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AQUA

PROGRAM
&
ABSTRACTS

AQUA MEETING
11th – 16th JULY 2010

North Stradbroke Island, Queensland

Contents

1. Introduction to North Stradbroke Island

North Stradbroke was formed by the accumulation of unconsolidated Cainozoic sediments of northern New South Wales origin on Triassic volcanic outcrops (Laycock 1978; Clifford and Specht 1979; Kelley and Baker 1984). The "island" was initially a series of coastal dunes situated on the fringe of the Australian continental shelf, formed during the arid, windy glacial phases of the Quaternary (Kelley and Baker 1984). The mid-Holocene marine transgression (ca. 6 kyr) flooded Moreton Bay and effectively isolated the dunes into an off-shore barrier island (Neal and Stock 1986; Evans et al. 1992; Walters 1992; Beaton 1995).

The NSI shoreline is characterised by coastal swamps (e.g. Eighteen mile Swamp) and beach-ridge systems (e.g. Flinders Beach) (Kelley and Baker 1984). However, the most significant feature are the extensive, transgressive, parabolic sand dunes that dominate the island (Laycock 1978; Harwood et al. 1999). The dominance of the southeasterly winds in transporting sand to southeast Queensland during the last glacial (and through to modern times) (Lees 2006) is reflected in the general orientation of the sand dunes to southeast-northwest (Laycock 1978; Harwood et al. 1999). The dunes are believed to have developed during a series of dune-building phases from Marine Isotope Stage (MIS) 12 (486 – 430 kyr) through to the mid-Holocene (Kelley and Baker 1984; Ward 2006). The dune sands are well-sorted and dominated by quartz (>90%) with traces of rutile, ilmenite and zircon (Thompson 1992). Spatially, the older dunes occur on the west of the island and are composed largely of podzols (Harwood et al. 1999). By comparison, the younger dunes generally have poorly developed soil profiles (Harwood et al. 1999).

There are over 450 species of plant recognised at NSI, with communities ranging from sedgeland to heaths to woodland to schlerophyll forest to rainforest (Clifford and Specht, 1979; Thompson, 1992). The dominant genera on the island are *Eucalyptus, Acacia, Banksia, Melaleuca,* and *Leptospermum* (Laycock, 1978; Clifford and Specht, 1979).

NSI has an extensive freshwater groundwater reservoir, with numerous freshwater lakes and lagoons (Laycock, 1975; Laycock, 1978). The vast majority of lakes on NSI are perched, forming as a direct result of a sand layer of relatively low permeability retarding the downward percolation of precipitation excess (Laycock, 1975; Laycock, 1978). Such a sand

layer may form as a result of heavy minerals being leached out (by weathering) of the sand to form a barrier to the downward permeating water (Laycock, 1978).

NSI is classified as 'sub-tropical' (Colls and Whitaker, 1990), but is situated close to the border of the temperate climate zone (Bureau of Meteorology, 2010). At the present time NSI has a summer rainfall regime, and the dominant wind direction is westerly. Average annual rainfall over the island is approximately 1600 mm (Clifford and Specht, 1979; Thompson, 1992).

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2. Conference program

SUNDAY JULY 11	
5:00PM	**Ice breaker:** BBQ at Moreton Bay Research Station (MBRS)
MONDAY JULY 12	
9:00AM	Meeting open/welcome (Patrick Moss)
9:40AM	Session 1: Tropical & subtropical regions (chair: Patrick Moss)
10:20AM	*Morning tea/coffee*
10:40AM	Session 2: Tropical & subtropical regions (Patrick Moss)
12:20 PM	*Lunch*
1:20PM	Session 3: Temperate Australia (chair: Lydia MacKenzie)
3:20PM	*Afternoon tea/coffee*
3:40PM	**AQUA AGM**
6:30PM	**AQUA trivia night**
TUESDAY JULY 13	
9:00AM	Session 4: Temperate Australia (chair: Lydia MacKenzie)
10:40AM	*Morning tea/coffee*
11:00AM	Session 5: Temperate Australia (chair: David Alexander)
1:00PM	*Lunch*
2:00PM	**NZ/OZ-INTIMATE MEETING**
WEDNESDAY JULY 14	
9:00AM	**Field trip** around North Stradbroke Island. 9am departure from MBRS.
THURSDAY JULY 15	
9:20AM	Session 6: Semi/arid environments (chair: Lynda Petherick)
10:40AM	*Morning tea/coffee*
11:00AM	Session 7: Semi/arid environments (chair: Lynda Petherick)
12:00PM	*Lunch*
1:00PM	Session 8: NZ (chair: Lincoln Steinberger)
2:40PM	*Afternoon tea/coffee*
3:00PM	Session 9: NZ (chair: Lincoln Steinberger)
6:30PM	**Conference dinner** at the Straddy Pub, Point Lookout
FRIDAY JULY 16	
9:00AM	Session 10: South Pacific, southern Africa & Asia (chair: Anita Staniland)
10:40AM	*Morning tea/coffee*
11:00 AM	Session 11: Poster session
12:00PM	*Lunch*
	Meeting close

MONDAY JULY 12

Session 1: Tropical & subtropical regions (chair: Patrick Moss)		
9:00	**Meeting open/welcome:** Late Quaternary Environments of North Stradbroke Island, South East Queensland	Patrick Moss
9:40	**#4.1** Radiocarbon, OSL and sedimentary analyses at Gledswood Shelter 1, a late Pleistocene aged rock shelter from inland north Queensland.	Lynley Wallis
10:00	**#4.2** Holocene sea levels of the Great Barrier Reef: new evidence from Magnetic Island and surrounds	Stephen Lewis
10:20	*Morning tea*	
Session 2: Tropical & subtropical regions (Patrick Moss)		
10:40	**#4.3** Mid- to late-Holocene sea-level change in the northern Whitsundays Queensland	Shelley Wright
11:00	**#4.4** Diatom Community of Lake Wivenhoe, Queensland, Australia	Deb Gale
11:20	**#4.5** Groundwater input and geomorphology generate stability over millennia in the ecosystem of a coastal-dune lake	Jon Marshall
11:40	**#4.6** Multi-proxy, high resolution record of the LGM in eastern Australia	Lynda Petherick
12:00	**#4.7** To see the world in a grain of sand: biological and earth history as revealed by Australian subtropical sand islands	Tim Page
12:20	*Lunch*	
Session 3: Temperate Australia (chair: Lydia MacKenzie)		
1:20	**#3.1** 8,000 years of El Niño: Towards data-model integration	Stephen Phipps (Keynote)
2:00	**#4.8** Evidence of solar and tropical ocean forcing of hydroclimate variability in south-eastern Australia for the past 6500 years.	Hamish McGowan
2:20	**#4.9** Palaeo-climate records of south eastern Australia: -climate variability over the past 2000 years.	Rhaelene Freeman
2:40	**#4.10** Multi-decadal wave climate change and shoreline response in south-eastern Australia over the past millennium.	Ian Goodwin
3:00	**#4.11** The prehistoric and historic fire regimes of Kosciusko National Park: fine resolution macroscopic charcoal in the sediments of Blue Lake.	Laura Boness
3:20	*Afternoon tea/coffee*	
3:40PM	**AQUA AGM**	

TUESDAY JULY 13

Session 4: Temperate Australia (chair: Lydia MacKenzie)

9:00	**#3.2** The Barwon Estuary – see change?	Jessica Reeves (Keynote)
9:40	**#4.12** Determining Holocene sea-level changes on an exposed coastline: a case study of the Coffs Harbour area mid-north NSW	Glenn Smedley
10:00	**#4.13** A fluctuating southern hemisphere Holocene relative sea-level model: new sites, possible errors, sources and mechanisms?	Robert Baker
10:20	**#4.14** Using the past to plan for future sea-level rise from global warming: a case study of the Hexham Swamp, Hunter River, NSW	Sarah McGowan
10:40	*Morning tea*	
Session 5: Temperate Australia (chair: David Alexander)		
11:00	**#3.3** Waterhole sedimentation in the dryland Moonie River and loss of drought refugia for fish.	John Tibby (Keynote)
11:40	**#4.15** A fine-resolution reconstruction of climatic variability in western Victoria over the last 1500 years.	Cameron Barr
12:00	**#4.16** Boulder Assemblages on the New South Wales North Coast, Australia: Sedimentology, Age and Origin	Kirsty Wilkes
12:20	**#4.17** Environmental Change in Freycinet National Park since the Last Glacial Maximum	Lydia MacKenzie
12:40	**#4.18** What should we take from the past into the future?	Stuart Pearson
1:00	*Lunch*	
2:00	**NZ/OZ-INTIMATE MEETING**	

THURSDAY JULY 15

Session 6: Semi/arid environments (chair: Lynda Petherick)		
9:20	**#3.4** Palaeoenvironmental change over the last glacial cycle at Lake Gregory (Mulan), Great Sandy Desert, northwestern Australia.	Kat Fitzsimmons (Keynote)
10:00	**#4.19** A New Cosmogenic Isotope, Manganese-53, For	Toshiyuki Fujioka

	Exposure Dating: Preliminary Results From Iron-rich Rocks In Arid-semiarid Australia	
10:20	**#4.20** Palaeoenvironments of the Paroo/Warrego Region, Australia: a Multi-proxy, Multi-site study.	Lucy Gayler
10:40	*Morning tea/coffee*	
Session 7: Semi/arid environments (chair: Lynda Petherick)		
11:00	**#4.21** Environmental change at Lake Mungo, Willandra Lakes World Heritage Area	Tim Barrows/Kat Fitzsimmons
11:20	**#4.22** Attempts at dating some rock art sites near Cue, central inland Western Australia	Esmée Webb
11:40	**#4.23** A reconsideration of the age and significance of Mulka's Cave, a profusely decorated Aboriginal rock art site near Hyden, Southwestern Australia	Esmée Webb
12:00	*Lunch*	
Session 8: NZ (chair: Lincoln Steinberger)		
1:00	**#3.5** The Kawakawa Tephra time-slice - regional paleoclimate reconstruction for Event 8w of the New Zealand Climate Event Stratigraphy.	Peter Almond (keynote)
1:40	**#4.24** Ecological and limnological history of the Ashburton Lakes region, South Island, New Zealand	Anita Staniland
2:00	**#4.25** The last glacial maximum and deglaciation in southern New Zealand: new pollen-climate reconstructions.	Louise Callard
2:20	**#4.26** A tale of two proxies: A high resolution record of environmental change from New Zealand spanning the Last Glacial/Interglacial Transition (LGIT).	Craig Woodward
2:40	*Afternoon tea/coffee*	
Session 9: NZ (chair: Lincoln Steinberger)		
3:00	**#4.27** The timing of Late Pleistocene glaciation of New Zealand	Tim Barrows
3:20	**#4.28** A steady-state mass-balance model for the Franz Josef glacier, New Zealand: testing and application	David Alexander
3:40	**#4.29** Glacial Sedimentology of the Rangitata Valley, Canterbury, New Zealand	Jamie Shulmeister
4:00	**#4.30** Reconstructions of local-scale Holocene sea-level fluctuations in the New Zealand archipelago	Craig Sloss

FRIDAY JULY 16

Session 10: South Pacific, southern Africa & Asia (chair: Anita Staniland)		
9:00	**#4.31** Island of fire: volcanoes as agents of death, destruction and migration on Flores Island, Indonesia.	Kira Westaway
9:20	**#4.32** Nauru: the palaeoecology of a remote and transformed Pacific island ecosystem	Mat Prebble
9:40	**#4.33** Late Quaternary environments in the Lesotho highlands, southern Africa	Stephanie Mills
10:00	**#4.34** Study on the relation between loess palaeoclimate	Xiuming Liu

	trend and uplift of Tibetan Plateau	
10:20	**#4.35** Millet agriculture in north-central China: evidence from human remains	Pia Atahan
10:40	*Morning tea/coffee*	
Session 11: Poster session		
11:00	**#5.1** Linking archaeology and palaeoenvironments in SE Bulgaria	Simon Connor
	#5.2 Pollen distribution across a wetland and a pollen transport model	Peter Shimeld
	#5.3 Bioclimatic modelling with palaeoecological attitude: A koala (*Phascolarctos cinereus*) case study.	Christine Adams-Hosking
	#5.4 The Darwin / Hatherton Glacial Sytem. A proxy for Antarctic Ice Sheet Recession after the Last Glacial Maximum	Kurt Joy
	#5.5 Late Quaternary climate change in South East Queensland	Tamara Daus
	#5.6 Pollen records from tropical North Queensland.	Lincoln Steinberger
	#5.7 A sequence stratigraphy framework for the Castlepoint Formation at Castlepoint, New Zealand	Anna Habeck
	#5.8 Water quality changes in a Fraser Island perched lake: Lake McKenzie. Preliminary data investigating the influences of recreational activities on lake water quality.	Sarah Hembrow
	#5.9 Environmental Changes indicated by grain-size and trace-metal analysis over the past 700 years at Annaburroo Lagoon, NT, Australia	Xinrong, Zhang
12:00	*Lunch*	
	Meeting close	

3. Abstracts: KEY NOTE SPEAKERS

#3.1 8,000 years of El Niño: Towards data-model integration

Steven J. Phipps*[1], Helen V. McGregor[2]

[1]Climate Change Research Centre, University of New South Wales, [2]School of Earth and Environmental Sciences, University of Wollongong.

Past changes in El Niño-Southern Oscillation (ENSO) provide an opportunity to learn more about ENSO dynamics. To study the changes in ENSO over the past 8,000 years, a lowresolution
climate system model is used to simulate the evolution of the global climate over

this period. The simulations are then compared with the coral record from two sites in the tropical Pacific Ocean.
The model is able to reproduce the trends in the coral data. The simulations show a gradual strengthening of ENSO, with an increase in both the frequency and magnitude of El Niño events. This strongly suggests that the changes in ENSO variability over the past 8,000 years represent a response to external forcing – and particularly orbital forcing – over this period, rather than merely representing low-frequency internal stochastic variability.
Examination of the model simulations reveals that the changes in ENSO variability are driven by decreasing summer insolation over the Asian landmass. This results in a weakening of the easterly trade winds in the western Pacific, creating conditions more favourable for the development of El Niño events. As the trade winds weaken, there is also a change in the nature of the simulated ENSO, with an eastward shift in the location of greatest sea surface temperature variability.
The coral data shows strong variability on decadal timescales, accompanied by rapid switches between ENSO modes. This model simulations exhibit similar behaviour, although the model appears to exaggerate the magnitude of the decadal-scale variability. The combination of strong low-frequency variability and rapid transitions between modes has considerable implications for simulations of future changes in ENSO behaviour.

#3.2 The Barwon Estuary – see change?

Jessica Reeves

RMIT University.

This project enables the effects of climate change, shifts in land-use practices and increased urbanisation, on the Barwon Estuary to be quantified and assessed. Sediment cores from Lake Connewarre and Reedy Lake have been analysed to determine faunal variability (ostracod, foraminifer), salinity and vegetation changes to infer the environmental conditions over the past ~500 years.
Lake Connewarre and Reedy Lake are two natural wetlands, separated during the Last Interglacial by a laval flow from Mount Duneed. During the Holocene marine transgression, both lakes were inundated with seawater and formed an open embayment. Since the mid-Holocene highstand, sea-levels have receded ~1.5 m, leaving the Lower Barwon an estuarine system. Before regulation, the tidal prism extended to Geelong. Two breakwaters were constructed in the 19th Century, near Belmont and immediately downstream of Reedy Lake. Hence Reedy Lake is now a freshwater system, whilst Lake Connewarre is truly estuarine, ranging from 0-40 ppm salinity in most years.
Lake Connewarre is now very shallow; 0.5-0.9 m through most parts. Flows from the Barwon into the lake have been steadily decreasing through the last decade due to decreased rainfall and increased abstraction. With resultant increased salinity, seagrasses are now migrating further into the lake and persisting for longer seasons. There is a strong call from local land holders to dredge the lake to increase flushing from marine waters. In addition, housing development within the region is set to increase 30% in the next 10-25 years.

Barwon Heads is an evocative place for locals and tourists alike. The future management of the estuary requires a clear understanding of the natural processes of the system and inherent variability. This combined study of both the modern fauna and environmental variables and

past conditions, allows a rigorous reconstruction of the pre-history of the Barwon Estuary to be established.

 # 3.3 Waterhole sedimentation in the dryland Moonie River and the loss of drought refugia for aquatic biota

John Tibby*[1], Jon Marshall[2], Jaye Lobegeiger[2], Theresa Myburgh[3], Quan Hua[4]

[1]Geographical and Environmental Studies (GEST), University of Adelaide, [2]Department of Environment and Natural Resource Management (DERM), Queensland, [3]GEST, [4]Australian Nuclear Science and Technology Organisation

Waterholes are important refugia in dryland rivers and are essential for maintaining viable populations of fish and other biota during and after drought. In-channel waterholes play this role in the Moonie River (northern MDB in southern Queensland) where periods without flow are common and can last up to 700 days. We surveyed the bathymetry of 15 waterholes and measured water loss rates to model waterhole persistence in the absence of flow and found maximum depth to be an accurate predictor of persistence.
The Moonie catchment has been extensively cleared for agriculture and there is prevalent gully erosion. Hence, we were concerned waterholes were filling with sediment. Our initial research, based on a single sediment core from the deepest waterhole, showed that over 2.3 m of fine sediment has been deposited within the past 50 years. This estimate was derived using "bomb pulse" radiocarbon dating. We have now expanded our work by extracting and dating more cores from this and two other waterholes. We are currently estimating sedimentation rates and future work will attempt to trace the sediment.
The implications of sedimentation for refuge function are serious as our persistence model estimates a 2.3 m shallowing of waterholes results in a more than one year less of water availability during drought. During the longest droughts, this would dry some otherwise permanent waterholes. This problem is of even greater concern given climate change projections of more extreme droughts. Our on-going work is considering the impacts this threat may have on the viability of fish populations in the system.

#3.4 Palaeoenvironmental change over the last glacial cycle at Lake Gregory (Mulan), Great Sandy Desert, northwestern Australia.

Kat Fitzsimmons*[1], James M. Bowler[2], John W. Magee[3], Gifford T. Miller[4], Nigel Spooner[5,6]

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[2]School of Earth Sciences, University of Melbourne, Parkville, VIC 3010 Australia
[3]Research School of Earth Sciences, The Australian National University, Canberra, ACT 0200 Australia
[4]INSTAAR and Department of Geological Sciences, University of Colorado, Boulder, Colorado 80309-0450 USA
[5]Defence Science and Technology Organisation, PO Box 1500, Edinburgh, S.A. 5111, Australia
[6]School of Chemistry and Physics, The University of Adelaide, SA 5005, Australia

The Australian summer monsoon accounts for the majority of precipitation over the largely arid to semi-arid region of northern Australia. The dependence of this region on a strongly seasonal rainfall regime influences landscape systems such as the monsoonal catchment of the Gregory Lakes in northwestern Australia. The large-scale lake system, located on the margin of the Great Sandy Desert and forming the drainage terminus of monsoon-watered Sturt Creek, forms a valuable terrestrial archive for Quaternary hydrologic and environmental change in an area where such records are scarce. The geomorphic relationships between arid landforms such as linear dunes and shoreline ridges – the latter representing permanent lake stands - enable the reconstruction of past climate variability and the relative strength and effectiveness of the summer monsoon. We present results of an investigation into the geomorphic relationships between landforms which respond to changing climatic regimes in the Lake Gregory basin. We also provide a broad chronologic framework for landscape change in response to climatic variability based on optically stimulated luminescence (OSL) dating, and discuss the implications of resulting age-depth relationships down the profile of a linear dune for the formation of these features. This study enables us to place the palaeoenvironmental evolution of northern arid Australia in the context of Quaternary change in the desert regions further south, which are less susceptible to the influence of the tropical monsoon.

#3.5 The Kawakawa Tephra time-slice - regional paleoclimate reconstruction for Event 8w of the New Zealand Climate Event Stratigraphy.

Peter Almond*
Lincoln University

Over recent years, a relatively complex structure for the last major cooling in the Last Glaciation in the Southern Hemisphere has emerged. Evidence from New Zealand (NZ) and Australia suggests cooling and ice advance began ca 30 ka with at least two phases of warming before the deglacial at about 18 ka. These climate fluctuations are now recognised within the New Zealand Climate Event Stratigraphy developed as part of the AUSTRALASIAN INTIMATE project. The initial cooling, starting at ca 30 ka (Event 9c), was terminated by the warming event 8w, the onset of which coincided with the widespread tephra marker bed, Kawakawa/Oruanui Tephra (KOT – 22,590 ^{14}C y B.P.). This paper presents a preliminary regional paleoclimate analysis based on published and other data for a time-slice based around KOT, updating an earlier analysis (Pillans *et al.* 1993) which can now be improved with more recent, detailed proxy records and a better estimate of the tephra's calibrated age. The time-slice analysis is a contribution to the present AUS-INTIMATE project which aims to derive dominant climate modes based on climate anomalies in six distinct climate districts of NZ for this and four other time-slices in the last 30 ky.

The KOT time-slice (Event 8w) was a time of warmer and perhaps wetter climate on the West Coast of the North and South Islands and in Northern New Zealand, relative to earlier and later climate events (Events 9c and 7c). The occurrence of KOT in solifluction deposits, loess and aggradation gravels in most areas of NZ, however, points to a significantly cooler climate than present in the axial mountain regions. There is evidence for both wetter and drier conditions for eastern NZ districts. The likelihood of Zonal, Trough and Blocking climate modes in the KOT time-slice are discussed.

Pillans B, McGlone M, Palmer A, Mildenhall D, Alloway B, Berger G (1993) The Last Glacial Maximum in central and southern North Island, New Zealand: a paleoenvironmental reconstruction using the Kawakawa Tephra Formation as a chronostratigraphic marker. *Paleogeography, paleoclimatology, Paleoecology* **101**, 293-304.

4. Abstracts: ORAL PRESENTATIONS

Introduction: Late Quaternary Environments of North Stradbroke Island, South East Queensland

Patrick Moss*[1], John Tibby[2], Hamish McGowan [1], Lynda Petherick [1] and Cameron Barr[2]

[1]Climate Research Group, School of Geography, Planning & Environmental Management, The University of Queensland, Brisbane, QLD 4072
[2] School of Geography and Environmental Studies, University of Adelaide, South Australia

Palynological records have been constructed from three sites, Blue Lake, Native Companion Lagoon and Tortoise Lagoon, from North Stradbroke Island in South East Queensland covering up to the last 40,000 years. These records, and associated sedimentological data, provide a detailed picture of environmental change for North Stradbroke Island itself, as well as allowing an assessment of the relative impacts of climate and people on the eastern

Australian subtropics for the late Quaternary period. In particular, the potential long-term impacts of the El Niño Southern Oscillation (ENSO) phenomenon on the region's environment; the response of the region's ecosystems to abrupt climate change that characterizes the Late Quaternary period; evidence of initial human impacts, particularly their use of fire, on the eastern subtropical landscape; and any signal of human intensification (e.g. increased burning) during the late Holocene period, which has been suggested from archaeological records from the region, as well as other parts of Australia.

 # 4.1 Radiocarbon, OSL and sedimentary analyses at Gledswood Shelter 1, a late Pleistocene aged rockshelter site from inland northwest Queensland

Lynley Wallis*[1], Kathryn Fitzsimmons[2], Ben Keys[3] and Ian Moffat[4]

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[2]Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology Deutscher Platz 6, D-04103 Leipzig, Germany
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Despite a recognition that the tropical savannah regions of northern Australia have a very long and important role in the history of Aboriginal occupation (eg Horton 1981; O'Connor and Veth 2000; Veth 1989, 1993), only limited archaeological research has been carried out in these areas. A review of all dated archaeological sites in Queensland shows that less than 4% (n=10) are situated in the northern savannah (Ulm et al. 2001). Initial excavations during the 1980s at the sites of Cuckadoo Shelter (Selwyn Ranges) and Mickey Springs 34 (Porcupine Gorge) established that occupation of the broad northwest Queensland region extends to at least ca 15,000 bp (Davidson et al. 1991; Morwood 1990, 1992). However, beyond the Colless Creek and Gregory River 8 sites within the Riversleigh refugia (see Hiscock 1988; Slack 2007; Slack et al. 2004), sites pre-dating the LGM have not yet been located. The patterning of sites raised the question as to whether the wider northwest Queensland savannah corridor was indeed occupied in the pre-LGM period. In this paper we present the results of radiocarbon and OSL determinations, and sedimentary analyses from the recently excavated Gledswood Shelter 1 site. This site is the first rockshelter outside a well-watered local refuge in the savannah corridor of northwest Queensland to produce evidence for human occupation in the pre-LGM period, thus fitting colonisation models presented by Hiscock and Wallis (2005) and Veth (1989, 1993). The presence of stone artefacts, ochre and charcoal at Gledswood Shelter 1 are testimony to its repeated use throughout at least the last 28,400 years, though it is not yet clear whether it was continuously occupied or abandoned through the height of the LGM before being reoccupied in the Holocene.

 # 4.2 Holocene sea levels of the Great Barrier Reef: new evidence from Magnetic Island and surrounds

Stephen Lewis*[1], Raphael Wust[2], John Collins[3], Shelley Wright[4] and Geraldine Jacobsen[5]

[1]Australian Centre for Tropical Freshwater Research, James Cook University, Townsville
[2]School of Earth and Environmental Sciences, James Cook University
[3]School of Marine and Tropical Biology, James Cook University
[4]School of Behavioural, Cognitive and Social Sciences, University of New England,
[5]Australian Nuclear Science and Technology Organisation.

Accurately measuring sea-level change along the Great Barrier Reef is important to better predict and manage future changes. Despite abundant sea level data from along the eastern Australian coastline, the precise timing, magnitude and mechanisms for sea-level change are disputed. Here we present a series of recently published and unpublished sea level data from Magnetic Island and immediate surrounds to examine and critically review the reliability of the different sea-level indicators used in reconstructions. These indicators include coral microatolls, oyster beds, barnacles and foraminifera-based transfer function. We show that these sea-level indicators can produce markedly different results for assessing sea-level change over the last 7000 years. We assess these differences and suggest potential changes to uncertainties in sea-level reconstructions to reduce the apparent disparities within these sea level datasets. We show that the early Holocene sea-level rise had reached its present position by 7000 years BP and reached at least 1.0 m higher during the mid-late Holocene. We also review the evidence for potential oscillations over this period and show that sea-level reached its present position by at least 800 years BP.

 # 4.3 Mid- to late-Holocene sea-level change in the northern Whitsundays Queensland

Shelley Wright* and Robert Baker

Geography and Planning, BCSS, University of New England, Armidale, NSW.

Relic fixed intertidal biological indicators (FIBIs), in the form of calcareous tubeworms, barnacles and oysters have previously been used to identify former sea-levels for the south west and south east Australian coast and North Queensland. In this study, sub fossil assemblages of oyster and barnacle species preserved in growth position on Hook Island and Cape Gloucester, in the northern Whitsundays, provide evidence of higher than present mid to late Holocene sea-level.

While evidence from relic oysters, fossil microatolls and raised beachrock has previously suggested higher than present sea-levels for the nearby Edgecumbe Bay and Bowen region, evidence of elevation from the Whitsunday Islands is sparse. Here we present the first Holocene sea-level time-elevation data recorded for Hook Island.

Models of predicted hydro-isostatic rebound, along with previous radiocarbon dates from emerged fossil microatolls in North Queensland, have been used to propose a higher relative sea-level in the mid Holocene with a linear fall to present. However, time-elevation data obtained from the northern Whitsunday region appears to support an oscillating model of higher than present mid to late Holocene sea-level previously identified for the areas to the north of this region and from south-east and south-west Australia.

As an understanding of present intertidal zonation and the environmental requirements of sessile marker species is essential to FIBI methodology we are undertaking extensive surveys of the current rocky shore intertidal zonation at each location. This knowledge enables a more

precise interpretation of the biological associations represented within the sub fossil assemblages and therefore a better understanding of palaeo environmental conditions and change.

 # 4.3 Diatom Community of Lake Wivenhoe, Queensland, Australia

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Lake Wivenhoe is located in south east Queensland, and is the primary water supply to 2.7 million people in Brisbane city and surrounding areas. The storage has a capacity of 1.16 million megalitres and covers over 10,000 hectares at full supply. The region is one of the fastest growing urban areas in Australia and has experienced extreme drought conditions in recent times. To inform management of reservoir health traditional monthly water quality monitoring has been undertaken for the past 13 years, however, in times of low storage volumes there is little flexibility in management of water supply as offtake depth and volume are limited. Therefore, there is a need to develop robust indicators of reservoir health to better inform management of these systems, especially in times of drought as monthly monitoring may not detect short term events relevant to management. Diatoms are powerful indicators of environmental change as individual species of diatoms have narrow tolerances to environmental conditions and these may be recorded over time through deposition within sediments. In this study, sediment samples from 15 sites were collected throughout the storage to establish the spatial variability of the diatom community throughout the storage. Samples were cleaned of organic and inorganic carbon and the diatom community quantified using both light and scanning electron microscopy. Over 50 species of diatoms were identified, with dominate species belonging to the typically planktonic genera *Aulacoseira* and *Cyclotella*. Other diatoms present in high abundances are species from the benthic genera *Achnanthes* and *Nitzschia*. Known environmental preferences for each species were compared to environmental parameters measured during routine environmental monitoring that is undertaken monthly. The spatial variability of the diatom community within Lake Wivenhoe is demonstrated as well as the difference in species observed between light microscopy and scanning electron microscopy. Our findings suggest that planktonic diatoms dominate the storage however in shallow areas with higher water clarity a significant benthic community is established. The diatom community identified in this study can be used to assess past changes in water quality with the use of sediment cores and future changes by incorporating monitoring of the diatom community into the routine water quality monitoring.

 # 4.5 Groundwater input and geomorphology generate stability over millennia in the ecosystem of a coastal-dune lake

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Under the twin influences of drought and rapid population growth, new sources of water are needed to supply users in south east Queensland. Groundwater within the sand-mass aquifer of North Stradbroke Island is one such potential source. However, this aquifer also supplies water to significant groundwater-dependent ecosystems including Blue Lake; a clear, acid, oligotrophic dune-lake which supports important flora and fauna.

We investigated the risk posed by groundwater extraction to the ecology of Blue Lake by identifying natural variability in lake attributes that support its ecology, and then considered how groundwater extraction may influence this variability and thus lake ecology.

Our results indicate Blue Lake is highly stable in terms of bathymetry, water quality and ecology. Data from within the last 30 years indicate water quality and geomorphological stability and analysis of the lake bed sediments revealed ca. 7,500 years with no significant diatom community variability, indicating that the environment of the lake has long been stable.

We suggest this stability is due to a unique combination of the geomorphology and hydrology of the lake, island geology and connection to the regional water table.

As long as groundwater input to the lake exceeds evaporative and seepage loss, we believe lake depth will remain constant because of the regulating influence of a natural vegetated outflow weir. Thus, habitat availability should not change as a consequence of groundwater extraction. However, any reduction in the rate of groundwater input will reduce water retention time, potentially altering the bio-geo-chemical processes that produce clear, acidic and un-stratified water characteristic of the ecosystem for millennia. This may have profound impacts on lake ecology and therefore provides a basis for managing extraction from the aquifer.

 # 4.6 Multi-proxy, high resolution record of the Last Glacial Maximum in eastern Australia

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A continuous, high resolution (average ca. 22 year) record encompassing the Last Glacial Maximum (LGM) has been developed using multiple proxies (aeolian sediment flux, grain size, pollen and charcoal) in lake sediment from Tortoise Lagoon (TOR), North Stradbroke Island, Queensland, Australia. The presence of *Asteraceae tubilifloreae* and spineless *Asteraceae* (common indicators of glacial conditions in Australia) at TOR indicates significantly cooler temperatures (mean annual temperature up to 6^{o}C lower than today).

Similarities between the vegetation at TOR during the LGM and that at temperate sites e.g. Caledonia Fen, Victoria (Kershaw et al. 2007), Redhead Lagoon, New South Wales (Williams et al. 2006) and Barrington Tops, New South Wales (Sweller and Martin 2001) suggests that this record reflects regional conditions across southeastern Australia. The TOR record also correlates well with that from nearby Native Companion Lagoon which suggests that the LGM was actually an extended period of ca. 8 – 10 kyr, characterised by 2 periods of

increased aridity (ca. 30 – 26.5 kyr and 21 – 19.5 kyr) (Petherick et al. 2008). A growing number of records from across the Southern Hemisphere e.g. New Zealand (Suggate and Almond 2003; Alloway et al. 2007; Newnham et al. 2007), Chile (Denton et al. 1999), Antarctica (Röthlisberger et al. 2002; EPICA 2006) and Australia (Smith 2009) also show evidence that the LGM encompassed a longer period of time than traditionally accepted, and was not uniformly cool and dry.

 # 4.7 To see the world in a grain of sand: biological and earth history as revealed by Australian subtropical sand islands

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The large sand islands of southeastern Queensland have attracted the interest of geologists, hydrologists and biologists because of the sequential formation of ancient and recent dunes and the presence of abundant and varied freshwater ecosystems. These range from small coastal creeks, water-table "window" lakes and isolated "perched" lakes set well above the groundwater table. These islands have only been separated from the mainland for a relatively short 6000 years or so and thus theoretically should display little differentiation from mainland populations.

We sequenced mitochondrial DNA from 14 freshwater species (9 fishes, 3 shrimps, 2 crayfish) to investigate the nested island-within-island nature of freshwater-restricted taxa on these islands. This can reveal potentially interesting biogeographic patterns between water bodies on islands, between islands themselves and between the islands and the mainland, such as any genetic influences of Quaternary sea-level oscillations. When phylogeographic patterns are related to geomorphological ones, inferences can be made about the methods, timing and direction of faunal colonisation and geologically induced vicariance.

We discovered a series of lineages, ranging from cryptic species, whose divergence dates fall in the Miocene/Pliocene and so considerably predate the islands themselves, to shallow differences within and between islands and the mainland that probably date to the Pleistocene. This implies that the ice age sea-level changes may have structured these populations, although there is little observable influence of the last glacial maximum (~18 thousand years ago). Most estimates for the age of the landscape (dunes, lakes) also fall within the Pleistocene and so the effect of sea-level change may be seen both in biology and geology.

 # 4.8 Evidence of solar and tropical ocean forcing of hydroclimate variability in south-eastern Australia for the past 6500 years.

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Evidence of solar and tropical ocean forcing of climate cycles has been found in numerous proxy palaeoclimate records. Numerical modelling studies show physical mechanisms by

which direct and indirect solar forcing may affect temperature and precipitation, while there is mounting evidence of solar forcing of tropical ocean-atmosphere decadal oscillations such as the Pacific Decadal Oscillation (PDO). We present a 6500 yr record of dust deposition from the Snowy Mountains, Australia which we have shown to be a proxy for regional hydroclimate variability. Spectral analysis of the record provides evidence of statistically significant cycles in dust deposition of 35 to 43 yrs, 62 to 73 yrs, 161 yrs (> 95% C.I.) and 2200 yrs (>90% C.I.), which correlate with phases of the PDO and variability in solar irradiance associated with the Gleissberg, Suess and Hallstattzeit solar cycles. Analysis of the spectral content of the non-stationary dust deposition time series using Morlet wavelet analyses identified the ≈ 35 yr cycle was most pronounced during the past 300 years with a trend toward a slightly longer period of ≈ 43 yrs around 250 yrs BP. This cycle also appeared to be dominant around 550 and 850 yrs BP, while the ≈ 63 to ≈ 73 yr cycle was dominant around 550, 1000 and 1500 yrs BP, and then again between 4000 to 4500 yrs BP. The longer ≈ 160 yr cycle was most pronounced during the past 1000 yrs (centered on 500 yrs BP) encompassing the Maunder, Spörer and Wolf solar minima. The results confirm that solar and tropical ocean forcing of climate at multi-decadal to millennial time scales affects the hydroclimate of southeast Australia and must be considered in predictions of future climate variability.

 # 4.9 Palaeo-climate records of south eastern Australia: - climate variability over the past 2000 years.

Rhaelene Freeman* and Ian Goodwin

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The practice of cataloging multiple geohistorical proxy records for the purpose of synthesizing variability in past climate has become common place in contemporary climate change science. The effectiveness of these assessments in establishing a clear regional synopsis is entirely reliant on the temporal and spatial, range and resolution of the contributing datasets.

The temporal and spatial distribution of the Holocene palaeo-climate record over the Australian continent is not comprehensive. There are very few high-resolution terrestrial datasets, with the majority of records resolved at centennial to millennial timescales. The record is dominated by palynological and sedimentary evidence concentrated in the upland and coastal regions of south eastern Australia, but also supports pockets of research in the tropical north, the central deserts, and south west Western Australia. Nevertheless, much of the continent remains uninvestigated, many valuable records remain poorly resolved and the palaeo-climate record in the late Holocene is particularly porous.

This study forms the initial stages of larger project that aims to develop a comprehensive understanding of decadal variability in trans-Tasman climatology over the past 2000 years with particular focus on variability in large scale synoptic patterns, and magnitude and frequency of relationships of extreme east coast low events. The purpose of this preliminary work is threefold: 1) Review the existing Holocene palaeo-climate record with particular regard to south eastern Australian environments over the past 2000 years. 2) Use contemporary rainfall and temperature data to highlight zones sensitive to variability in the major climate modes. 3) Develop a target list of sites sensitive to climate variability with the potential to fill critical temporal and spatial gaps in the south eastern Australian record and inform on trans-Tasman climatology over the late Holocene.

 # 4.10 Multi-decadal wave climate change and shoreline response in south-eastern Australia over the past millennium.

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Strandplain and shoreline alignment evolution and sediment budgets will be presented for northern New South Wales (NSW) (Goodwin et al., 2006) and south-east Queensland (Qld), Australia from detailed reconstructions of late Holocene strandplains. These are constrained by sand deposition ages using optically stimulated luminescence (OSL) methods. Also presented are new data sets on wave climate for the past century, and a 1200 year long reconstruction of multi-decadal mean wave direction for the NSW shelf.

Variability in longshore sediment transport and phases of regional coastline progradation, recession and realignment in response to wave climate change are identified for the past 1200 years. The research on regional coastline alignment rotation describes a framework for understanding large-scale coastal behaviour. The emerging geo-historical record also provides the scientific basis for geo-evidence based projections since it contains the coastline response to the range of potential climatic impacts over the coming centuries.

#4.11 The prehistoric and historic fire regimes of Kosciusko National Park: fine resolution macroscopic charcoal in the sediments of Blue Lake.

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The controversy regarding grazing activity in the Snowy Mountains and the 2002/03 bushfires, which burnt extensive areas of Kosciusko National Park, the Monaro region and the Australian Capital Territory, raised a number of concerns over the fire management practices in the alpine ecosystems of mainland Australia. It has been suggested that a better understanding of pre-historic fire activity and how this altered during the historic period would build capability with respect to management strategies. This study presents a reconstruction of the fire regime in the alpine area surrounding Blue Lake (Kosciusko National Park) in the period since the mid-Holocene and compares this to previous records of climate change and to the archaeological and historic records.

The increasing variability of Australian climate in the last 5500 years is reflected in the fire record for Blue Lake, with a large number of the peaks in fire activity occurring around times of transition or rapid change. The changes do not appear to be the result of Aboriginal activity, as the low fire frequency and prolonged periods of absence of fire activity does not correspond to the generalised views of fire stick farming. This, together with the lack of

archaeological finds above the winter snowline, supports the theory that the Aboriginal tribes were only seasonal visitors to the alpine regions and did not manage the area through fire.

The historic period is marked by a significant increase in fire frequency, with an average period of 14 years between fires, reflecting the land management practice of encouraging a 'green pick' through low intensity burning. The fire activity decreased after the area came under National Parks control in 1967 and rotational burning was introduced to the region, with any recent fire events corresponding to El Nino events. These changes in frequency suggest that both humans and climate influenced the historic fire regime.

 # 4.12 Determining Holocene sea-level changes on an exposed coastline: a case study of the Coffs Harbour area mid-north NSW

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The mid to late Holocene sea-level history of the Australian region provokes intense ongoing debate. Has the sea-level been static to smoothly falling or was it characterised by rapid fluctuations, possibly containing a eustatic signal? A range of evidence types has been utilised by researchers, on all sides of this debate, to establish, develop and provide evidence for their positions.

In this study, the relic crusts of the tubeworm *Galeolaria caespitosa,* a fixed intertidal biological indicator (FIBI), have been sought out, surveyed and radiocarbon dated. *G. caespitosa* has a limited growth range in the intertidal zone and when the vertical difference between the relic crusts and current *G. caespitosa* is measured a sea-level variation with a small vertical error can be established. The sites described in this study are from the Coffs Harbour area of the NSW mid north coast.

Three sites were identified; the first on Mutton Bird Island, the second on Coffs Harbour's southern headland and a third on Sawtell's northern headland. Relic crusts were surveyed and samples removed and dated from two levels on Mutton Bird Island and single levels at the other two sites.

Six samples in total were dated with the higher site at Mutton Bird Island yielding two samples ~2.0m above current *G. caespitosa* with ages of 3875 Cal. yr BP and 3626 Cal. yr BP (Midpoints of age range).A sample from the southern headland of Coffs Harbour was elevated 1.60m above current *G. caespitosa* and yielded an age of 3509 Cal. yr BP.

The lower site on Mutton Bird Island contained two discrete relic crusts of *G. caespitosa,* with horizontal separation of 1.0m, 1.44m above current crevice

G. caespitosa. The most northerly crust was dated at 1590 Cal. yr BP and the southerly at 1845 Cal. yr BP.

The sample from the Sawtell site was dated at 2535 Cal. yr BP and was 1.75m above the highest current living crevice *G. caespitosa*.

Some characteristics of the sea-level history in this area are suggested by the nature of these relic crusts. Barnacles, both underlying and overlying the *G. caespitosa* crusts, signify a sea-level that has been both rising and falling. The existence and perseverance of the crusts indicates that they have been stranded by a sea-level that has fallen rapidly.

The results of this study challenge the underlying tenants of the hydro-isostatic model while providing support for a fluctuating sea level model.

 # 4.13 A fluctuating southern hemisphere Holocene relative sea-level model: new sites, possible errors, sources and mechanisms?

Robert Baker* and Shelley Wright

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There is an on-going debate on the mechanisms and sources that could underpin the extensive relic mid- to late-Holocene higher shoreline evidence found around Australia, SE Asia and southern Brazil. Is the evidence regionally specific and variable from hydro-isostatic rebound or is there a relative climate-induced coincidence in the time-elevation measurements suggestive of common response mechanisms? This research reports on a number of advances looking at these alternative hypotheses. Firstly, dating and relative height measurements of relic and present fixed inter-tidal biological indicators of the same species at new sites in South Australia, Western Australia and Tasmania (*Galeolaria*) and in Queensland (*Saccostrea*) seem to support an oscillating-type model in the context of height measurement of variations in the current inter-tidal zones at these localities and tidal regimes. Secondly, a same species comparison between Tasmania, King Island and the Australian mainland suggest a rate of hydro-isostatic readjustment in Bass Strait. Similar work is being undertaken for The Great Barrier Reef. Thirdly, the rates of change in the +/-1m statistical oscillating model is broadly coincident with the timing of glacial advances and retreats of southern hemisphere glaciers during the mid-late Holocene and such events could occur as multiples of ~1400yr Bond Cycles. The exception could be an event 2600 to 2800 yrs BP, where apparently anomalous higher sea levels of ~1.5 to ~2.5m above present occurred for a short period of time (significantly above the millennial average of +1.0m above present). The possible origin could be a sudden melt of the Antarctic Ice Sheet at that time, from a warming of over 1.0^{o}C for a ~120 yr period from 2850 to 2730, rather than from any fluctuation produced from glacial melting.

 # 4.14 Using the past to plan for future sea-level rise from global warming: a case study of the Hexham Swamp, Hunter River, NSW.

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Predicted sea-level rise poses many challenges to coastal communities. At present in Australia, planning authorities are framing policy on the potential impacts of sea-level rise on areas adjoining estuaries based on IPPC projections. Such projections are based on computer estimates of a complex and only partially understood climate system. An alternative approach is to use possible evidence from past Holocene and Pleistocene shorelines and to develop proxies that give some indication of the relationship of sea-surface temperatures of the past with these higher shorelines. This is a controversial approach, since there is currently debate of whether this evidence is a result of a coincident southern hemisphere climate signal or the differential regional hydro-isostatic rebound of the coastline. However, in terms of likelihood estimates for planning, these remnants of higher shorelines provide a direction for a better observational basis to coastal zone planning, rather than the simulated IPPC projections. This approach is applied to a case study undertaken in the Hexham Swamp, Hunter Valley, NSW, where a number of heights are considered by 2100, including the 0.9m IPPC estimate (NSW Department Environment, Climate Change and Water), the IPPC plus Holocene estimate of 2.6m and the 5.0m Pleistocene interglacial scenario. These heights were mapped using the fine resolution LiDAR data for this area and an infrastructure audit conducted on the vulnerability of the built environment there to these future sea-level scenarios.

#4.15 A fine-resolution reconstruction of climatic variability in western Victoria over the last 1500 years.

Cameron Barr

High-resolution palaeoclimate records extend our knowledge of long- and short-term climatic variability beyond the limit of instrumental records. However, to date, no millennial-length, sub-decadal climate records are available from mainland Australia. In part, this is due to the absence of suitable archives of proxy data amenable to high-resolution analysis. Due to their short life span and sensitivity to water chemistry, diatoms are an ideal proxy for high-resolution studies, where suitable sites exist.

Here, we present the results of a study of two crater lakes in western Victoria. A statistically robust diatom-conductivity transfer function was developed and applied to fossil diatom assemblages from Lakes Elingamite and Surprise. The results indicate that, over the past 1500 years, both lakes responded to a common regional-scale climate signal, with Lake Surprise being the more sensitive site. Conductivity reconstructions, a proxy for moisture balance, indicate distinct periods of differing climates prior to European arrival. Both lakes record evidence of a severe, and prolonged, dry phase centered around AD 700, which was far more severe than the drought currently afflicting the study region. Between ca. AD 900 and 1500, the climate was highly variable, with substantial fluctuations in effective moisture. Thereafter, a lengthy period of positive moisture balance is evident from ca. AD 1500-1850, with a marked reduction in the amplitude of variability.

Correlations with studies from further afield suggest that ENSO, and possibly the Indian Ocean Dipole, are the key drivers of the observed shifts in moisture balance. The records constitute the first evidence of centennial- and decadal-scale climatic

variability from mainland Australia. This enables the current drought to be viewed in an historical context for the first time and provides insight into past climate regimes across southeastern Australia in general, and western Victoria in particular.

 # 4.16 Boulder Assemblages on the New South Wales North Coast, Australia: Sedimentology, Age and Origin

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A *boulder beach* is a longshore assemblage which forms between the headland and embayment, whilst *boulder pockets* can be found in channels and caverns of the rocky headland area. The sedimentary characteristics, age and origin of such deposits has been the focus of few studies in Australia and boulders are still poorly represented in the literature of coastal sedimentary environments. Investigation of two boulder beaches and twenty-four boulder pockets on the NSW north coast demonstrates that these assemblages have distinct sedimentary characteristics. Moreover, these findings are similar to those reported by Oak (1981, 1984) for five boulder beaches on the NSW south coast and by Chen & Chen (2009) for a boulder beach in southeast China. With few exceptions, along-beach and up-beach fining of sediment, an absence of shape and sphericity zoning, low foreshore slopes and an increase in the rounding of boulders along-beach are the sedimentary properties which appear to define coastal boulder deposits. These results suggest that the boulders have been re-worked over a long period of time, a conclusion supported by additional field observations and radiocarbon dating. The boulders appear to have been derived locally during times of higher Holocene sea-levels and have been gradually worked into well-graded deposits by storm and normal waves since this time. The effect of a 2009 storm surge on these boulders beaches appears to be negligible.

 # 4.17 Environmental Change in Freycinet National Park since the Last Glacial Maximum

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Palynological studies are becoming strong tools within Australia for quantifying past environments, particularly examining vegetation response to periods of significant climate change and the relative impacts of people, both Aboriginal and European, on the Australian landscape. Many significant and extensive records are now available throughout mainland Australia and along the west coast of Tasmania that provide detailed information on late Quaternary dynamics, while relatively few studies have been published along the drier east coast of Tasmania. A 1.5 m sediment core has been extracted from Hazards Lagoon, Freycinet National Park that provides a detailed picture, through pollen, charcoal and sedimentological analysis, of environmental change for this region for the last 21,000 years. In particular, this record is expected to highlight key vegetation transitions along the east

coast since the last glacial maximum, as well as exploring the relative impacts of climate forcing and human impacts on the Freycinet landscape.

 # 4.18 What should we take from the past into the future?

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Linking palaeo records with the results of modern herbarium data-mining may provide insights into the environments that existed in the past. This project uses Holocene plant remains of vegetation in the MacDonnell Ranges (NT) and Yathong (NSW) as a test set. These are further analyses of the results from Erin Greentree's analysis of stick-nest rat middens from Yathong Nature Reserve, that has been severely degraded by goats, and Alex Cockerill's analysis of middens in the MacDonnell Ranges, degraded by horse grazing. The modern national distribution of the species approximates the bioclimate and other variables that control or predict the distribution of the vegetation community. These variables provide the aggregate environmental envelope for the sites at specific points in the Holocene. So far these late Holocene records show remarkable stability in arid Australia and are in contrast to the records of distant corals or predictions of models.
The step-wise changes observed between the fossil material and the current vegetation are dramatic but are dwarfed by the collapse of fauna recorded in middens. Building novel ecosystems is now underway often using the evidence of past dynamics. The changes that managers face in the arid zone are daunting and how palaeo-records can influence resource and other decisions needs AQUA's careful consideration. This paper will end with a reflection on my experience with communication of environmental change information and resilience-thinking over the last 3 years that suggests that the place-based approaches of the Association members have never been more important.

 # 4.19 A New Cosmogenic Isotope, Manganese-53, For Exposure Dating: Preliminary Results From Iron-rich Rocks In Arid-semiarid Australia

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The method for a new cosmogenic isotope, manganese-53 (^{53}Mn), has been developed at the ANU, which to date is one of only two facilities with this capability in the world. ^{53}Mn has a half-life of 3.7 million years (Ma), which is longer than the 1.5 Ma of the commonly used beryllium-10, and thus extends our capability of surface exposure dating to >10 Ma. With the iron as the only primary target, ^{53}Mn is also attractive in the study of lateritic surfaces in arid-semiarid Australia. In this paper, we present our preliminary data from ancient iron-rich rock surfaces collected from the Pilbara region, northwest Australia.

 # 4.20 Palaeoenvironments of the Paroo/Warrego Region, Australia: a Multi-proxy, Multi-site study.

Lucy Gayler

Kingston, Tasmania

The records of environmental change in Australia's arid zone can be greatly enriched by employing a multi-proxy approach and landscape-scale analysis. This research uses these tools to construct a palaeoenvironmental history of the semi-arid wetland system of the Paroo/Warrego Region. In summary, high lake water levels prevailed prior to the Last Glacial (LG). The extreme aridity at the onset of LG caused long term drying of the lakes and mobilisation of the red sand dunes. In latter stages of the glacial phase the aridity gave way to periodic fluctuations between flood and drought events that probably lasted until 16 000 - 14 000 BP. The new climatic regime resulted in formation of gypsum lunettes and later, following reduction in gypsum supply, clay lunettes. The orientation of red sand dunes and lunettes indicates a more northerly extent of the westerlies than in modern times. Around the late Pleistocene-early Holocene boundary the climate became more stable and wetter, but still somewhat drier than during the pre-LG lacustrine phase. As a result, the region's lakes reverted to a permanent and semi-permanent status. A strong aridity signal, comparable to the semi-regular droughts of the Last Glacial, was recorded in the Paroo/Warrego lakes during the late 1890s-1940s period of below average rainfall. It was followed by 50 years of wetter conditions with two extremely wet phases in the 1950s and the 1970s. Finally, the most recent records suggest a new drying trend.
Aside from the environmental history, this research provided an interesting insight into the short- and long-term survival strategies of the semi-arid vegetation. In response to the Region's modern flood-drought cycles the herbs and grasses expand with the onset of wet conditions before being replaced by Chenopodiaceae as the landscape starts to dry. During prolonged arid phases the dry and shrunken lake basins and water courses act as refugia, which transform into dispersal foci with the return of wetter conditions.

 # 4.21 Environmental change at Lake Mungo, Willandra Lakes World Heritage Area

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Lake Mungo, at the southern end of the Willandra Lakes World Heritage Area, is an icon of Australia's indigenous heritage. The region is one of the few areas in the Australian semi-arid zone providing a rich archive both of archaeological material and past environmental change. Lake Mungo preserves some of the earliest archaeological traces on the continent, and the lunette in which the remains were found records alternating periods of permanent and ephemeral lake conditions reflecting climatic change through time. However despite its high

profile, Lake Mungo suffers from a relative dearth of systematic and integrated archaeological and palaeoenvironmental studies. Here we present a chronostratigraphic framework of parts of the Lake Mungo lunette not studied previously, using optically stimulated luminescence (OSL) dating. The high frequency sampling technique employed in this study provides critical information relating to both the timing and processes of sediment and artefact deposition. The OSL chronology elucidates the complexity of the lunette's stratigraphic record, enabling a systematic combination of the hydrological and environmental history with archaeological traces. Integration of the geological and archaeological information will provide a basis for understanding how indigenous Australians in this region responded to long-term landscape and climate change

 # 4.22 Attempts at dating some rock art sites near Cue, central inland Western Australia

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In 2002, testpits were excavated into the deposits within three decorated rockshelters located east of Cue. The shelters selected for investigation were Gidgee, which houses a shelf of deeply weathered pecked cupules and more recent petroglyphs; Gilla, which houses both pictograms and an unusual array of well-preserved petroglyphs, including zoomorphs; Yarraquin-4, which houses deeply weathered and unpatinated petroglyphs and pictograms, both stencils and paintings (Gunn and Webb 2000). Gidgee appears to have been in use between 4500 and 2000 BP. The first dates obtained from Gilla and Yarraquin were more difficult to interpret. Gilla appeared only to have been visited briefly about 1900 BP, when *Leporillus conditor* (the Greater Stick-nest Rat) was still extant. The dates from Yarraquin were inverted, but suggested that the site might have been in use between 1900 and 1500 BP (Webb 2009). Given that the deposits in Mulka's Cave have now been dated to >7000 BP (Rossi and Webb, in prep.) and ochre was found at Walga Rock in levels below a date of 10,000 BP (Webb and Gunn 1999), the ages obtained from Gidgee, Gilla and Yarraquin while unsurprising, the artefacts can be attributed to the Small Tool phase, were disappointing. Additional samples were submitted to Waikato in late 2009 from all three sites to verify and clarify the ages already obtained. At Gidgee and Yarraquin the new samples were stratigraphically related to the rock art. The ages of all the samples will be discussed, as will the dates obtained 10 years ago from Madoonga and Wurarga rockshelters (Webb 1996), both of which house pictograms, although that was not my research focus at the time.

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 # 4.23 A reconsideration of the age and significance of Mulka's Cave, a profusely decorated Aboriginal rock art site near Hyden, Southwestern Australia

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The aim of my MA research was to investigate the conflicting opinions on the age and significance of Mulka's Cave put forward by Bowdler *et al.* (1989), who test excavated the deposits inside the cave both and retrieved 210 stone artefacts and a date of 420 ± 50 BP from spit 13A, just below the lowest artefact they found, and Gunn (2006), who recorded the >450 motifs in detail, and to attempt to determine where people camped when they visited the site (Rossi 2010). Bowdler concluded the site was fairly insignificant and only visited intermittently in the recent past; Gunn argued that it was the most important art site in the Southwest and that the motifs were probably made 3000-2000 BP. I dug four small pits around the site in 2006-2008, and submitted five charcoal samples to Waikato for 14C dating. The results suggested that people had been camping at the site for at least 6500 years. In 2009, I reanalysed the artefacts recovered in 1988, tripling their number, and submitted charcoal from spit 15 for dating. The resultant age, 7386 ± 30 BP (Wk-27113 - 8245 ± 85 calBP), caused me to reassess the cave's chronostratigraphy. Funding is being sought from ECU to date charcoal samples from spits 12, 14 and 16 to verify Wk-27113. The results of these dates and my reinterpretation of the age and significance of Mulka's Cave will be presented at the meeting.

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 # 4.24 Ecological and limnological history of the Ashburton Lakes region, South Island, New Zealand

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This paper presents preliminary results from paleoecological research in the Ashburton Lakes region of the South Island, New Zealand. Maoris arrived in New Zealand about 700 years ago and although they did not settle permanently in the South Island high country, they certainly used it on a seasonal basis and modified the natural fire regime. Since European settlement the New Zealand high country vegetation has been hugely modified due to clearance of forest and farming. Recently, large areas of the high country stations are being returned to conservation management. This project aims to determine what the natural vegetation regime was, and what impacts human settlement has had on the waterways. The New Zealand Department of Conservation has plans to restore the natural values of this area in future.

Nine lake and bog cores have been taken from Maori Lakes, Spider Lakes, Lake Emma and Lake Clearwater, the four most promising lakes and wetlands in the area. Preliminary analysis of the cores shows that several of the cores penetrate to pre-Maori occupation. The cores are layered peat and sediment, and will provide information on both sedimentary characteristics and vegetation reconstruction. Initial pollen analysis of the Maori Lake core indicates there are substantial changes in vegetation from pre-Maori times to the present. Latest findings will be presented at the conference.

 # 4.25 The last glacial maximum and deglaciation in southern New Zealand: new pollen-climate reconstructions.

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[2]Geological and Nuclear Sciences, New Zealand

Recent (polar) ice core records from Greenland and Antarctica have transformed understanding of climate change, demonstrating that change, once initiated, can proceed at dramatic pace. However, the extent to which the polar ice core records are representative of hemispheric or even global conditions, especially during periods of significant change, is still unclear. Current work in New Zealand, highlighted by the New Zealand INTIMATE project, is pointing towards strong coherence between New Zealand and Antarctic records of climate change and hence asynchronous timing between the northern and southern hemispheres for some climate transitions during the Last Glacial Maximum (LGM) and Last Glacial Interglacial Transition (LGIT). These findings are tentative, however, and based on a limited number of well-resolved records. This project aims to produce new, high resolution, Late Quaternary palynological records to test the current models of changing climate in southern New Zealand. Four, new palynological records spanning all or part of 30-8 ka BP have been developed. This contribution will focus upon the results of two sites used in the project, both of which are located in the Westland region, South Island. At each study site, the palynological results will be set in the context of sedimentary and geomorphic evidence for glacial advance and retreat, with radiocarbon and tephrostratigraphy providing chronological control. The recently developed pollen-climate transfer function will be applied to the pollen data to provide estimation of mean annual temperature change. In addition, this project is linked to collaborative investigations aimed at determining the potential to apply other palaeoecological proxies at these sites, including chironomids, plant macrofossils and coleoptera.

 # 4.26 A tale of two proxies: A high resolution record of environmental change from New Zealand spanning the Last Glacial/Interglacial Transition (LGIT).

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[2]School of Geography, Archaeology and Palaeoecology Queen's University Belfast, U.K.

We present a record environmental change from Lake Hawdon, New Zealand based on chironomids, pollen, and other available proxies. This record spans the period between 9,500 and 17,000 calendar years before present (cal BP) and the age model is based on 40 radiocarbon dates, with an average of 1 date every 200 years.

Chironomid-based summer temperature reconstructions indicate large roughly millennial scale fluctuations prior to ~ 13,000 cal BP. There were two “warmer” phases with summer temperatures between 0 and 2 °C cooler immediately after deglaciation (17,000 cal BP) and at least as warm as present day about 14,500 cal BP. The two cooler phases were 15,500 to

16,500 cal BP (3 – 5 °C cooler) and 13,000 to 14,500 cal BP (1 – 3 °C cooler). The pollen record indicates the presence of a barren landscape in this region prior to 13 ka BP with the pollen assemblage dominated by grasses, daisies and shrubs. There is no clear evidence in the pollen record for a vegetation response to these millennial scale temperature fluctuations.

Summer temperatures were more stable after 13,000 cal BP with temperatures equivalent to present day between 11,000 and 13,000 cal BP and at least 1 °C warmer between 9,500 and 11,000 cal BP. Pollen and macrofossil evidence indicate a rapid colonisation by *Halocarpus* and then *Phyllocladus* (*P. alpinus*) shrub conifers shortly after 13,000 cal BP. There is evidence for a prolonged succession towards podocarp forest in this valley beginning about 12,500 cal BP with macrofossils and lake sediments indicating the presence of substantial forest cover at the site about 11,500 cal BP.

This record provides further insight into LGIT climate variability in the southern mid latitudes and how landscape instability and development following deglaciation modulates the response of vegetation to climate change.

 # 4.27 The timing of Late Pleistocene glaciation of New Zealand

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The central West Coast of New Zealand represents the classic glacial sequence of the Late Pleistocene of New Zealand, broadly grouped as the Otira Glaciation. The current age model of glaciation based on the work of Suggate and Almond is derived from radiocarbon dating only. Glaciation is thought to have first occurred in the early Otira Glaciation during Oxygen Isotope Chronozone 4, and to have culminated 21,000 cal yr BP. The final phase of glacier advance occurred between 19,000 -17,000 cal yr BP depositing the Moana Formation. We have reassessed the limits of ice advance in the lower Taramakau and Arnold River catchments and conducted an exposure dating campaign to place direct age estimates on each of the major advances. Here we present preliminary findings from the project. We found little surface expression for moraines deposited during Oxygen Isotope Chronozone 4. Additionally, we found that the division between the Larrikins-1 and Larrikins-2 Formations needs reassessment. Finally, the age of final retreat of ice was later than originally estimated.

 # 4.28 A steady-state mass-balance model for the Franz Josef glacier, New Zealand: testing and application

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We describe a simple steady-state mass balance model for the Franz Josef glacier, South Island, New Zealand. The advantages of this model are simplicity and speed, the ability to

view the calculations during modelling, and the ability to include both climate and debris-cover (ablation reduction) parameters. Instead of using an ice-flow rule in the model, a simple basal-shear-stress rule is calibrated to yield glacier surface slope as a function of ice depth. We test the model against the Anderson and Mackintosh (2006) mass-balance/ice-flow model, and obtain very similar results for the degree of cooling required to emplace the Little Ice Age and Waiho Loop moraines. Finally we use our model to represent the reduction of ablation due to a rock avalanche falling on to the ablation zone of Franz Josef glacier about 10000 - 13000 years ago; it shows that at the temperature prevailing at that time (0 - 2°C cooler than present, according to proxy data), rock avalanche debris covering a proportion of the ablation zone could cause an advance of the glacier from near Canavan's Knob to the Waiho Loop. By contrast, the ~5°C cooling required for a purely climatically-driven advance to the Loop contradicts proxy data. These findings are of significance to the ongoing debate on the climatic significance, or otherwise, of the Waiho Loop Moraine. The simple approach to glacier modelling developed in this study has the potential to test the effects of climate change and rock avalanches on glacier behaviour easily and effectively in glacial environments worldwide.

 # 4.29 Glacial Sedimentology of the Rangitata Valley, Canterbury, New Zealand

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The Rangitata Valley is one of the major glacial valleys on the eastern side of South Island, New Zealand. Some of the glacial limits in this valley have been mapped by earlier workers but both the geomorphology and more particularly the sedimentology was virtually undescribed. This is surprising as there is an extensive suite of outcrops in the middle valley reaches recording numerous glacial and parglacial environments. This talk will concentrate on outcrops between Forest Creek and the Potts River in a tectonically controlled pull apart basin (Butler Downs). In the Potts River a large, deep glacial lake formed at least two glaciations ago. This lake was probably impounded by ice in the main Rangitata Valley. Above this, repeated sections of outwash gravels and shallower lake deposits interspersed with thin ice contact units. Last Glaciation Maximum advances occupy only the top few metres of outcrop. In the main Rangitata Valley the deposits are dominated by relatively thin sheet like units in most locations. In the main, shallow ponds and outwash settings are recorded. Glacial striae are persistent. This contrasts with the deeper and more extensive lacustrine deposits typical of the Rakaia Valley to the North.

Like the Rakaia and Hope Valleys, extensive suites of pre-LGM deposits are preserved well upstream of the LGM limits, indicating that LGM ice was unable to excavate older deposits in the lower valley. Unlike those valleys which were relatively constrained, in the pull apart basin grounded ice was common and large lakes either did not form or were not persistent enough to dominate sedimentation. It appears that for extended periods the Rangitata and tributary glaciers extended into but not beyond the Butler Downs area.

 # 4.30 Reconstructions of local-scale Holocene sea-level fluctuations in the New Zealand archipelago

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Local-scale Holocene sea-level curves for five regions within the New Zealand archipelago have been constructed, based on 212 dates compiled from 37 published and unpublished reports, papers and theses. Results indicate that in northernmost New Zealand (above latitude 37º S) sea-level rose from -3 m PMSL c. 8,000 cal yr BP, attaining PMSL by c. 7,700 cal yr BP. While this is c. 1,000 cal yrs earlier than indicated by Gibb, it is consistent with recent reconstructions of Holocene eustatic sea-level from the east coast of Australia. Sea-levels in the Auckland-Northland region peaked at +0.9 m PMSL from 6,300-5,600 cal yr BP, dropping steadlily to PMSL by c. 2,000 cal yr BP. On the southwest coast of the North Island, at latitude 41º S, sea-level rose from rose from -16 to -1.5 m PMSL between 9,000-8,100 cal yr BP. PMSL was attained c. 7,500 cal yrs BP. Sea-levels reached a maxima of +1.2 m PMSL by 6,800 cal yr BP, dropping to PMSL c. 5,400 cal yr BP. Sea-levels then rose again to c. +0.6 m PMSL by 4,700 cal yr BP. There is insufficient data to comment on later sea-level changes on the southwest coast of the North Island. In Pegasus Bay, on the east coast of the South Island, about latitude 43.5º S, sea-level rose from -34 m PMSL c. 10,350 cal yr BP to -8.4 m by 8,200 cal yr BP. PMSL was most likely attained sometime between 7,100 – 6,600 cal yr BP; however, this is not definitive. Again, there is insufficient data to accurately comment on mid- and late Holocene sea-level changes here. On the Otago Peninsula, southern South Island, at latitude 46º S, sea-level rose from -1 m to +0.2 m PMSL between 7,600-6,800 cal yr BP, and remained at this higher level until c. 6,300 cal yr BP. Through the mid-Holocene sea-level appears to have fluctuated between PMSL and -1 m PMSL.

 # 4.31 Island of fire: volcanoes as agents of death, destruction and migration on Flores Island, Indonesia.

Kira Westaway

Macquarie University

Volcanoes form the central spine of Flores Island and have dominated every square metre of island space since it was formed ~12 million years ago by submarine volcanism. The stratigraphy and archaeological evidence found at two sites on Flores can be used to reconstruct the relationships that existed between hominins and volcanoes on this section of the Indonesian archipelago. These sites are: Soa Basin, an ancient lakeshore environment near Bajawa in central Flores and Liang Bua an inland cave site located close to Ruteng in western Flores. Both sites display evidence of massive volcanic destruction; with large erosion contacts, thick tephra deposits and lack of occupation deposits immediately after each event. This evidence suggests that the dominance of Flores by volcanoes was not restricted to just visual appearance but influenced the survival and preferred location of hominins and

other fauna, particularly *Stegodon*. This influence will be discussed in relation to the ~800 ka hominins from Soa, and 17 ka eruption on the inhabitants of Liang Bua. The sediments at Soa are inherently volcanic, ranging from deep tuffs to ignimbrites and lava flows, and demonstrates the consistent volcanic influences on the sedimentology and environment of this area. In contrast, the sediments at Liang Bua are periodically punctuated with evidence of volcanic events, with the two largest occurring at ~17 and 12 ka. The volcanic events at Soa caused death, destruction and possibly the extinction of certain *Stegodon* species (*Stegodon sondaari*), while the Liang Bua events may have caused migration to another less affected area of Flores.

 # 4.32 Nauru: the palaeoecology of a remote and transformed Pacific island ecosystem

Mat Prebble* and Nick Porch

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The raised phosphatic limestone island of Nauru is most recognised for the profound ecological and social changes tied to the last 100 years of open-cast phosphate mining. Little is known about the ecological changes spanning the Holocene, the timing of initial human colonization, or ecological changes tied to human activity prior to the 20th Century. We present a set of preliminary Holocene pollen records obtained from organic-rich coastal swamp deposits, indicating major shifts in coastal vegetation from mangrove to exotic vegetation associated with human activity. This transformation has culminated in the decline of indigenous species, now making up only around 10% of the modern flora with most exotics probably introduced in the last century. These records are unique in providing insights into past ecological change on low-lying remote Pacific Islands where few palaeoecological records have been retrieved. Comparisons are made with records obtained from raised limestone islands elsewhere in the Pacific.

 # 4.33 Late Quaternary environments in the Lesotho highlands, southern Africa

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There has been continued debate in southern Africa concerning whether the Lesotho Highlands experienced glacial conditions during the Late Quaternary. Records of past climate data for southern Africa are sporadic and there is currently no reliable temperature or rainfall proxy data for climate change prior to the present interglacial for Lesotho. Consequently, Late-Quaternary glaciation of this region remains highly controversial. Geomorphic evidence of former glaciation in the high mountain region of southern Africa dated to the Last Glacial

maximum (LGM) implies that specific climatic conditions would have been required to sustain active glaciers. This paper presents results for various sites in the Lesotho highlands, which host linear ridges interpreted as glacial moraines. The process origin of these features was determined through a multi-method approach and glacier reconstruction and modelling was applied to determine whether these locations could have supported glaciers. Results indicate reconstructed glacier Equilibrium Line Altitudes (ELA) between 3071 and 3127 m a.s.l. and palaeoglacier mass-balance characteristics comparable with modern analogues, reflecting viable, if marginal glaciation. The importance of topographic shading on determining the location of the glaciers is reflected through insolation mapping and the potential of this shading on glacier mass balance is quantified from energy balance model calculations. The reconstructed palaeoclimatic conditions during the LGM suggest that snow accumulation in the Drakensberg was significantly higher than considered by other studies, suggesting that there was a major shift in rainfall zones across south eastern southern Africa during the last glacial cycle.

 # 4.34 Study on the relation between loess palaeoclimate trend and uplift of Tibetan Plateau

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Grain-size and magnetic susceptibility are two basic and most useful parameters for studying paleoenvironmental change in loess and paleosol sequences; those indicate variation of winter and summer monsoon history. Their variation of peaks and valleys with loess and soil layers has been confirmed to be controlled by Milankovich cycles. These climatic records, therefore, are the function of time; which should be different from tectonic component, a non-cycle factor. The curves of Chinese loess generally show two obvious trends. Grain-size gradually becomes coarser from the bottom to the top, which implies winter monsoon becoming stronger. At the same time, the value of magnetic susceptibility gradually increases, which implies summer monsoon becoming stronger. We attribute the trend of this non-cycle factor to the uplift of Tibetan Plateau, This trend show an angle (or slope) to the time axes. Which is therefore very likely related to the intensity of uplift. By examing long term tendency of grain size and susceptibility for the last 22 Ma's aeolian deposit, our data show two 3 pieces of straight trend lines (3 uplift stages) separated by two transition points. Two turning points were occurred around 8 and 2.6Ma respectively, responding to two major relatively sudden and strong uplifts of Plateau.

 # 4.35 Millet agriculture in north-central China: evidence from human remains

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The millet plants *Panicum miliaceum* and *Setaria italica*, with short growing seasons and high tolerances to cold and arid conditions, are commonly cultivated in marginally arable areas of north China. Previous work finds millet to have dominated the diets of agriculturalists and livestock there at various times since the Yangshao Period (ca. 7000-5000 BP). Whilst cultivation of millet may have allowed human populations to persist in times of agriculturally unfavourable conditions, heavy reliance on the cereal is associated with health declines, as people adopted less varied diets.

$\delta^{13}C$ values of collagen, amino acids and cholesterol in human bone are used to gain specific information about pre-historic food consumption in north-central China. Here we report on fourteen human bone samples derived from several archaeological sites, and which range in age from ca. 4035 ^{14}C yr BP to ca. 920 ^{14}C yr BP. Considerable difference in C_4 plant consumption is apparent within the samples, and this dietary diversity is discussed along with related factors such as spreading agricultural technologies, land arability and human population health.

5. Abstracts: POSTER PRESENTATIONS

#5.1 Linking archaeology and palaeoenvironments in SE Bulgaria

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At the cross-roads of Eastern Europe, Anatolia and the Mediterranean, the Thracian Plain has been home to a great array of cultures that each left a distinct mark on the landscape. Agriculture entered the European continent from the Fertile Crescent via the Thracian Plain some eight thousand years ago. Until now there have been no local data on the environmental conditions associated with this cultural event. A joint Australian-Bulgarian team has been surveying archaeological sites and conducting palaeoenvironmental analyses to better understand the connections between prehistoric settlement patterns and Holocene environmental change in SE Bulgaria. Sediment cores from wetlands and lakes are being analysed for pollen and other microfossils, charred particles and magnetic susceptibility. The results provide new insights into conditions during the introduction of agriculture, showing that, in contrast to other parts of Europe, agriculture's appearance in SE Bulgaria was not accompanied by wholesale deforestation. In fact, it seems that oak forests expanded in tandem with agriculture. Not until later, during a period of widespread settlement abandonment between 4200-3200 BC, did these forests disappear, giving way to grasslands in which fire and grazing played a prominent role.

#5.2 Pollen distribution across a wetland and a pollen transport model.

Peter Shimeld

School of Geography and Environmental Studies, University of Tasmania

This poster presents the results of a study on modern pollen deposition across a narrow wetland in Port Stephens, New South Wales and suggests a model to explain the patterns observed in the distributions of several terrestrial pollen taxa.

The region experiences two distinct seasonal wind regimes; summers are dominated by onshore south-easterly winds and winters by west and north-westerly winds. The pollen deposition patterns of several arboreal species reflect the prevailing winds that were dominant during the flowering seasons. The forest-wetland boundary also influences the deposition patterns of pollen, and from these a wind-flow model of pollen transport from local and non-local sources onto the wetland is presented. The model is also applied to an earlier pollen transport study in Tasmania that examined *Eucalyptus* pollen along three long transects from woodland onto heath.

#5.3 Bioclimatic modelling with palaeoecological attitude: A koala (*Phascolarctos cinereus*) case study.

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Climate change will challenge the existence of many species worldwide and will exacerbate the detrimental anthropogenic effects on biodiversity such as habitat loss and fragmentation currently being experienced by natural ecosystems. Systematic conservation planning encompasses numerous scientific disciplines and non-scientific parties and requires a variety of tools to make the best possible conservation decisions and reserve designs. Often overlooked in conservation planning however, is the value of examining the deep history of this planet's climate and ancient species through palaeontology and palaeoclimatology. A longer-term historical perspective assists the understanding of present and also future ecological dynamics. Numerous bioclimatic modelling techniques using species occurrence data such as Bioclim, Domain and GARP can predict where species may occur. Such models that solely consider climatic parameters are extremely useful for predicting future range shifts although they have inherent limitations such as: 1) uncertainty regarding future climatic conditions and ecological niches and 2) a lack of consideration of other influences on a specie's range such as vegetation and soil types and habitat loss. Bioclim was employed to generate a 'climate envelope' for koalas throughout their natural range in eastern Australia. Using this climate envelope, a sensitivity analysis using climatic scenarios from the Last Glacial Maximum, current climate conditions and future climate change projections predicted core ranges for this species. These predictions were integrated with the fossil records for the Family Phascolarctidae to provide useful hindcasting and additional insights regarding the distribution of koalas. When selecting areas for reserves, considering only the current climate is inadequate. Having a palaeoecological understanding of regions that species have occupied in the past and perhaps used as refuge areas during past climatic eras enriches future decision making. These findings highlight the value of combining the past with the future to provide another important tool in the systematic conservation planning toolbox.

#5.4 Diamond Hill, Darwin Glacier. A proxy for the West Antarctic Ice Sheet?

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In the Ross Sea embayment during the Last Glacial Maximum (LGM, 18-22ka), the grounding line of the West Antarctic Ice Sheet (WAIS) advanced northwards into the Ross Ice Shelf (RIS). This effectively dammed the drainage of the Transantarctic Mountain outlet glaciers and caused significant downstream thickening of their glacier profiles (Conway et al 1999).

The Darwin / Hatherton Glacial System (79.5° S, 158° E) provides a number of sites that contain geological evidence of WAIS fluctuations. Previous geomorphic and pedological studies in the area (Bockheim et al. 1989, Denton & Hughes 2000) have used these sites to constrain the timing and magnitude of the LGM ice sheet advances. As Diamond Hill lies at the confluence of the Darwin Glacier and RIS its glacial geomorphology should reflect the thickening caused by the advancing WAIS.

Insitu cosmogenic nuclide dating has being used at sites along the Darwin/Hatherton as a

proxy to recreate the timing and magnitude of both WAIS and EAIS advances. By measuring the concentrations of Beryllium-10 and Aluminium-26 in quartz rich lithologies, the time since the deposition of a moraine can be calculated.

Early interpretations based on cosmogenic ages from the Lake Wellman area (Fink et al 2009, Storey, et al. 2010) show up to 800 meters of thickened ice approximately 2 million years ago. Moraines previously assumed to be the limit of LGM ice expansion, date to 30-40 ka. This suggests that while early EAIS Quaternary expansion was large; ice volume at the LGM may be little changed from the present.

Two transects were sampled on Diamond Hill that cover an altitude range of 1100 meters. Preliminary ^{10}Be cosmogenic dates show a similar trend to that seen further up glacier in Lake Wellman, in the case of Diamond Hill the WAIS was approximately 900 meters thicker than the current Rose Ice Shelf configuration at ~1.5Ma and with only small advances in the last 10ka. As with Lake Wellman no evidence of large scale LGM advances were found.

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#5.5 Late Quaternary climate change in South East Queensland

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Aside from the war against terror, global climate change is the most discussed issue in the media. The IPCC predicts that without a reduction in greenhouse gas emissions, temperatures will rise by 2.4-6.4 degrees Celsius by 2099. As a result, a number of changes will ensue, including sea level rise, widespread ecosystem reconfiguration and adverse affects on human industries and services. To predict global climate change in the future, it is logical to first

look at global climate change in the past. One of the oldest and most reliable methods to study past climate change in the Late Quaternary, which is the period of time covering the last glacial cycle, is to use pollen proxy records. Within Australia, palynological research has typically centred on the temperate south-east corner of the continent, however research in North-East Queensland has shown a distinct latitudinal gradient that has operated alongside climatic change in the past to influence changing vegetation patterns. There is also evidence to suggest Aboriginal people have used fire as a tool to control the landscape since their arrival to Australia at approximately 45 000 BP, altering the vegetation to inadvertently reflect that which favours fire. Research in recent years has been focused on teasing apart the influences of humans and climate on past environmental changes, which can only be addressed by site-specific investigation. This research project aims to address the lack of Late Quaternary climate change research in the subtropical region of Australia which is centred between the well-studied north- and south-east corners. Using a record taken from the Gold Coast, South-East Queensland, multi-proxy analysis is presented which uses pollen, charcoal, sediment characteristic analysis and several radiocarbon dates to provide a detailed picture of Late Quaternary climate change and Aboriginal settlement in this region.

 # 5.6 Pollen records from tropical North Queensland.

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 # 5.7 A sequence stratigraphy framework for the Castlepoint Formation at Castlepoint, New Zealand

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An exposed shallow marine carbonate-rich sequence at Castlepoint in the Wairarapa region of the North Island of New Zealand provides a record of sedimentary cyclicity and sea level oscillations of Early Pleistocene age. The formation comprises fossil-rich sandstone and coquina limestone and overlies the Early Pliocene mudstone of the Rangiwhakaoma Formation. The Castlepoint Formation is associated with a minimum of four faults, minor seismic deformation and at least 46 macrofossil species. Bedding not disrupted by the high abundance of faunal elements is laminated, with rare cross-bedding. Five complete and two partial cyclothems, largely based on molluscan faunal assemblages, are identified in this study. In contrast to the laterally extensive successions of similar age at Wanganui and Hawkes Bay (North Island, NZ), the Castlepoint Formation shows no sign of subaerial exposure during lowstands and is characterised by cold water faunal assemblages deposited under higher energy conditions on a narrower and more exposed continental shelf influenced by southern ocean currents. Cyclothems within the Castlepoint Formation start with cold water fossil-rich coarse-grained lowstand marine shelf deposits and pass progressively up through transgressive phases to less fossiliferous units containing both cold and warm water species representing mid shelf highstand deposits. These Early Pleistocene sequences extend

cyclothem recognition into coarser grained carbonate-rich shallow marine shelf deposits affected by sea level fluctuations.

#5.8 Water quality changes in a Fraser Island perched lake: Lake McKenzie. Preliminary data investigating the influences of recreational activities on lake water quality.

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Fraser Island, is the largest sand island in the World and is located on the east coast of Australia. The Island has remained relatively untouched over time, with only minimal impacts since its European occupation in the 1840's. However, increasing tourism numbers are causing concerns for the maintenance of pristine conditions in the perched freshwater lakes. Lake McKenzie is situated in the southern half of the Island on the western side of the Great Sandy Biosphere. Hadwen *et al.* (2003) identified Lake McKenzie to be one of the top two lakes on the Island under threat from tourism related impacts. This is supported in the results of a case study by Fleming *et al.* (2008) that estimates visitation numbers to Lake McKenzie to reach 2000 people per day in holiday seasons throughout the year. Concern has been expressed regarding the influence of tourism and recreation on Lake McKenzie or other Fraser Island freshwater lakes. Studies that have been conducted focus on the nature and changes of the Island in an ecological and evolutionary context with particular reference to climatic and vegetation changes. Research that focuses upon water quality changes in lakes needs to be conducted to identify any potential impacts of recent anthropogenic activities on the island's perched lakes. A palaeoecological approach using diatoms as fossil indicators is ideal to identify these potential trends. This study reports on preliminary data from an honours thesis. By developing knowledge of Lake McKenzie's water quality history, not only will bench marks be created for future use on a regional level, but it will also allow appropriate techniques to be selected in the management and monitoring of the perched lakes to mitigate current and future impacts.

#5.9 Environmental Changes indicated by grain-size and trace-metal analysis over the past 700 years at Annaburroo Lagoon, NT, Australia

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The research on Annaburroo lagoon spanned several years and many cores were taken. Only during the last 2 seasons of coring (2001 & 2002) longer cores were obtained. This paper discusses the results from the longest core (23 cm) and show that the lagoon has been receiving sediments at a very steady rate since 655 BP. Prior to this "steady" period; there is some evidence to suggest that some major floods deposited coarser material. The overall chemical fingerprint shows variable levels of metals , but no gradual increase due to possible "European" mining activities in the catchments. Despite the well documented mining activities in the area the lagoon seems to be a natural sink for fine sediments and associated metals are related to the geology of the catchment. The lake is only inundated in the most severe monsoonal floods and most of the time has no connection to Mary River. Most of the sediment is autogenic.