A High Resolution Record
of
Late Quaternary
Climatic and Environmental Change
in
Taranaki, New Zealand

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Abstract

A high-resolution characterisation of climatic and environmental change in Taranaki, New Zealand over the last 80,000 years using biotic and abiotic proxies is presented. This research contributes to the small set of sediment cores that extend from the present back through the Last Glacial Maximum (LGM) in the southern North Island, and adds to the small number of near-continuous cores in New Zealand.

Fossil pollen data presented here provides a record of vegetation changes in response to climate change (temperature, wind and rainfall). In addition, the project applies a recently developed pollen temperature transfer function (Wilmshurst *et al*. 2007) to quantify, for the first time, temperature change across the entire LGM in this region, and elucidates the timing of Late Quaternary New Zealand climatic events and phases. Climate change timing and magnitude is tested against the climate event stratigraphy (CES) developed by the NZ-INTIMATE (INTegration of Icecore, Marine and Terrestrial archives) group (Alloway *et al*. 2007), including: Last Glacial Coldest Period (LGCP); the mid-eLGM Interstadial; the Last Glacial-Interglacial Transition (LGIT); Termination I; the Antarctic Cold Reversal (ACR); the Late-Glacial Warm Period (LGWP), the Late-Glacial Reversal (LGR); and Early Holocene Warming (EHW).

During the Moerangi Interstadial between 40,000 and 30,000 cal yrs BP, both the Eltham and coastal Taranaki pollen records show that cold-climate taxa such as *Nothofagus menziesii*, *Nothofagus* subg. *Fuscospora*, *Hoheria*, *Plagianthus*, *Phyllocladus* and Poaceae dominated the pollen assemblage. In addition to being cold, low numbers of fern and tree fern spores imply that conditions were drier than present. The LGCP at Eltham (29,000 – 18,000 cal yrs BP) began around 1,200 years earlier than similar records from elsewhere in New Zealand. Transfer functions suggest that mean annual temperatures at the LGCP/ LGM at Eltham were 5.7°C cooler than present. Within the LGCP, the mid-eLGM Interstadial described in similar records from New Zealand seems to be evident in the W-MAT-derived temperature curve at Eltham, where warming of around 0.8°C occurs between 27,000 and 24,500 cal yrs BP.

The LGIT appears to have begun around 18,000 cal yrs BP and concluded around 14,600 cal yrs BP at Eltham, which agrees well with speleothem data from Northwest Nelson, but is more short-lived than at Otamangakau Bog where the LGIT is thought to have persisted for another 1,500 years. A period of sharp cooling inferred from the Eltham pollen record between 16,600 and 15,000 cal yrs BP, when mean annual temperature fell between 1°C and 4°C from the previous period, is matched in time, but not in intensity at some other western and central North Island, and some South island sites, and may be a sampling artefact. The LGWP duration at Eltham (14,600 – 13,500 cal yrs BP) broadly corresponds with NZ-INTIMATE and Northwest Nelson estimates of 14,800 – 13,500 cal yrs BP; mean annual temperatures at Eltham came within 0.6°C of modern-day mean annual temperatures at this time.

The timing of the LGR at Eltham shows good agreement with NZ-INTIMATE estimates (Alloway *et al*. 2007; Lowe *et al*. 2008), that is, from around 13,500 to 12,500 cal yrs BP. The LGR onset at Eltham preceded onset at the Auckland maars by 600 years and concluded 1,500 years earlier than at Auckland; mean annual temperature at Eltham at this time was approximately 2°C cooler than the present day MAT of 11.2°C. The EHW event commenced at Eltham around 12,500 cal yrs BP, around 1,000 years earlier than at Kaipo Bog, Otamangakau Bog; and largely synchronous with the Auckland maars and Okarito.

Pollen records from coastal Taranaki sites span $\delta^{18}O$ Stage 5a (Otamangakau Interstadial, *c*. 80,000 yrs BP) through to $\delta^{18}O$ Stage 2 (Last Glacial-Interglacial Transition, *c*. 18,500 cal yrs BP), and encompass the stadial complex between these two interstadials ($\delta^{18}O$ Stage 4, *c*. 70,000 – 60,000 yrs BP). These records contribute to the small number of pollen-based paleoenvironmental and paleoclimatic narratives for New Zealand extending from the LGIT to the Otamangakau Stadial ($\delta^{18}O$ stage 5a) time periods. A major contribution of the current

study is to reconstruct and characterise $\delta^{18}O$ stage 5a and $\delta^{18}O$ stage 4 temperatures based on two pollen transfer functions developed by Wilmshurst *et al.* (2007).

During $\delta^{18}O$ Stage 5a around 80,000 cal yrs BP, conditions were warmer and wetter than the succeeding glacial. $\delta^{18}O$ Stage 4 and the early part of $\delta^{18}O$ Stage 3 were cool with relatively low precipitation and were likely to have been windy at coastal Taranaki sites. Although $\delta^{18}O$ Stage 4 was cool, it was not as cold as the LGM: pollen transfer functions showed decreases in estimated mean annual temperature from $\delta^{18}O$ stage 5a, with mean annual temperatures falling around 2°C to reach 7°C. Precipitation likely decreased during $\delta^{18}O$ stage 4, as indicated by low levels of drought-intolerant taxa *Dacrydium cupressinum*, *Cyathea smithii*, and monolete spores, whilst low shrub diversity implies that disturbance was likely to have been low.

During early $\delta^{18}O$ stage 3, the climate warmed and became wetter in coastal Taranaki, as indicated by increasing conifer abundance; in particular *Dacrydium cupressinum*, high abundance of *Cyathea smithii*, and a decline in cold-tolerant *Nothofagus*, *Halocarpus*, Asteraceae, and Poaceae after 60,000 yrs BP. These conditions persisted for < 5,000 years before temperatures decreased again, then between 50,000 and 40,000 yrs BP the decline in Poaceae and cold-tolerant shrubs *Phyllocladus*, *Halocarpus* and Asteraceae, as well as the sharp rise in tall tree conifers, all point to climate amelioration. Conditions were still relatively cool; although pollen transfer functions imply that that mean annual temperatures increased slightly, with mean annual temperature estimates fluctuating between 7°C and 8°C, this was approximately 3 to 4°C cooler than present.

For the first time in New Zealand, aerosolic quartz dust was extracted from organic sediments; this peat-derived data informs a paleowind narrative for Taranaki. The technique used in the current study to extract quartz from peats can be considered successful, insofar as relatively pure samples of quartz could be isolated in sufficient mass to be able to measure them, and relate the data to the age model and the coeval pollen influx.

The paleowind reconstructions from Eltham can be summarised as follows: strong winds dominated between 36,200 and 35,100 cal yrs BP, 30,746 and 32,101 cal yrs BP, 28,364 to 17,477 cal yrs BP, and 16,118 to 15,806 cal yrs BP. Intermediate winds occurred between 30,746 and 28,364 cal yrs BP, 17,477 and 16,118 cal yrs BP, and 15,619 to 14,916 cal yrs BP; winds of light intensity dominated between 34,777 and 32,101 cal yrs BP and 14,916 and 9,900 cal yrs BP. Major dust peaks at 31,358 cal yrs BP; 21,300 cal yrs BP and 15,955 cal yrs BP all correlated well with the Vostok ice core as well as marine core P69 (Stewart & Neall 1984), and Onaero and Waitui in northern Taranaki. Similarly, dust minima after about 15,000 cal yrs BP at Eltham, Vostok, marine core P69, Onaero, and Waitui suggests that the quartz dust signature at Eltham is consistent with both global and regional estimates of dust influx as the atmospheric dust load responded to changes in wind direction and strength, in particular the intensity of westerly winds, and changes to sediment source area characteristics such as vegetation cover.

Combining fossil pollen data and aerosolic quartz dust results is a new technique to investigate the relationship between wind intensity, temperature and plant assemblages. The Eltham fossil pollen and aerosolic quartz data was analysed to determine how the relative proportions of competitive, stress tolerant and ruderal taxa respond to winds of differing intensities over time, as well as quantifying the impact of wind of different intensities on plant diversity over the period 36,200 to 9,900 cal yrs BP. In essence, competitor, *C*-selected taxa increased in relative abundance, and stress-tolerant, *S*-selected and ruderal, *r*-selected taxa decreased over the last 15,000 years at Eltham, as both temperature and wind intensity ameliorated.

Wind data was examined against pollen diversity data to test the Intermediate Disturbance Hypothesis (IDH) in the vegetation of the Taranaki region. A moderate relationship between floral diversity and dust flux was found, with periods of high and low dust flux corresponding to lower diversity, and periods of intermediate dust flux corresponding to higher diversity, as predicted by the IDH.

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Table of Contents

Abstract

Acknowledgements

Table of Contents

List of Figures

List of Tables

1. Introduction

1.1. Research Rationale and Importance of Study 1

1.2. Research Objectives 3

1.3. Research Questions 4

2. Taranaki Geography, Geology & Soils

2.1. Introduction 5

2.2. North Island Tectonics and the Taranaki Volcanic Lineament 6

2.3. Taranaki Soils 8

3. Present Climate of Taranaki

3.1. Introduction 8

3.2. Temperature 9

3.3. Winds

3.3.1. Introduction 11

3.3.2. Taranaki Winds 12

3.3.2.1. Strong-Gale Force Winds, Tropical Cyclones and Tornadoes 13

3.4. Precipitation 14

4. Late Quaternary Climate Change in New Zealand 16

5. Characteristics and Dynamics of Taranaki Flora, Plant Responses to Stress, Plant Strategies and Floral Biodiversity

5.1. Vegetation History of Western North Island since 80,000 years BP 22

5.2. Modern Taranaki Vegetation 29

5.3. Plant Responses to Stress

5.3.1. Effects of Cold Temperatures on Plants 33

5.3.2. Effects of Wind on Plants 34

5.3.3. Plant Adaptations to Resource-Rich *vs*. Resource-Poor Environments 36

5.3.4. Fire Regimes and Charcoal 36

5.4. Plant Strategies

5.4.1. *r*-*K* Selection Theory 38

5.4.2. Grime's *C*-*S*-*R* Theory 39

5.4.3. Plant Succession Following Volcanic Disturbance 41

5.5. Floral Biodiversity

5.5.1. Introduction 43

5.5.2. Intermediate Disturbance Hypothesis 46

5.5.3. Floral Representation in the New Zealand Pollen Rain 50

5.5.4. Pollen Transfer Functions 50

6. Aerosolic Dust

6.1. Introduction 53

6.2. Aerosolic Dust and Terrestrial Biogeochemical Cycles 55

6.3. Antarctic Ice Core Studies 57

6.4. New Zealand Aerosolic Dust Studies 59

6.5. Australian Dust Sources 61

6.6. The Effects of Vegetation on Dust Entrainment 63

7. Methodology

7.1. Site Descriptions and Stratigraphy 65

7.1.1. Eltham Swamp 65

7.1.2. Stent Road 76

7.1.3. Okaweu Stream 78

7.1.4. Opunake Beach 83

7.1.5. Kaupokonui Beach 87

7.1.6. Lizzie Bell 89

7.2. Core Extraction 94

7.3. Palynology and Charcoal Methodology 100

7.4. Taranaki Radiocarbon Dates

7.4.1. Eltham Radiocarbon Dates 102

7.4.2. Coastal Taranaki Radiocarbon Dates 103

7.4.3. Eltham Swamp Age Model 104

7.5. Aerosolic Quartz Methodology 114

7.6. Pollen Transfer Functions 116

7.7. Biodiversity Indices 117

8. Results

8.1. Results of Pollen Analysis

8.1.1. Eltham Swamp 120

8.1.2. Stent Road 139

8.1.3. Okaweu Stream 142

8.1.4. Opunake Beach 146

8.1.5. Kaupokonui Beach 151

8.1.6. Lizzie Bell 156

8.2. Results of Quartz Analysis of Eltham Swamp 161

8.3. Results of Charcoal Analysis of Eltham Swamp 175

9. Discussion

9.1. Pollen Transfer Functions 177

9.2. Climate Phases and Chronocorrelation

9.2.1. Regional Taranaki 85,000 – 30,000 yrs BP 179

9.2.2. Eltham and NZ-INTIMATE CES 186

9.3. Aerosolic Quartz

9.3.1. Aerosolic Quartz at Eltham 192

9.3.2. Aerosolic Dust Entrainment Distances and Wind Intensity Definitions 195

9.4. Charcoal and Fire Regimes 199

9.5. Climate Change and Biodiversity Change 201

10. Conclusions and Future Work

10.1. Conclusions 209

10.2. Future Work 213

11. Appendices

11.1. Taranaki Weather Stations 215

11.2. Palynological and Aerosolic Dust Sites Referred to in Text 216

11.3. Wilcoxon Signed Rank Test for Eltham Core 6 219

11.4. Aerosolic Quartz Extraction Methodology Rationale 220

12. References 229

List of Figures

1. Major Landform Regions in Taranaki
2. Tectonic and Geological setting of Taranaki Volcanoes
3. Oil Derricks at Moturoa, New Plymouth, with Ngamoti beach
4. Mount Egmont as seen from Eltham
5. New Zealand's Position in the South Pacific Ocean
6. Isotherm Map of Median Temperatures for Taranaki Region, 1971 -2000
7. Mean Monthly Temperatures for Selected Taranaki Sites.
8. Windrose, New Plymouth Aeroclub 0600-1100 hours
9. Windrose, Stratford Demonstration Farm
10. Windrose, Normanby EDR
11. Isohyet Map, January–December 2011
12. Mean Annual Rainfall vs Altitude for Selected Taranaki Sites
13. Eltham Swamp Pollen Diagrams *c*. 3,000 – 14,000 ys BP
14. Seed size (cm), production (seeds m^{-2}) and periodicity (1961-1967) for five New Zealand podocarps
15. The Frequency of *C*-, *S*- and *R*-strategies along the *r*-*K* Continuum
16. Intermediate Disturbance Hypothesis Parabola
17. Relationship between Disturbance and Diversity for Japanese Forests
18. Species Richness of Tree Communities in French Guiana as a Function of Pioneer Stems
19. Antarctica Ice Core Drilling Sites
20. Lake Eyre and Murray Darling Dust Sources
21. Australian Dust Sources and Trajectories Across the Tasman Sea
22. Quartz Distribution in Ocean Sediments around Australia, and South-eastern Dust Path
23. Satellite photograph of Eltham Area
24. Eltham Swamp Lithology Core A
25. Eltham Swamp Lithology Key
26. Taranaki Study Sites
27. Stent Road Site
28. Okaweu Stream Site and Lithology
29. Opunake Beach South Site and Lithology
30. Kaupokonui Beach Site and Lithology
31. Lizzie Bell Site and Lithology
32. Coastal Taranaki Sites Lithology Key
33. Taranaki Pollen Site Tephra and Debris Avalanche Correlations
34. Coring Rig at Eltham
35. Livingstone Coring Apparatus at Eltham
36. Eltham Swamp Lithology Core B, and Core A and B Correlation
37. Age-Depth Models for Eltham Swamp
38. Rarefaction Curve for Eltham Swamp
39. Eltham Swamp Pollen Diagram 40,000 – 9,750 cal yrs BP
40. Samples Containing Low Pollen Counts, 21,000 – 18,000 cal yrs BP

41. Eltham Swamp Pollen Diagram 19,400 – 9,750 cal yrs BP
42. Stent Road Pollen Diagram 24,730 – 18,540 cal yrs BP
43. Okaweu Stream Pollen Diagram 33,730 – 24,770 cal yrs BP
44. Opunake Beach Pollen Diagram 33,800 – 25,565 cal yrs BP
45. Kaupokonui Beach Pollen Diagram 55,000 - 33,900 cal yrs BP
46. Lizzie Bell Pollen Diagram 80,000 – 55,000 cal yrs BP
47. Aeolian Mass Accumulation Rate for Marine Core E26.1
48. Weight of Quartz per cm^3 of Sediment by Size Class, Eltham Swamp
49. Eltham Quartz Dust Concentration and Eltham and Vostok Dust Influx
50. Dust Accumulation Rates and Fossil Pollen Curves for Marine Core P69
51. Eltham Quartz Grain Distribution for Individual Samples
52. Eltham Quartz Grain Distribution Combined Samples and Cumulative Distribution
53. Modern Australian Dust Samples
54. Quartz Dust Grain Size Distribution and Influx at Waitui and Onaero
55. Vostok Dust Concentration and Influx
56. Dust Particle Size Distribution from Marine Cores E39.75 and E26.1
57. Eltham LPG Ratio, Charcoal Concentrations, Temperature Reconstruction & Correlation to NZ Climate Events
58. Eltham LPG Ratio, Shannon Index, Temperature Reconstruction and Correlation to NZ Climate Events
59. Windroses, Normanby and Waitara
60. Taxa Richness vs Wind Disturbance, Eltham Swamp
61. Taxa Richness vs Mean Annual Temperature, Eltham Swamp
62. Eltham Quartz Concentration by Size Class, Proportion of *C*-, *S*- or *R*- taxa
63. Eltham Quartz Concentration by Size Class and Influx, Proportion of *C*-, *S*- or *R*- taxa; Diversity Indices
64. Eltham Quartz Concentration by Size Class and Influx, Proportion of *C*-, *S*- or *R*- taxa; Charcoal Concentration
65. XRD Plots for Selected Eltham Quartz Dust Samples

List of Tables

1. Relationship between 2007 NZ-INTIMATE CES and 2013 NZ-INTIMATE CES
2. Modern Limits of New Zealand Flora as a Function of Altitude, Latitude and Temperature
3. Typical Differences between *r*-selected and *K*-selected Plants
4. Basis for the Evolution of *C*-*S*-*R* Strategies in Vascular Plants
5. Red Queen and Court Jester Models at Different Geographic and Temporal Scales
6. Classification of Eolian Materials by Size
7. Mineral Composition, New Zealand Dust Storms
8. Taranaki Radiocarbon Dates
9. Age Ranges for Eltham Swamp and Coastal Taranaki Sites
10. Correlation between Mean Annual Temperature and Pollen Types for Taranaki Sites
11. Comparison Between Inferred Climate at Taranaki and Other New Zealand Sites 85,000- 30,000 cal yr BP
12. Comparison Between Inferred Climate Events at Eltham and NZ-INTIMATE Defined Climate Events
13. Maximum Quartz Grain Entrainment Distances for Selected Wind Velocities, Turbulence and Grain Sizes
14. Correlations for Quartz Dust, Charcoal, MAT, *C*-, *S*-, and *R*-selected Taxa for Eltham Swamp

15. Wilcoxon Signed Rank Test for Eltham Core 6
16. Percentage Recovery of Quartz and Albite after H_2SiF_6 Treatment at Various Temperatures
17. Percentage Recovery of Untreated and Pre-treated Quartz after ten washing-centrifugation-decantation cycles
18. Times to Separate Different Grain Size Fractions by Sedimentation and Centrifugation