	Generalised representation of the plate tectonic setting of the New Zealand landmass.....	62
3.4	Generalised physiography of mainland New Zealand.....	63
3.5	Generalised geology of the North Island, New Zealand.....	65
3.6	Generalised geology of the South Island, New Zealand.....	65
3.7	Distribution of soils in the North Island.....	68
3.8	Distribution of soils in the South Island.....	69
3.9	Mean annual precipitation in New Zealand.....	72
3.10	Mean annual temperature in New Zealand.....	73
3.11	Distribution of lake types in New Zealand.....	82
4.1	Map of Northland.....	92
4.2	Topography of Northland.....	93
4.3	Generalised geology of the Northland-Auckland-Coromandel region.....	96
4.4	Distribution of Late Pliocene-Quaternary volcanic rocks in northern New Zealand.....	105
4.5	Quaternary sand accumulation in Northland.....	106
4.6	Climatic types of the North Island.....	121
4.7	Mean annual wind frequencies of surface wind in Northland.....	124

4.8	Mean annual precipitation in Northland	125
4.9	Seasonal distribution of precipitation in northern New Zealand	127
4.10	Seasonal distribution of mean temperatures in northern New Zealand	128
4.11	Major surface water resources of Northland.....	133
4.12	Distribution of dune, volcanic, and riverine lakes in Northland.....	141
5.1	Proportions of the individual cover groups of the present vegetation cover of New Zealand.....	168
5.2	Generalized distribution of the present-day main types of native and adventive vegetation in New Zealand	168
5.3	The extent of the indigineous forest cover in the North Island prior to European colonization and present	178
5.4	The extent of the indigineous forest cover in the South Island prior to European colonization and present	178
5.5	Generalised distribution of Quaternary deposits in New Zealand.....	180
5.6	Climatostratigraphy of the New Zealand Quaternary glacial/interglacial sequences	181
5.7	New Zealand physical environment at the height of the Last Glacial Maximum....	186
5.8	Vegetation cover of New Zealand at the height of the Last Glacial Maximum	187
5.9	Late Holocene vegetation cover of New Zealand at about 3 ka	196
6.1	Pre-European vegetation of Northland	223
6.2	Present day indigenous forest cover of Northland	224
7.1	Model of the interrelationships between lacustrine sedimentation and human activity within a lake drainage basin.....	249
7.2	Location of coring sites in Northland, New Zealand.....	248
8.1	Distribution of the Kerikeri basalts	287
8.2	Monthly rainfall normals (1935-1973) for Kerikeri	296
8.3	Monthly temperature normals (1945-1973) for Kerikeri.....	296
8.4	Location and physiography of the Wharau Road Swamp.....	305
8.5	Stratigraphy for cores 1-7, Wharau Road Swamp	306
8.6	Radiocarbon chronology for Wharau Road Swamp, Core 5	309
8.7	Grain-size classes and organic matter content for cores 1-3 and 5, Wharau Road Swamp	309

8.8	Sediment chemistry of core 5, Wharau Road Swamp	312
8.9	Summary pollen diagram (core 5) for Wharau Road Swamp.....	316
9.1	Location and physiography of Lake Tauanui.....	324
9.2	Stratigraphy for cores 1-5, Lake Tauanui	327
9.3	Stratigraphy for core 1, Lake Tauanui.....	327
9.4	Radiocarbon chronology for Lake Tauanui, core 1	329
9.5	Grain-size classes and organic matter content for core 1, Lake Tauanui	329
9.6	Grain-size classes and organic matter content for cores 2 and 4, Lake Tauanui	329
9.7	X-ray diffractograms from core 2, Lake Tauanui	332
9.8	Summary pollen diagram (core 1) for Lake Tauanui.....	336
10.1	Geological setting of the Aupouri and Rangiawhia Peninsulas.....	341
10.2	Location and physiography of Lake Taumatawhana	343
10.3	Stratigraphy of the sediment core from Lake Taumatawhana	343
10.4	Radiocarbon chronology for Lake Taumatawhana.....	344
10.5	Grain-size classes and organic matter content of the Lake Taumatawhana sediment core.....	345
10.6	X-ray diffractograms of the sediment core from Lake Taumatawhana	346
10.7	Sediment chemistry for Lake Taumatawhana.....	347
10.8	Summary pollen diagram for Lake Taumatawhana.....	350

LIST OF TABLES

Table	Short title	Follows page number
5.1	New Zealand Late Pliocene and Quaternary biostratigraphic subdivision.....	180
8.1	Radiocarbon dating of samples from core 5, Wharau Road Swamp.....	on 308
9.1	Radiocarbon dating of samples from core 1, Lake Tauanui	on 328
10.1	Radiocarbon dates of samples from Lake Taumatawhana sediment core	on 345

LIST OF PLATES

Plate	Short title	Follows page number
8.1	Wharau Road Swamp, coastal Bay of Islands	305
9.1	Lake Tauanui, inland Bay of Islands, Northland	324
10.1	Lake Taumatawhana, central Aupouri Peninsula, Northland.	341