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Quaternary AUSTRALASIA

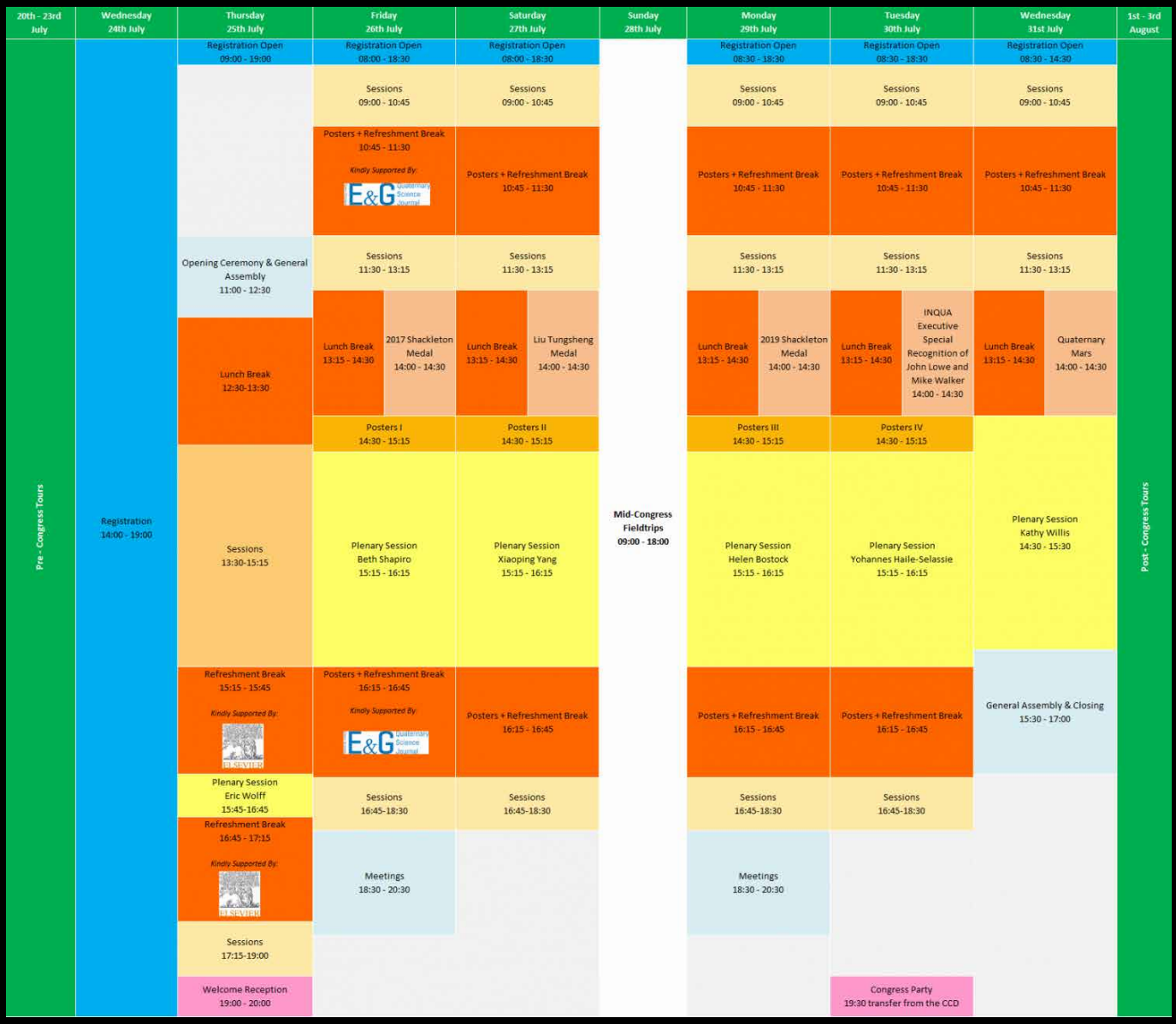
XX INQUA Dublin

Remembering Bob Galloway

Gender in AQUA

INQUA 2019
Dublin, Ireland 25th-31st July 2019

20th INQUA Congress to be held in Dublin Ireland 25 – 31 July 2019.
Programme Overview



The INQUA 2019 online programme is now available.
www.inqua2019.org/online-programme

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Front cover photo:

Coring one of many giant *Araucaria bidwillii* trees in Bunya Mountains National Park – and yes I did manage to reach the centre!
(Photo credit: Heather Haines)

Below:

Jessica Reeves and Henry, 2008.
(Photo credit: Jessica Reeves)

EDITORIAL

Dear Quaternarists,

Politics is big news at the moment.

The resignation of the recent British Prime Minister over Brexit; the US President steam-rolling all-comers on whatever doesn't suit his agenda; Australians still scratching their heads over the recent land slide victory of the Liberal party (in what was touted as the 'Climate Election' and a shoo-in for Labour); and an unprecedentedly large number of Google searches by Australians ...'relocating to New Zealand'.

(Interestingly a news poll prior to the recent Australian Federal election noted that if the current New Zealand Prime Minister was running for office in Australia, she would have won!).

All this 'news' distracts from the biggest issue the world is currently experiencing – that of climate change. The more extreme or unusual weather events become, the more species that disappear, ice sheets that disintegrate and islands that submerge, the greater the distraction away from the issue. But, the effects of climate change are making small inroads into mainstream media. Recently, several New Zealand cities (Christchurch, Nelson, Auckland, Hawkes Bay) declared "climate emergencies", following the same declaration in the UK.

In New Zealand, the Iwi Chairs Forum climate change spokesman Mike Smith said climate change was the biggest issue facing humanity and needed to be treated seriously, noting that climate change is "probably the biggest issue that humanity has ever faced... "a slowly evolving issue that is rapidly increasing in speed.... And "we have to react with speed and scale."

While declaring a climate emergency does not compel a local or regional government to act, it does highlight the scale and severity of the problem, and certainly signals the urgency required to address it. "It is easy to be complacent when you hear the word climate change all the time – we need to step up the way we are messaging the climate crisis with language that reflects how serious it is." (McLachlan, 2019)

With INQUA just around the corner we anticipate that this will be a much-discussed topic.

In this issue of Quaternary Australasia Leoni Peti reflects on the December 2018 AQUA conference keynote speakers, with an analysis of the gender break down of attendees, based on information from Tim Barrows and Jessica Reeves. There are Field Reports from Heather Haines (an AQUA travel grant recipients and this issue's 'Meet a Member') and Mariani Connor and an update on the Anthropocene global markers from Larissa Schneider and Simon Haberle. We also reflect on tributes to Bob Galloway and Tony Martin; both who passed away earlier this year.

We look forward to seeing AQUA members in Dublin at the XX INQUA Congress. To be sure!

Yours Quaternarily,

Sanja van Huet and Carol Smith
Co Editors

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PRESIDENT'S PEN

Dear fellow AQUA members,

It's the end of a teaching semester for many in Australasia and the start of field seasons for those that work in the hotter parts of Australia. Having just returned from the Northern Territory where the fly population is very much alive and well the AQUA team wish you the best for any pending fieldwork. We have some new faces on the AQUA executive after our last annual general meeting in May so I would like to take the opportunity to thank Georgina Falster and Emily Field who are stepping down from their roles on the AQUA executive. I would also like to welcome two new faces; Heather Haines (Treasurer) and Alex Wall (Secretary). One of the decisions which we are in the process of enacting is the reduction in the cost of AQUA student memberships. We would encourage all full members who have students (Honours, Masters or PhD) to motivate their student cohort to join AQUA. Next year annual subscriptions for students will drop to $25 with QA hard copy / $20 electronic.

INQUA is almost upon us and we had an extremely high calibre of applicants for the AQUA travel awards. In this issue we formally announce the successful recipients. Many of these also secured funding from elsewhere showing the calibre of Quaternary science in Australasia at present. For those that are attending INQUA we are organising an AQUA meeting on Tuesday 30th July, 13:30 – 14:30 and we will also advertise for an AQUA social event.

Lastly and on a sad note the AQUA community lost another great scientist. Bob Galloway was a well renowned Quaternary scientist (and an AQUA president) and in this issue Several AQUA members reflect on Bob's many salient contributions and his life as a very important figure in the Quaternary sciences.

Tim Cohen
AQUA President

AQUA 2018 TRAVEL RECIPIENTS

Georgy Falster, The University of Adelaide

Leonie Peti, The University of Auckland

Haidee Cadd, The University of Adelaide

Xianglin Zheng, The University of NSW

Mandy Shao, The University of Adelaide

Elise Thornton, Federation University

Heather Haines, Griffith University

AQUA 2018 PRIZE WINNERS

Best poster (joint winners):
Valerie van den Bos, Victoria University of Wellington;
Charlie Maxson, The University of Adelaide

Best non-PhD presentation:
Sarah McDonald, The University of Adelaide

Best student presentation:
Haidee Cadd, The University of Adelaide

INQUA TRAVEL PRIZE RECIPIENTS

Valerie De Bos, University Wellington

Heather Haines, Griffith University

Stacey Priestley, ANSTO

Georgina Falster, Geoscience Australia/University of Adelaide

Tim Pollard, University of Melbourne

Ellen Corrick, University of Melbourne

Tegan Hall, University of Sydney

NEWS

Prize winners from the 2018 AQUA Conference

Congratulations to everyone who was awarded a travel prize to attend the AQUA conference.

Best Poster (jointly awarded): Valerie van den Bos Victoria University, Wellington, N.Z; Charles Maxon, University of Adelaide, South Australia.

Best Student Talk (Hons or MSc): Charles Maxson, University of Adelaide, South Australia.

Best non-PhD presentation: Sarah McDonald, University of Adelaide, South Australia.

Best student presentation: Haidee Cadd, University of Adelaide, South Australia.

Figure 1: The award winners: Valerie Van Den Bos, Charles Maxson, Sarah McDonald, Haidee Cadd.

Figure 2: The travel award prize winners: Back row – Georgy Falster, The University of Adelaide; Leonie Peti, The University of Auckland; Haidee Cadd, The University of Adelaide; Xianglin Zheng, The University of NSW; Mandy Shao, The University of Adelaide. Front Row – Elise Thornton, Federation University; Heather Haines, Griffith University

MEET A MEMBER OF THE AQUA EXECUTIVE COMMITTEE

HEATHER HAINES, AQUA TREASURER

Heather is an adjunct research fellow at the Australian Rivers Institute, Griffith University where she completed her PhD in 2018. Born and raised in Toronto, Canada she spent many years of her youth camping, hiking, and exploring the Boreal Forests around her home. A love of science and the outdoors led Heather to earn her BSc from the Department of Geography at The University of Western Ontario in London, Canada where she reluctantly took a final year course in dendrochronology. Three weeks in she was hooked on tree-ring science and managed to earn a summer student position in the Dendrogeomorphology Lab. After falling in a bog on a day of field research and not complaining about being covered in mud her supervisor was suitably convinced that she was actually tougher than she looked and offered her a spot to undertake her Master's research. Over 7 years Heather worked as a research scientist in the Western Dendro Lab while completing her MSc with several summer field seasons spent in the glacial environments of the Canadian Rocky Mountains. After moving to Australia and finishing up her Master's degree in 2012 Heather was unsure about how to undertake a PhD project as there are very few dendrochronological research programs in Australia. Through word of mouth from members of the AQUA community Heather was directed to an ARC Linkage project at Griffith University looking for a PhD student to reconstruct rainfall using tree-rings. It was a perfect match and Heather found her niche working in tropical dendrochronology. She now hopes to continue her Australian based research and increase the use of dendrochronology across the many environments of this massive country.

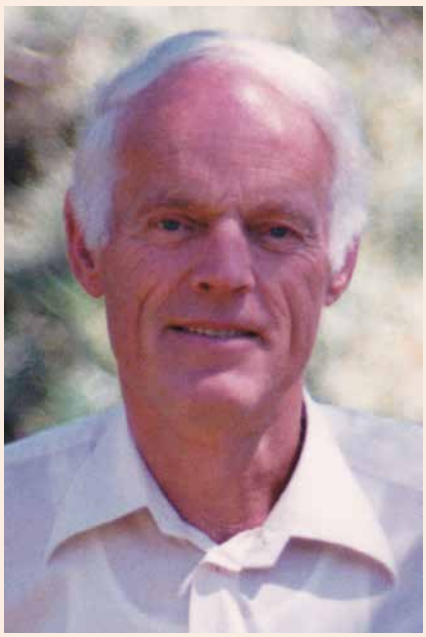
Heather inside an ice cave on Mount Edith Cavell, Alberta, Canada.

While she does still miss her home in 'The Great White North' Heather has felt overwhelmingly welcomed by the AQUA community and is happy to give back in the role of Treasurer. In her spare time Heather enjoys running, reading sci-fi novels, and supporting the Ottawa Senators and London Knights Ice Hockey teams.

A TRIBUTE TO ROBERT (BOB) W GALLOWAY (18 AUGUST 1929 – 1 APRIL 2019)

Tim Barrows

Professor of Environmental Change, Department of Geography, University of Portsmouth, UK; Future Fellow, University of Woolongong



Bob Galloway: Photo credit Carolyn Galloway

Bob was born in Banff, Scotland where he lived the early part of his life. He graduated with undergraduate and Masters Degrees in Geography at the University of Edinburgh in 1951. He attained a scholarship (for the princely sum of £300/year) and stayed on at Edinburgh to complete a PhD looking at periglacial phenomena in Scotland. Part of his scholarship allowed him to travel for a year to other departments in Europe to visit a professor who was an expert in periglacial geomorphology. He spent 9 months in France and 3 months in Germany. The budget was tight and he mapped most of his field area by push bike because he couldn't afford a motorbike. At one stage in France at the end of 1953 he was down to only £1 and could only afford 1 kg of apples, which he ate all at once. His studies were interrupted when he spent 2 years in military service from 1953-1955 as a soldier, including a tour in cold war Western Germany, and received a commission as a pilot in the army.

At the end of his PhD he was looking for work and noticed that the CSIRO were looking for graduates through Australia House in London. He jumped at the opportunity and came out to Australia on the October long weekend of 1958. Bob's job was flexible in that he could divide his time between CSIRO regional surveys and independent research. The CSIRO Land Research Surveys were an important part of Bob's career and comprised much of his output.

The regional surveys were largely from aerial photographs with some fieldwork where Bob supplied expertise as the geomorphologist. The approach gave birth to the "land systems" approach now widely used in geomorphology. He co-authored 7 surveys such as "Lands of the Alligator Rivers Area, Northern Territory", up to the programme's close in 1977, something of a dramatic change from the highlands of Scotland. He worked on many volumes with Bob Story and Bob van der Graaff, together known as "three bobs worth".

Bob developed an interest in Lake George and the Snowy Mountains from 1960 onwards, being based close by in Canberra. He is best known for the two sole-authored papers in 1963 (on the glaciation at Kosciuszko) and 1965 (on Lake George's climate history). It is hard to overestimate the importance of these two works, which together represented a watershed in Quaternary geology and climate interpretation of the late Pleistocene, and are still a good read 50 years on. The 1963 paper ended half a century's worth of speculation on the extent of glaciation in the Snowy Mountains. The prevailing model at the time descended from the end of the 19th century and consisted of a three phase model of glaciation through time. The first was a large ice cap covering most of the high altitudes, succeeded by a phase of valley glaciation, followed by cirque glaciation. Bob's model was elegant in its simplicity and showed the bulk of the evidence for glaciation outside the cirque phase could be explained by periglacial or other processes. His approach stressed the importance of equifinality in granite landscapes. The competition followed up with a rebuttal, but one which never openly referenced Bob's paper. The authors even tried to have Bob's paper retracted, but the test of time has shown that it was their work that faded into obscurity.

Bob's work on Lake George combined a keen eye for geomorphology with an analytical mind. The work consisted of three parts. The first was to map the extent of periglacial deposits in south-eastern Australia. Bob's work in Scotland meant he was ideally placed to recognise deposits others had not noticed. Through a lot of walking (Bob was a keen member of the Canberra Bushwalking Club) he made the first map of the extent of periglacial solifluction in southeast Australia. Bob used the relationship of the treeline with solifluction to estimate palaeotemperatures during the late Pleistocene, at least 9°C colder in the Canberra region, a number which many colleagues were uncomfortable with at the time. Secondly, Bob built on his work in the Snowy Mountains to estimate the height the snowline rose at the end of the ice age. Combining this with the periglacial limits he showed that precipitation was probably half that of today.

Thirdly, he used his observations of high lake level stands at Lake George to show it had more water in it during the ice age. Using his temperature estimate, he showed that the lake could be maintained at a higher level on less than half modern precipitation.

Later in his years, Bob worked on a snow cover model (1988) which he used to not only explore the extent of snow during the last ice age but also to estimate how snow as a resource would decline with global warming. We've recently revived this model and found it needed little updating.

Bob's papers had a very strong influence on me as an undergraduate student. I was enthralled by his perceptive eye in the Snowy Mountains and fascinated by the line of reasoning he constructed to elegantly show that precipitation had to be lower during the coldest times, despite the landscape being flooded with water. I couldn't wait to show him my Honours field site in 1995 that clearly supported his ideas of low altitude periglacial activity. We looked at scree slopes I'd identified on the southern slopes of Black Mountain. Bob was very interested because he hadn't spotted them after decades of walking across Black Mountain to work. We also looked at a gully section with fan deposits clearly showing slope instability at low altitudes in the past. A measure of the integrity of the man was a story he had about the gully. During one walk around the mountain he found a full set of golf clubs thrown into the gully by a thief. Many people I know would have taken them home, but Bob took them to the police station. A few weeks later they called him and asked him to come and collect his unclaimed golf clubs. He was also very generous and gave me his library when he retired. On a subsequent trip in 1997 to Kosciuszko where I was remapping and dating moraines he had identified, he became a personal hero of mine when we reached the top of Mt Twynam and he pulled a beer out of his backpack!

Bob published 92 journal articles (including 2 in French), book chapters, surveys, report sections, technical memoranda, conference papers and science communication articles. Much of this grey literature isn't well known today because it doesn't make its way into electronic bibliographic databases and because some journals haven't fared well with time.

Bob served as President of the Australasian Quaternary Association from 1989-1990.

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A TRIBUTE TO BOB GALLOWAY

Bob Wasson

Bob Galloway was one of the finest geomorphologists to have worked on the Australian continent and I owe him a considerable personal debt.

My first knowledge of Bob came when I heard him speak on a few occasions in Canberra while I was first at ANU. He spoke particularly about his 1965 paper in the Journal of Geology in which he had quantitively reconstructed climate for the Late Quaternary in Australia, paying particular attention to Lake George. But I didn't get to know him until 1982 when he became my boss at the Division of Land Use Research, CSIRO. He and I designed a research program to document the historical trajectories by which the Australian landscape had reached its current (often parlous) state. The point was to understand this trajectory and its causes so that remediation would be more effective.

Bob's experience of the very impressive land system surveys, that had been in vogue in CSIRO as a basis for development, was highly relevant to our plans because he understood landscape not as a static palimpsest of rocks, soils, landforms and biota, but as a dynamic set of interactions driven by climatic and geomorphic processes. His Quaternary expertise was critical to this view, and one that he somehow managed to maintain at a very high level despite all of the other calls on his time. He also recognized the impact of European land use, and that was what we focused on.

So, we set about designing how to use reservoir sediments as an archive of catchment changes, married to catchment sediment budgets. Bob was involved in many parts of this endeavor, and I recall that even he, a Scot with field experience in the Scottish Highlands, found some winter days on the Southern Tablelands surveying gullies and farm dams and their sediment contents, all too much. He was not the only one! But for much of the time we devoted to this research, he was in the background, providing advice and encouragement.

Bob's lasting legacy was his demonstration that we could blend basic and applied research in the application-oriented organization of CSIRO, although at that time the organization had a freer hand than it does now. This had a huge influence on my career, and it was very much in my mind as we developed the use of geochemical tracers of sediment sources. If we were to successfully apply these methods, we had to understand them, and that understanding when we started was limited.

Bob was also a fine boss. He understood, as did the then Chief of the Division Dick Millington, that creative people need to be given bounds and then left alone to get the job done. They don't need to be constantly assessed. And if there is evidence of wayward behaviour, reason is used not threats to get people back on track. This was Bob's style and I very much appreciated it.

So, these are to me the key legacies of a fine geomorphologist who I am pleased to have worked with. But I don't want to end this by giving the impression that we only had a working relationship. On fieldtrips we would engage in spirited debates about the British Empire, the nature of research, and how best to extract money from the pokies in RSL clubs. The Scot rose to the fore dealing with pokies. RSL clubs had their pokies at the front of the building, before you could get to the restaurant. Bob would insert the smallest coin possible and would always win! What a record. He also had a great sense of humour which he employed in many different circumstances. In seminars this was sometimes disarming for the speaker, and therefore very effective. And he would speak with great affection of his family in Canberra while we travelled many hundreds of kilometers together.

A TRIBUTE TO BOB GALLOWAY

Bruce Thom

I will never forget my first meeting with Bob Galloway in Sydney in 1961. He had recently arrived in Sydney and was taking up his position in Canberra with CSIRO. I had heard from contacts in Canberra, Joe Jennings, I think, that Bob had undertaken periglacial research for his PhD in Scotland and was keen to discuss periglacial-glacial studies in the Snowy Mountains. I had just spent the summer with Alec Costin's team (Alpine Ecology, CSIRO) looking at solifluction features and was only too delighted to meet and talk to someone who knew a lot about such features. Bob was certainly the man. For the first time in Australia we had an expert in this area of geomorphology who could tell the difference between glacial and periglacial features.

Why was this an issue? For decades the geological establishment in Australia led by the eminent W.R. Browne, had determined a glacial history for the Snowy region on the assumption that glacial processes were the driver for landscape features. Their experience of periglaciation was very limited. Joe had recognised this and saw in Bob a person who was able to critically review the evidence. Bob proceeded to do this. He walked over much of the area during the summer of 61-62 and I had the pleasure of joining up with him on several occasions. There was even a visit by Browne and colleagues to try to reconcile different interpretations. Bob was not fazed by their eminence. He demonstrated how many landforms were not the result of glacial deposition but due the periglacial effects. This was later published in the Linnean Society proceedings. The significance of this was profound in my view. Bob had emphatically highlighted the need to see this landscape through different eyes, eyes trained to see the impact of processes other than those of geologists who had focussed on a different model of landscape evolution. So from 3 glaciations we went to clearly just one with a range of periglacial impacts. This was a major breakthrough.

Bob set to work with CSIRO Land Research on regional surveys across Australia. He was a member of a team which undertook enormous amount of field work to establish patterns in landscape evolution and function. It followed an established model that required collaboration with other field scientists. The product of these regional surveys at the time was an improved understanding of interrelationship of landforms, soils and vegetation that was breathtaking. Through the many well-documented reports, it provided a better context for understanding constraints and opportunities in the development of Australian lands. I recall his involvement in such a study of the Hunter Valley. This work enabled him to address other questions such as Quaternary history including sea level change. Standards were set by these teams as to how to conduct such surveys using tools available at the time. Although they may not be used so much today, I am of the view that without them we would still be searching for ways to define at a regional scale the inter-relationship of land processes in the way shown by these teams—Bob was a key member of this outstanding work.

While at CSIRO and later, Bob's interest in the Quaternary remained and this led to several significant papers. Here his Scottish background and initial Snowy work was enhanced by an appreciation of how climatic change has impacted on landforms and just what could be inferred from those landforms about the nature of climate change. I am reminded of his work on water balance at Lake George during the Quaternary. Later he started to apply this knowledge to projections of impacts of future climate under global warming such as snow cover in the Snowy Mountains. This was far-sighted thinking for which he is widely acknowledged as an early leader.

I must also note his contribution to the discipline of Geography. He served the Institute of Australian Geographers for many years including as an Editor of its journal. This is often a thankless task but he served with great dedication to which I as a former President of IAG am extremely grateful.

TONY MARTIN - A PIONEER OF AUSTRALIAN PALAEOECOLOGY

Geoffrey Hope and Michael Macphail

Archaeology and Natural History, School of History, Language and Culture, Australian National University, Canberra, ACT, Australia

A.R.H (Tony) Martin was born on 26 May, 1926 in Coventry, UK and studied in South Africa in the early 1950's. Tony's research was both in African pollen morphology and in the vegetation history of Groenvlei, coastal swamps on the south-eastern part of South Africa. He was awarded a PhD in 1955 for his Groenvlei work by the University of London, where he spent 2 years as a PhD student supervised by Prof W.H. Pearsall.

His early connection with Australia was the publication of his stratigraphic results in the new *Australian Journal of Botany* in 1958.

In 1956 he and his wife Daphne and daughter Clare moved from Rhodes University in the Eastern Cape province, South Africa to Australia to take up a lectureship in Botany at the University of Sydney. This position had been created at the urging of Alec Costin, whose seminal work in mapping the soils and vegetation of the Snowy Mountains from 1950-1954 had raised many questions about the history of the communities there, including long term fire effects.

On arriving in Australia with his family Tony looked at coastal swamps near Sydney and north to Myall Lakes and New England. He soon started a long research effort in the Snowy Mountains. He also continued his work on pollen morphology and pollination mechanisms, with a particular emphasis on the Proteaceae.

Tony set up a palynology laboratory at Sydney University with a comprehensive modern pollen collection and submitted numerous carbon dates to the Sydney University radiocarbon laboratory.

Tony lectured in systematics and ecology and started the first palaeoecology course in Australia, which leant heavily on his work in NW Europe.

Tony supervised both Azra Khan for his PhD on the Tertiary palynology of New Guinea and the late Bob Selkirk for his PhD on Tertiary fungi. He guided M.K. (Mike) Macphail for an Honours study of Fingal Bay, north of Newcastle.

Mike went on to complete his PhD on Tasmanian post-glacial vegetation dynamics at University of Tasmania. This occasioned a rift between the developing activities of a newer entrant to Quaternary palynology, the Department of Biogeography and Geomorphology at ANU, which despatched students to Tasmania and the Snowy Mountains in the 1970's, in apparent ignorance of the work already underway on related sites by Tony and his students. In the early 1980's this was patched up when Tony became a visiting fellow for a year at ANU department, a time that let him complete several palynological projects.

There is a curious history of palynology (and community ecology) having been supported in the 1950's and 60's in botany departments such as Melbourne and Sydney. These departments were captured by new international fashions so Australian-centred disciplines such as historical, and even community, ecology were widely abandoned in the 1980's. Staff like Tony at Sydney and Isabel Cookson and Suzanne Duigan at Melbourne were poorly supported and not replaced when they left. Nearing his retirement in 1991 Tony's dedicated lab was stripped and valuable collections were taken to the dump in his absence. A small permanent gas leak in the lab was discovered, explaining a persistent smell of gas over the years. The centre of gravity for vegetation history and biogeography moved to geography departments (as they were quaintly called at the time).

In retirement Tony published notable papers on Kurnell dunefield fens and Kosciuszko bogs at Diggers Creek as well as a major study on alpine vegetation with Peter Clarke. He entrusted unpublished data on peatlands to ANU, some recently incorporated in a paper on Rennix Gap bog (Hope et al., 2019) while his peat dates are published in Hope and Nanson (2015) with the help of Richard Gillespie and old Sydney radiocarbon files.

Tony was an excellent field ecologist and had an outstanding knowledge of coastal and subalpine plants. His work sought to link pollen data to vegetational structure. Somewhat of a perfectionist, he was slow to complete projects until all details were available. Quiet but sociable, he was an incisive mentor and inspiring to work with in the field and laboratory. His death in January 2019 leaves an under-appreciated legacy of achievement in our knowledge of the Snowy Mountains and coastal swamps.

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GETTING STARTED WITH PAST LAND-COVER RECONSTRUCTIONS IN SOUTHEAST AUSTRALIA

Michela Mariani[1,2] and Simon E. Connor[2]

1 University of Nottingham, Nottingham, UK

2 Australian National University, Canberra, Australia

During the last 70,000 years, two main phases of human-driven landscape transformation occurred in Australia: the arrival of Aboriginal peoples and European colonisation. What are the legacies of these transformations in today's terrestrial ecosystems? To reconstruct past vegetation, we traditionally rely on the analysis of pollen grains preserved in lake or bog sediments. However, pollen analysis has some important biases that have been puzzling palynologists since the beginning of the discipline more than 100 years ago (Birks & Berglund, 2017). For instance, different plant species produce different amounts of pollen which submit to the laws of particle motion in different ways. Fortunately, these biases can be overcome with recent modelling techniques involving models for pollen dispersal (Sugita, 2007; Theuerkauf *et al.*, 2013).

To get started with quantitative land-cover reconstructions, the first step requires the creation of modern pollen-vegetation dataset to estimate pollen productivity and dispersal of key plant taxa (Figure 1). The overall methodology was previously applied in Tasmania, Australia (Mariani *et al.*, 2016; Mariani *et al.*, 2017), although the suite of plant taxa needed for reconstructing land-cover change in mainland Australia is different and a new calibration dataset is required. To fulfil this requirement, we organised an expedition around Victoria, Australia, in April this year. In order to better capture the native vegetation of the region, the fieldwork took place in the Alpine, Wilsons Promontory and the Grampians National Parks (Figure 2). GIS-based planning before the trip was undertaken to maximise the variety of vegetation types and plant taxa captured in the 9 days available to travel. Fire history maps were also factored in to avoid the collection of surface samples (moss) affected by recent burning. Some opportunistic sampling was also done outside National Parks, to take into account regional pollen transport from pasture and cropland.

We travelled more than 3,000 km (odometer reading!) and bush-bashed into most vegetation types around the state to capture the relevant plant taxa for past environmental reconstructions (e.g. *Allocasuarina*, *Eucalyptus*, *Acacia*, Poaceae, *Callitris*). A total of 25 surface samples were collected and plant cover % was determined for over 270 vegetation quadrats during the trip. The plan is now to use the information collected in the field to extract plant cover % in rings around each surface sample through GIS analyses. This information will be then used to model pollen productivities and dispersal using R. Once this calibration work is complete, we will be able to apply modelling techniques to quantify past land-cover changes from potentially any pollen record in the region, which will provide new perspectives on Australia's ancient landscapes.

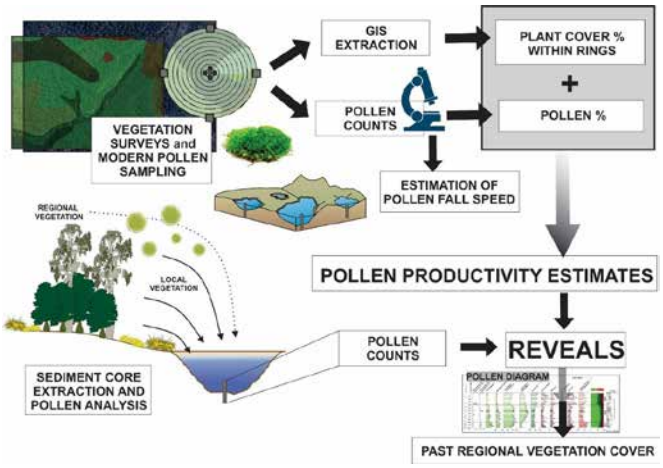

Figure 1: Workflow for regional land-cover reconstructions using the REVEALS model (Sugita, 2007). Credit: Michela Mariani.

ACKNOWLEDGMENTS

This work was supported by the Australian Research Council CABAH (Centre of Excellence for Australian Biodiversity and Heritage). Dr. Michela Mariani is the coordinator of the LandCover6ka REVEALS working subgroup for the Australasian region. Special thanks to Haidee Cadd and Matthew Adeleye for their help in the field.

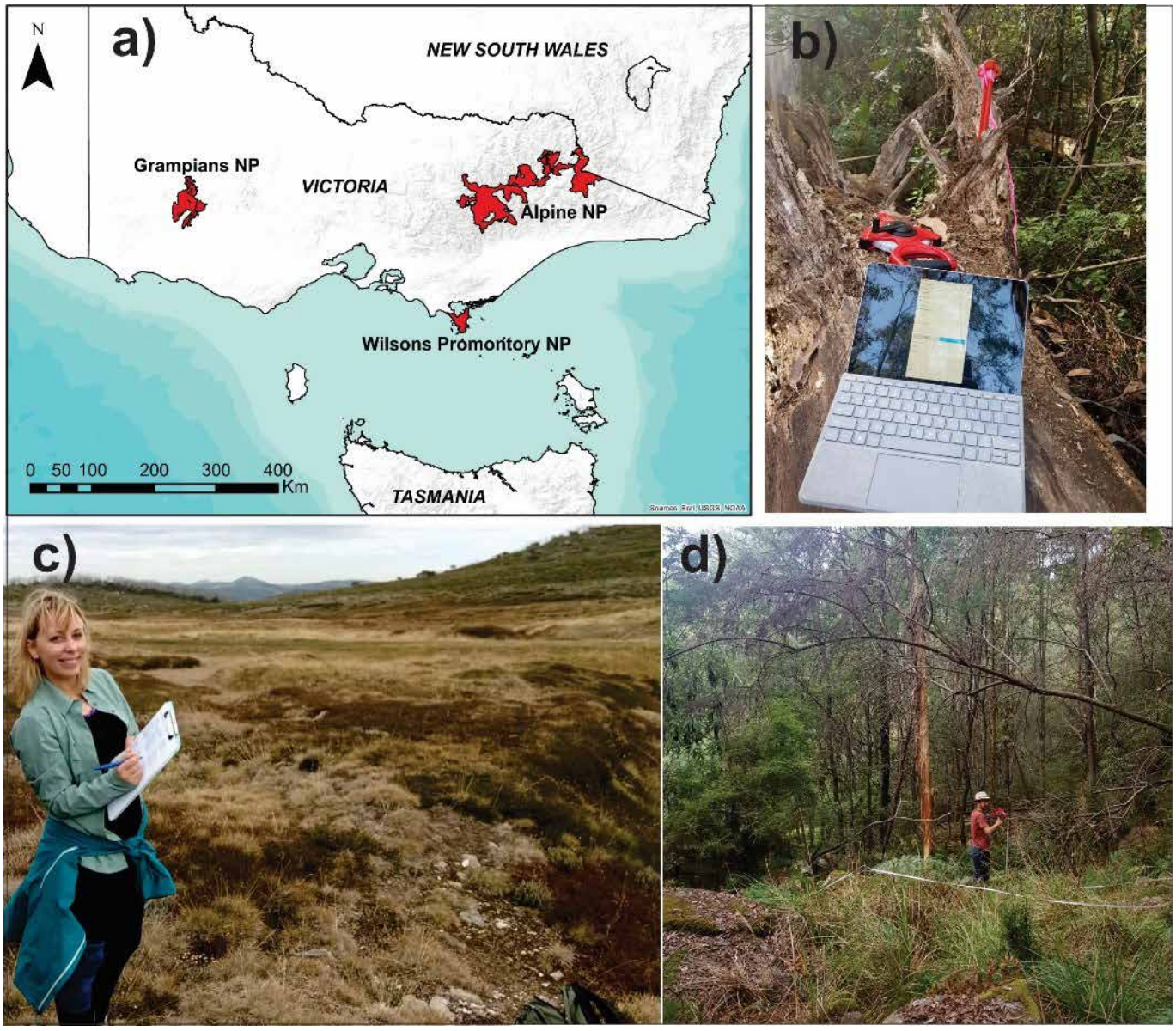

Figure 2: a. Map showing the location of the National Parks surveyed; **b)** high – and low-tech field equipment used for vegetation surveys; **c-d)** photographs taken during the fieldwork in the Alpine National Park. Credit: Michela Mariani and Simon Connor.

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AQUA 2018 CANBERRA: KEYNOTE LECTURES AND JOHN CHAPPELL MEMORIAL LECTURE

Leonie Peti

School of Environment, University of Auckland, New Zealand.

Each day of regular session presentations was crowned by outstanding keynote lectures (Figure 1). The wide variety in the background of the speakers and their topics truly highlight the diverse interests and interdisciplinarity of the AQUA community.

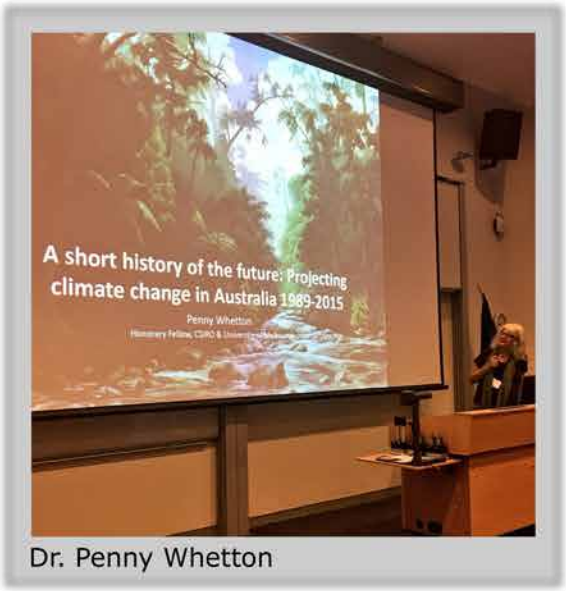
The keynote lecture of day one was given by Dr Penny Whetton on climate change projections in Australia. Penny presented her experience in climate projection work released in National Statements on Australia's future climate over the last almost three decades. The challenges of uniting climate modelling and research and management of climate impacts were certainly new material of thought but very interesting to the AQUA community. Important questions on the use and need of uncertainties to be reported to users were explored and illustrated with examples. The first keynote lecture of the conference clearly reminded everyone of what is at stake in the future and the responsibility carried by the wider climate science community – a great scene setting for the exciting science to come over the following days.

This outstanding lecture was followed by the John Chappell Memorial Lecture presented by Brad Pillans[1]. An outstanding Quaternary scientist and remarkable human came to life for the younger generation by the many great stories and anecdotes shared by Brad Pillans. In no doubt, beautiful memories were relived by those who knew John Chappell. Brad did a fantastic job celebrating the life and legacy of "the father of Quaternary research in Australia" (Prof. Bruce Thom) through stories, pictures contributed by the wider community and his detailed family tree of PhD supervisors.

At the end of the second conference day, Jonathan Tyler (University of Adelaide) gave an outstanding keynote lecture on chronological uncertainties. His call for more rigour with respect to reporting conclusions and their related uncertainties under the increasingly crucial role of paleoclimatological and paleoenvironmental data resonated with many of the AQUA community. Timing of changes and correlations of records are severely hindered by chronological uncertainties and Jonathan's work is on the forefront of exploring tools to address this in respect to paleo-data. The use of iterative Monte Carlo methods allows more robust assessment of the periodicity in paleoclimate records, probability of timing of events and the identification of regionally coherent patterns of change. This lecture has reminded the community to pay more attention to chronology development and uncertainty and offered numerical tools to solve many problems.

In the second keynote lecture on Tuesday, Tas van Ommen (Australian Antarctic Program), showed beautiful pictures from the Antarctic continent alongside fantastic science. Drawing on his extensive experience in ice core paleoclimatology and Antarctic glaciology, he presented a great overview of the findings drawn from the Law Dome ice cores and other near coastal high snow accumulation locations. Even though ice core science is not the trademark discipline of the AQUA community, the audience could easily follow his great talk. Teleconnections between Antarctic climate parameters such as snowfall and winds and Australian hydroclimate certainly hit close to home for most of the audience. Much work is left, and big questions need to be answered, hopefully by a multi-national deep ice drilling project led by the Australian Antarctic Program. After Tas' brilliant summary of the past and outlook to the future, the AQUA community can only wait for more exciting results.

1 See also Lambeck 2019 (Quaternary Australasia 35 (2), 8) and Williams 2019 (Quaternary Australasia 35 (2), 9)



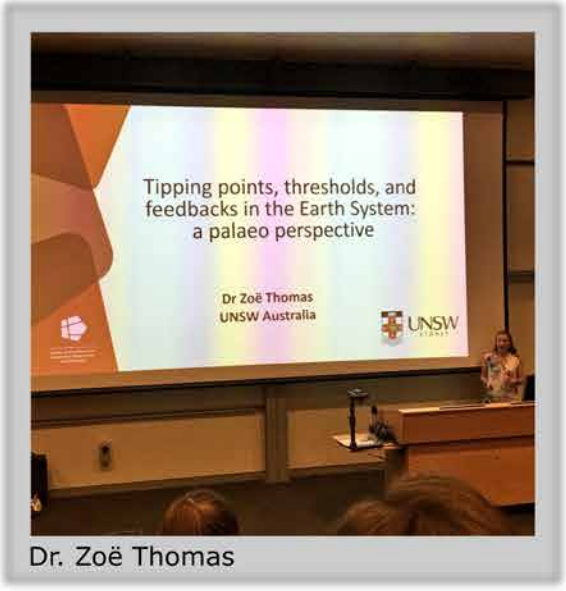
Dr. Penny Whetton

Prof. Brad Pillans

Dr. Jonathan Tyler

Dr. Tas van Ommen

Dr. Laura Weyrich



Dr. Zoë Thomas

Figure 1: Photos of all keynote speakers at the AQUA 2018 conference. Photo credit: Jacinta Greer (twitter: @jacinta_greer).

After a strong physics-focus in the keynotes of the first two days, Wednesday saw a shift towards biology: Laura Weyrich from the University of Adelaide took the audience on a ride; exploring DNA of micro-organisms and what we can learn from them about past climatic and environmental conditions. Careful sampling and laboratory techniques on diverse Antarctic samples point to past hydrothermal activity on the continent through novel metagenomic sequencing approaches. Conclusions such as a contribution of volcanism to glacial melt over 20 ka ago can be drawn in conjunction with geochemical, morphological and geospatial data. Laura concluded this outstanding presentation with a call to everyone to consider the potential application and scientific advances bacterial and archael DNA studies can bring to their field.

The final keynote lecture held on Thursday afternoon by Zoë Thomas (University of New South Wales) took the audience back to time-series data and many unresolved challenges. Zoë gave a fantastic introduction to the concept of 'critical slowing down': characteristic fluctuations in a time-series as a climatic or ecological system loses stability and approaches a tipping point. Detection of early warning signals before reaching the tipping point is of significant concern for future climate change. The search for tipping points and preceding signals in paleo-data sets is complicated by challenges related to low resolution and irregularly spaced data, as outlined well by Zoë. Her work focuses on late Pleistocene interglacial records with a special focus on the Southern Hemisphere. Changes in important tipping elements could have global impacts through a tipping cascade. Hence, the importance of Zoë's work on the forefront of detecting and quantifying tipping points and changes is obvious. However, parts of the audience could not stop wondering about the potential application of her skills to the stock market.

While the keynote speakers brilliantly highlighted the enormous diversity of the AQUA community, common themes of unanswered questions and challenges with incomplete, low-resolution datasets with chronological uncertainties have emerged. However, overarching all topics are ideas for effective (climate) science communication to politicians and the general population – An important reminder for everyone.

ACKNOWLEDGEMENTS

The author thanks the AQUA 2018 Organising committee for a fantastic conference, AQUA for the awarded AQUA travel prize supporting my attendance in Canberra.

The author would also like to thank AINSE Limited for providing financial assistance (Award – PGRA 12196) to enable work on chronology development of Auckland maar sediment presented at AQUA 2018 and financial support for the conference participation.

PARTICIPATION IN THE 2018 AQUA BIENNIAL MEETING

Prof. Timothy T. Barrows

University of Wollongong NSW Australia and University of Portsmouth, UK.

In late 2018, a study by Carter et al.[1] gathered data from 250 seminars in 10 countries and looked at the gender of the question askers. They found that female audience members asked proportionately fewer questions than male members. Furthermore, the gender of the second questioner appeared to be affected by the gender of the first questioner. This appears to indicate that women may be inadvertently discriminated against in the seminar environment. I know many confident, knowledgeable female scientists so I was curious as to whether these effects would show up at a local, friendly meeting like the Australasian Quaternary Association (AQUA) biennial meeting.

I collected data on the gender of all question askers at the 2018 AQUA meeting, including the order of questioner. I anonymised the questioner's identity. This survey was inspired by a similar survey conducted by Caroline Clason[2] in 2018 at the equivalent meeting in the United Kingdom—the Quaternary Research Association Annual Discussion Meeting. She found that males asked 77% of questions, despite being only 54% of the audience. Caroline did not test whether the order of questioner was influenced by the first questioner. She also did not test whether the gender of the session chair influenced the questioner. As an experiment to remove questioner bias, the 2018 AQUA organising committee arranged for all chairs to be female early career researchers. This created an opportunity to see whether questioner bias was influenced by this.

The data are summarised below. I also include the gender of the participants as recorded by the conference organisers.

Regarding possible biases; I was the only person who knew the data were being collected. I asked 4 questions, 1 first. One student that I know of was aware of Caroline Clason's study and I estimate that she asked approximately 20% of the female questions. Males dominated question-asking overall (62% M) and the first question (67% M), despite being the minority in the audience (45%). Females were marginally less likely to ask a question (or be chosen to ask) if a male asked one first (44% F). The numbers switch if a female asked the first question (67% F). However, the influence of 'order of questioner' is probably useful only as a general indicator, given the low counts (and certainly for Q3 onwards–data not shown).

	FEMALES	MALES
Registrations		
Students	15	14
Early Career Researchers	19	2
Academics	7	22
Keynotes	3	1
Others	4	6
Total	48	40
Talks	31	29
Chairs	all	0
Questioned speakers	26	23
Total Questions	53	88
No. M first Q[a]	33	M next 14
		F next 11
No. F first Q[b]	16	F next 8
		M next 4
Keynote Qs	2	17
First question		
F speakers	11	15
M speakers	5	18

Table 1. Participation data for AQUA 2018

a. Number of questions asked by males first, followed by the gender of the next questioner

b. Number of questions asked by females first, followed by the gender of the next questioner

What is going on here? AQUA is not an intimidating environment, and is well known for the participation of younger female and male members. I suggest that the answer probably lies in the gender makeup of the audience and their career level. Males dominated the audience in terms of "Academics" (76% M), which was self-declared during registration and probably represents those with ongoing positions. Anecdotally, I noticed most of the questions were asked by "academics", both male and female. It may be that those with more experience (and perhaps the security of a job?) feel most confident asking others about their work.

What about order of questioner? Where females asked the first two questions, the speakers were a mix of females (5) and males (3). Females asked notably fewer questions of male speakers, whereas gender was fairly evenly split for female speakers. From the speaker topics, there wasn't a noticeable clustering due to topics more researched by women (maybe apart from malacology). It does seem to be that when women ask a question, other women also speak up.

What about the effect of the chairs? There did not appear to be any effect on the gender of the questioner, since mostly males still had their hands up. I noticed on a few occasions that speakers over-ran their talks, even when they had ample warning of the time. This led to about 20% of talks not receiving questions. I suggest chairs could be drawn from the "academics" group (with 50% F, 50% M) since they might be more confident enforcing time and allowing for questions.

Lastly, it is worth noting one subset of data. Of the questions at the keynote sessions, males asked 89%! There are no excuses here. This is an environment where males are perhaps tempted to sell themselves more by asking an insightful question. This is most likely subconscious and is a very human behaviour, but perhaps there needs to be more self-awareness.

Questions are a vital part of a conference. In the early days of science, questions at meetings constituted the peer review for a paper. Feedback is important on our work before we publish and we need to share our ideas and expertise. But we need to have an environment where everyone is comfortable asking questions. I think we are on the road to that place but there is still a way to go, and further improvements will require conscious effort from both females and males. The gender imbalance in those with ongoing positions will take time to address as people move through the system, and we have a strong pipeline of female early career researchers. We need to be vigilant about creating an environment that reduces the historically appalling rates of attrition in women researchers. The organisers need to be commended for creating a great balance between gender and science at AQUA 2018.

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GENDER BALANCE AND AQUA CONFERENCES – A CONVERSATION

Jessica Reeves

Federation University, Ballarat, Victoria, Australia.

(With Contributions from: Tim Barrows, Helen Bostock, Tony Dosseto, Christine Kenyon, Georgy Maja, Sandra McLaren, Scott Mooney, Lynda Petherick, Jess Reeves, Georgia Roberts, Jacqui Tumney, Ingrid Ward.)

I had always considered (and still consider) the AQUA conference and AQUA community to be inclusive and supportive. I think most members would agree. In recent years, AQUA has been pro-active in including women, through adopting shadowing roles in the executive to encourage more female participation and supporting attendance at conferences for people with carer responsibilities. At the most recent conference, females were actively allocated chairing and organisation roles, as well as ensuring gender balance in keynotes and other presentations.

Elsewhere in this issue, Tim Barrows provides data he gathered on the participation of males and females at the recent AQUA conference.

"Studies have shown that males and females can influence each other's behaviour at seminars and meetings. I was curious as to what effect there might be at a local, friendly meeting like the AQUA biennial meeting. I was also curious as to the inclusivity of our meeting. Here is the participation data for Canberra 2018" Tim Barrows

The AQUA Facebook page hosted the statistical breakdown of Tim's data and an interesting subsequent discussion of gender balance followed. Whilst the thread commenced with Tim's data and some questioning of inherent bias, the discussion quickly broadened to what more can be done.

"Interesting. strong correlation between gender of seniority and order of Q – which is not really surprising"

"Rather than participation I think the more critical thing to address is this well-known gap: ECR's 19 (F) 2 (M): Academics 7 (F) 22 (M)".

Suggestion... "a mentor whose role would be to discuss career development with female EMCRs, encourage them and guide them through promotion."

" ...having a coordinated national framework would be good."

Members then suggested some of the existing programs in place at a national level:

"the Academy is working on the Women in STEM decadal plan: https://www.science.org.au/supporting-science/gender-equity.

Also STA is doing some pretty progressive stuff through the Superstars of STEM program: https://scienceandtechnologyaustralia.org.au/.../superst.../"

"...interesting... I've tweeted 'Women in STEMM Aust': "Some organisations have a senior mentoring program like this in place including @MonashUni and @WEHI_research, and others. Still in early years, but it would be excellent to see the outcomes over 5-10 years." https://www.monash.edu/gender-equity/programs/shadowing https://www.wehi.edu.au/about/institute-life/gender-equity"

"I'm aware of the 'Superstars of STEM' initiative... with all due respect, awards and media exposure are good, but what we need are concrete solutions and actions

"I agree with you. Increasing visibility is important...and can certainly help with promotion, but there are more systemic issues to address"

Members then questioned if the issue was in attracting or maintaining women in science – particularly in the conversion from Post-Doc to tenured academic:

"The 2 year 'gap' that is permissible in CVs across early careers to allow time to find the next opportunity or have children is a tough one from experience."

"...while mentoring is helpful...first the women have to get the jobs...there are lots of studies that show that males are more likely to be interviewed even if they have same qualifications as women"

"Both in the writing and assessing of applications. I think there can be a place to assist women in writing more 'confident' applications – I have certainly helped female students with this. Also blind assessment of applications – that is removing gendered-ness of applicant. this has been very successful in a lot of fields"

On a positive note, several members commended AQUA on its efforts for gender equity:

"I think the (AQUA) organising committee should be commended on F & ECR representation in keynotes, chairs, etc."

"Yes, that clearly shows that where we CAN take action, we can have a tangible effect. If we encourage our female colleagues to go for promotion, assist them with career

development, as well as AQUA was organised, the scientific community would be in a much better shape gender-wise!"

Although childcare remained an issue...which as far as I know, is yet to be resolved for Dublin INQUA.

"A small (but significant) step we could take as a community would be to think about childcare at our AQUA meetings".

"Totally agree. also supporting people taking carers leave to attend conferences more generally"

"I had a huge problem finding day care in Canberra. Most places won't do occasional care and three centres didn't even bother replying to me."

"Re: day care, students usually have child-friendly mates who are interested in making $$... perhaps at a spare room at the venue."

"... just for the record: I tried to organise childcare for the Canberra meeting and got no response in most cases and a negative response from one place."

As well as the Facebook messages, several female academics sent through longer responses via email (thank you) of some of the former shortfalls and more recent advances.

"This has been a topic since before the Cairns INQUA meeting..."

"At Cairns INQUA all the keynote speakers were male. We had several complaints from overseas female researchers and at least one did not come to the Congress in protest"

"We did get comments at the Cairns INQUA that there was no child-minding provided and I must admit I did not think of it when we were planning the conference."

"I am sure AQUA could organize child-minding provisions at conferences on a user pays system"

"For me field trips, when the children were young, were difficult as my husband was often away for work. Guilt was a big part of field trips and ... going to conferences"

"There are just not enough positions available in Australia. An academic needs to attract grant money ... but positions are usually one/two year contracts. I don't know how people plan a life on short-term contracts."

...and...

"In the interest of keeping things positive, I'd have to say that getting my DECRA – and ... getting the exemption from ARC to acknowledge the 12 years or so of career disruption – was a big tick towards advancing gender (and age) equity by the ARC"

"What I would like to see is more schemes like they have in the UK, such as the Daphne Jackson fellowship, which is aimed at providing an opportunity to return to a research career after a break (https://daphnejackson.org/about-fellowships). It's a great scheme because it also includes an element of retraining – a critical element in many science streams. A similar scheme is the Wellcome scheme (https://wellcome.ac.uk/funding/research-career-re-entry-fellowships)"

"All these are highly competitive schemes but at least offer some hope for those who've had a career disruption for whatever reason"

"Similarly I'd like to see more childcare travel grants such as that offered by ESA (https://www.ecolsoc.org.au/awards-and-prizes/esa-conference-awards- grants/esa-conference-childcare-travel-grants) and Capstone (https://www.capstoneediting.com.au/travel-grant)"

AQUA would be very happy to continue this discussion and see how we as a community can do things better. Feel free to send through any more thoughts on this issue to the AQUA Facebook page or editor@aqua.org.au.

Clockwise: Mothers in the field. Photo credits: Jess Reeves. **Figure 1:** Sharon Reid and Darby tracking carpet pythons in the Warby Ranges, 2000. **Figure 2:** Georgia Roberts and baby James GPRing wombat burrows. **Figure 3:** Jess Reeves and Henry AQUA, 2008, Coorong. **Figure 4:** Sandra McLaren, fieldwork Wentworth, 2016

UNDERSTANDING THE FOREST THROUGH THE TREES: AN ACCOUNT OF MY FIRST 5 YEARS OF FIELD RESEARCH IN AUSTRALIA

Heather Haines, AQUA 2018 ECR Travel Grant Recipient

Griffith University, Queensland, Australia

In 2013 I had the opportunity to begin a PhD project undertaking dendroclimatological research in the tropics and subtropics of Queensland. As a Canadian with 7 years of dendro training behind me mainly in temperate bogs or at alpine treeline I had no idea the challenges and amazing experiences I was about to face. In the late 1970s and early 1980s tree species in the Australian tropics were placed in the "too hard" basket for dendrochronology and the recommendation given was to focus on temperate Tasmania. Improvements in technology and modern analytical methods have caused the tropical Australian regions to once again become an area of interest. However, my knowledge of dendrochronology and all the reading in the world could not have prepared me for the experience of working in tropical forests.

By my first day in the field in Lamington National Park I was determined to better understand this beautiful and unique part of the world (Figure 1). But the work was not without its challenges and I soon began a list of things I needed to remember. Some of my most notable entries are:

1. The flora is as dangerous as the fauna! Wear gloves & undertake research on "stinging trees"
2. SPF 50 mandatory – is there anything higher???
3. Snakes sunning themselves on a ledge will not move – find a way around, don't poke with stick
4. Take note of small streams in the rainy season – they become fast flowing rivers in minutes

Regardless of all the challenges after my first look at a majestic giant *Araucaria* tree I knew that I needed to learn what these trees could tell me. Living giants are rare in the tropics and Australia has a few species that have the potential to contain century's worth of climate data. Of course to learn their stories I would first need to learn how to core them. Tree coring is a significantly more difficult process in tropical 'softwood' species (Figure 2) than normally encountered with temperate species. To ensure my ability to gather the longest series with the best data I not only learned new techniques but also joined a gym just so I would have the strength to handle the required equipment.

Since my original field forays in Southeast Queensland I have had the pleasure of visiting many more forests across Australia – each is as unique and enchanting as the last. I have visited the cloud forests inland of Cairns to measure growth in *Agathis atropurpurea* trees, discovered the after effects of massive bushfires in the Victorian ranges, examined European transplants in the Karst systems of the Blue Mountains, and had the pleasure of sampling bogwood at the famed Mt Cook dendro site in Tasmania.

While it seems as if I have covered much ground so far in my research I feel as if the Australian dendro community has only begun to scratch the surface of what there is to learn. To go along with my extensive forays into the field I have been working in collaboration with researchers at Griffith University, CQU, ANSTO, and UNSW to improve the analysis techniques we are using in tropical dendrochronology. I was extremely grateful to receive funding from AQUA to attend the 2018 conference in Canberra to present on some of the results of this research. If you missed out on my Canberra talk or are keen on learning more you can catch me in the "Continuous records of tropical climate and environmental history" session at INQUA in Dublin this July. Additionally, AQUA is heading into the Queensland tropics for our 2020 conference and I recommend to everyone to spend some time while they are there exploring the amazing Australian rainforests – a unique and awe inspiring region unlike anything I have experienced elsewhere.

Figure 1: The view from one of my fieldsites in Lamington National Park, Southeast Queensland, Australia Photo credit: Heather Haines.

Figure 2: Coring one of many giant *Araucaria bidwillii* trees in Bunya Mountains National Park – and yes I did manage to reach the centre! Photo credit: Heather Haines.

AUSTRALIAN QUATERNARY DATABASES: RETURN OF QUATDB

Tim Barrows

University of Wollongong, NSW, Australia and University of Portsmouth, UK.

The first digital database of Australian Quaternary data, QuatDB, was created in 1991. The project was jointly funded by the National Greenhouse Advisory Commission and the Bureau of Mineral Resources (now Geoscience Australia). The aim was to develop a database of palaeoclimate research and from this a set of palaeoclimatic maps for comparison with climate model outputs. The impetus for the project was the growing awareness of the impact of global warming. The database was designed by Geoff Hunt and Tim Barrows and written into ORACLE™ by Sonja Lenz (Hunt et al. 1996). The database was divided into 3 major sections:

1. Sites information
2. Datasets:
    a. Geomorphology
    b. Stratigraphy
    c. Palaeontology
    d. Palaeobotany
    e. Geochemistry
    f. Geochronology
3. Palaeoclimatic/palaeoenvironmental conclusions

The first step was to construct a bibliography to identify the appropriate literature (Bleys et al., 1994). Key sites, together with a set of sites likely to encompass most types of published data, were identified to begin data entry. Most of the data entry was in the form of site data and palaeoclimatic interpretations. With the Internet in its infancy, making the database available via the World Wide Web was a secondary consideration.

The conclusion of QuatDB was the CLIMANZ IV conference held in Canberra during February 1996. This was meant to coincide with the PAGES *Palaeoclimates of the Southern Hemisphere* (PASH) mapping project led by Tim Partridge together with Peter Kershaw as the Australian coordinator. CLIMANZ IV had its inception at the *Quaternary palaeoclimatic mapping: A protocol for Australia* meeting, chaired by Jim Bowler, at Monash University in 1992. QUATDB was used to provide the base maps showing sites and climate interpretations of key time slices, from the Holocene back to marine isotope stage 7. Unfortunately, the link with modelling through the CSIRO's Division of Atmospheric Research never came to fruition and the conference proceedings were never published (Chappell and Hunt, *manuscript*). However, the CLIMANZ maps were made available at a later date (Hunt and Barrows, 2000). The data collected for PASH also never made it onto the Internet and no maps of Australia were ever produced. Finally, the incoming government in 1996 dissolved Environmental Geoscience and Groundwater at the Australian Geological Survey Organisation (AGSO) where QuatDB was hosted.

At the end of 1996, the database contents were transferred from AGSO to Tim Barrows at the Australian National University, where he set up the Australian Quaternary Data Archive (AQUAdata). This was an attempt to keep the idea of the database alive but utilising the Internet to provide access to some of the database and to encourage users to contribute data to maintain its relevance (Barrows and Hunt, 1997; Barrows 1997a, 1997b, 1998). Take up of this idea was slow, combined with a lack of time and funding. Soon, international databases such as the World Data Center-A for Paleoclimatology and PANGAEA surpassed it. The public face of AQUAdata was taken down in 2012 from the AQUA website. My enthusiasm for providing data for the community declined after another research group used a database I put together and didn't acknowledge me.

Data format proved to be a major obstacle for QuatDB. Without digital maps, much time was wasted constructing lookup tables. There was no similar database with which to compare the field structure. Database design was iterative and was constantly adapted as new data became available. We attempted to include all data types, but the wisdom of this could be questioned when we were left with a gigantic, unwieldy database design. Specifically, we were discouraged from using a flat file system (such as text files and spreadsheets) and were forced to use the corporate database at BMR. The interface was a dinosaur even at that time and could not use spreadsheets, meaning all data had to be manually typed in, with rows and columns constantly duplicated. The database could only be interacted with through a VT220 terminal emulator. Reports had to be ordered days in advance and it was difficult to quality check the data.

In hindsight, the QuatDB project was a gargantuan task that suffered from mission creep. But once data entry began, it quickly became obvious that QuatDB could become more than what it was intended. With the rise of the Internet, QuatDB could become a powerful research tool. By 1994, the Australian Quaternary bibliography had already reached 1986 research items and with a large amount of grey literature, it was very difficult to perform a full literature search unless the topic was

narrow. We demonstrated the utility of using QuatDB as a research tool when we summarised climate output for the last glacial maximum (Barrows et al., 1996). We also quickly realised that palaeoclimatic interpretations had a finite shelf life and needed to be revised with time. We showed this by reanalysing the LGM data to construct a new set of maps (Barrows and Juggins, 2005).

The data entry component of QuatDB, without a research goal, proved problematic. For CLIMANZ IV (and the PASH project), paper forms were distributed for data contribution and then these had to be typed into the database manually, doubling the chance of transcription errors. Participation from the community was understandably slow. By employing the Internet and only dealing with digital files, AQUAdata solved some of these issues. However, take up was still slow. In the late 1990s there was a general reluctance to share the data that underpinned a paper. 20 years on and the next generation are far more conscious of data archiving and much more enthusiastic about utilising digital archives. Institutions and funding bodies now routinely use citation indices to measure performance, so it is in the best interests of workers to have their data available publically.

This article revives QuatDB by presenting the sites database via a geographical interface (Figure 1). Since the 1990s, online maps and digital globes have come of age and present an invaluable tool to explore the distribution of data. This interface uses Google Maps and is deliberately simple to begin. Geographic coordinates in QuatDB were either entered as presented in the paper, or estimated from maps in the paper or from a paper atlas. As can be seen from the map interface, the original data were sometimes questionable. Now, new coordinates can be entered into the spreadsheet or the marker can simply be dragged into the correct place for later refinement. Each entry is linked to its bibliographic record through a unique identification number. Basic information about the site is also presented, together with a list of the types of data that were found in the paper.

I invite people to use the interface as an exploration tool and to refine and add to the metadata that is available. A document is included on the site describing the database and how to contribute. Once the data have been checked over, I see a future in using a more powerful mapping tool such as ArcGIS online. In mapped

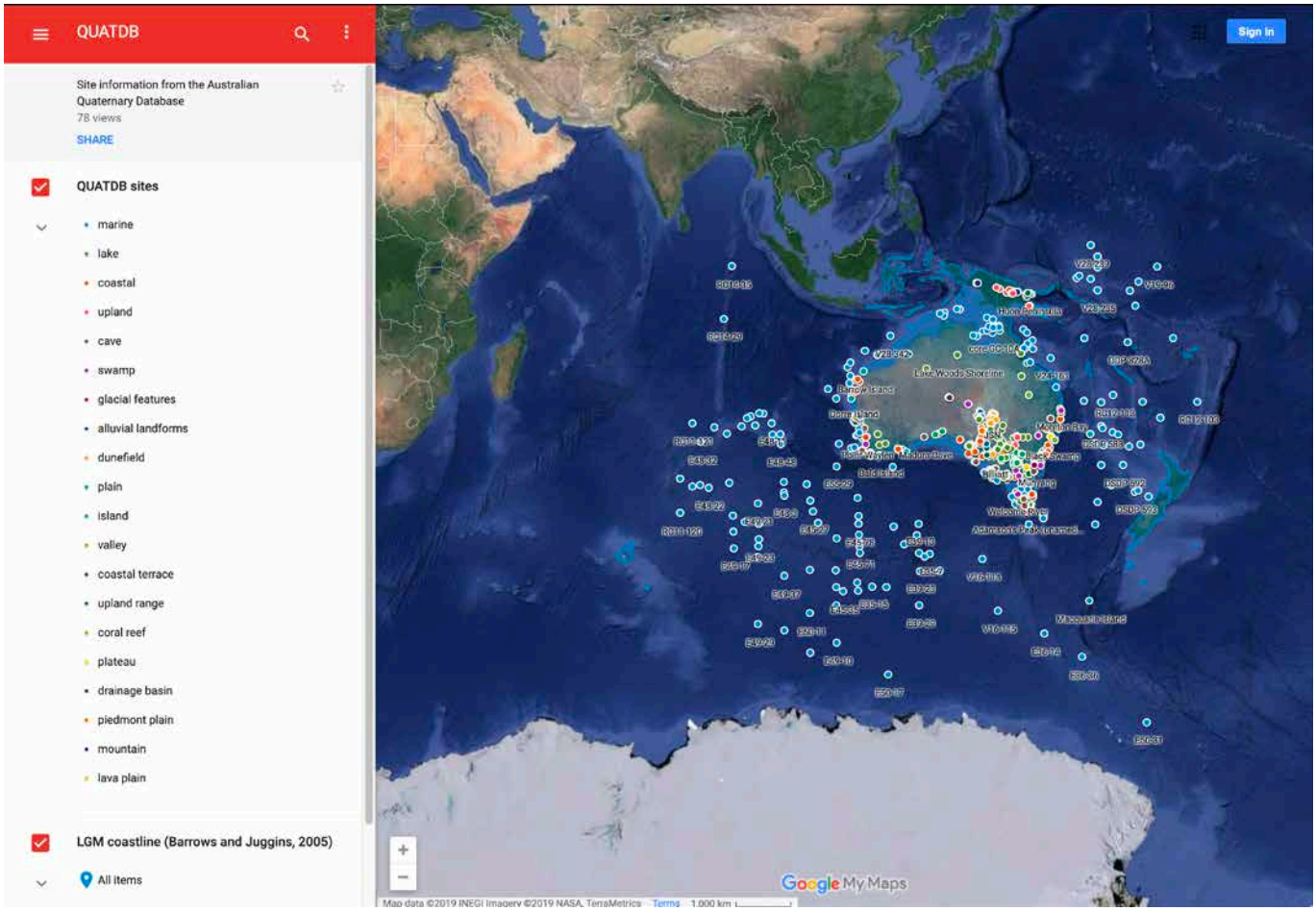

Figure 1: Site map of Australian Quaternary sites. The database will initially be hosted at: https://4dlandscapes.wordpress.com/quatdb

form, sites can be overlain onto climate, vegetation or geomorphological maps. The number of these maps is increasing steadily with time together with the digitisation of older maps. Many researchers routinely archive their data at one of the global data centres, but there is little effort to recover old data. I see QuatDB as an opportunity to fill this data archaeology niche, since it started with sites pre-dating 1996 and therefore digital archiving. These efforts will help prevent further loss of data when research funds are so difficult to come by. Most importantly I think we need to reach a point where we have collective ownership of metadata and individuals are motivated to make their studies known.

In the future, there is also the possibility of returning to a relational database format and linking data files. The curation of original data in QuatDB proved to be something of a nightmare. Fields constantly changed and were redesigned to fit new data and entries needed constant quality control. I think a central database is at present an unattainable goal. Data centres such as the WDC-A and Pangaea have multiple permanent staff and it is unlikely that an Australian institution would mirror this effort. I think it is far more profitable that data entry should be performed on a thematic or project basis, with a clear publishable research goal. Examples include the LGM time slice climate maps cited above or geomorphological compilations, such as dunefield distribution and glacial landforms, past vegetation maps or geochronological databases such as exist for cosmogenic nuclides and luminescence dating. There is also the opportunity to revisit the CLIMANZ concept, although the amount of data available now makes this a formidable task (but more informative?). Efforts to map and understand these important time slices has been ongoing for 40 years (e.g. Barrows et al. 2013) and can only be approached from a "big data" perspective.

Lastly, whilst it have been a long time since the QuatDB bibliography was created, it provides an invaluable archive to search the pre-Internet literature. I've made this available on the site via an Endnote database and by exported text in a spreadsheet. Also included in a post-1994 update and new papers need to be added if further sites are contributed.

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A QUATERNARIST'S GUIDE TO ATTENDING INQUA

Lydia Mackenzie[1], Patrick Moss[1] and Scott Mooney[2]

1 University of Queensland, Queensland, Australia; 2 University of New South Wales, New South Wales, Australia.

Editors note: this excellent article first appeared in the July 2015 edition of Quaternary Australasia. We thought it highly appropriate to include it in this edition, with a few edits for the Dublin Congress. Reproduced with permission from the authors.

With INQUA 2019 in Dublin rapidly approaching we thought we would put together a guide for AQUA members (especially first time INQUA attenders) about what to expect, as well as some tricks and tips for ECRs attending and presenting (and somethings that more experienced conference attendees should take note of as well).

WHAT IS AN INQUA?

An INQUA Congress is the Quaternarist's version of the Olympics! They are held every four years, bidding for them is highly competitive and they highlight the work of leading Quaternary scientists. In fact you will be overwhelmed by the volume of interesting talks and posters, often over four or five concurrent sessions, with a mass movement of people between seminars. This will be Lydia's third INQUA conference and Patrick's fifth and both of us agree that they are extremely valuable experiences, not only in terms of highlighting our research, but catching up with the newest ideas in Quaternary Science and seeing old friends and colleagues (often having not seen them since the last INQUA).

The INQUA Congress runs over eight days, beginning with an welcome reception in the evening (In INQUA 2019's case a Thursday), which is a great opportunity to meet fellow Quaternarist's in an informal setting. Three days of conference sessions include the conference opening, plenary sessions and INQUA Commission meetings. A day is then devoted for the Mid-Conference excursions (if you have had the foresight to join), self-guided excursions (for Reno 2003, Patrick and colleagues hired a car and drove around Lake Tahoe) or for recovery. The final three days return to the conference sessions with a range of pre– and post-conference field trips to be enjoyed. All of the INQUA Commissions are open to interested people and which Scott found a particular highlight of the last Congress and there are also a range of other formal and informal events occurring every night of the conference.

Our key piece of advice is to enjoy all that is on offer with this smorgasbord of Quaternary Science. But pace yourself as at some stage your head may explode from all the information flying past. The other key suggestion is to go through the conference program highlighting the key presentations/posters you want to see. You will be overwhelmed by some very interesting presentations that will often conflict – so identify the key ones you want to see, check out the room size (often popular talks will have an audience lining up outside the room) and estimate the time it will take to move to another room.

The size of the INQUA Congress (often a 1000+) can be daunting, particularly for people new to the wonderful world of the Quaternary, so we have included some general tips and tricks (which also apply to other conferences).

KNOW YOUR HEROES

Do you want to work for a particular lab-group in Europe? Is there an author who keeps popping up in your reference collection? The INQUA Congress is the perfect place for some serious stalking (aka 'networking'). Do your research so you can pick your personal hero from the crowds. What are they working on at the moment? Any new and exciting grants they might just need a post-doc for? You might be able to share a drink with them at the Icebreaker or a table at the conference dinner-just don't be creepy about it!

THE THREE P'S OF PRESENTING: PREPARE, PREPARE, PREPARE

Don't be 'that guy or gal' who can't go exploring, drinking or to the plenary session because you haven't prepared your presentation. Quaternary Scientists *like* the outdoors and chances are you're going to want to make the most of the location and colleagues. Don't make the mistake of trying to write your talk while on the train to the conference venue, analyse your data in the hotel late at night or memorise your speech the morning of your talk. Enjoy your partially-funded trip and feel smug when drinking that Guiness Beer the night before your presentation rather than panicked. This year the INQUA Early Career Research (ECR) team are running several events including workshops during the conference. Check out the details on the website. Make the most of it and come along to meet other ECR's and get helpful advice. You could also seek out your advisor or peers (if they are attending) for a practice run.

ORAL PRESENTATION

Most conferences outline a time for oral presentations-stick to it. The audience will appreciate it! Rather than presenting your entire PhD in 12 minutes pick a particular question or section you think will be appropriate for the audience. Too much information crammed into one talk can confuse your audience and end in a tangled heap of facts, figures and frustration. Even the most experienced presenters still get nervous so make sure that you have water present if you suffer from 'dry mouth syndrome' and that you pace your presentation (not to fast or slow – the Goldilocks principle of 'just right').

Rather than your final slide simply saying 'thankyou' you could include a summary of your talk and contact details. The final slide lingers on the screen during question time, allowing people to reflect on your key points and (possibly) write down your details.

Be prepared for questions at the end of the talk. Come up with a few that you may be asked and plan out a response. Thanking your ~~interrogator~~ audience for their thoughtful questions is a good way to buy time to formulate a concise answer. And be honest if you don't know the answer. In general the audience is interested in what you are presenting and several new collaborations (or postdocs) have emerged after a good INQUA talk.

And finally...make sure your format WILL work on the computers provided BEFORE it's your turn.

POSTERS

Poster sessions can be a great way to talk to people who are interested in your work. The best part-they come to you! So make it easy for potential viewers to find you, take away the key points and contact you later. The other key advantage over a seminar is that you have to finalize your poster prior to arriving at the conference and you won't experience the last minute preparation that is often a feature of oral presentations.

Lydia's favourite 'what not to do' poster example comes from INQUA 2011 where she spotted a presenter feverishly scribbling information onto their crowded poster while hung on the wall. A clear and concise poster is the way to go – keep the text to a minimum. Every year the School of Geography, Planning and Environmental Management, The University of Queensland runs a poster competition and it's always the simple, uncluttered and eye catching ones that win the prize (check out the GPEM website for last year's winners). The idea is not to data-dump your entire PhD onto a poster but to entice your readers to learn more.

How will viewers remember YOUR poster at the end of the day? You could try having business cards, printouts or a QR code that can be downloaded. This makes it easy for people to access the information and come back to it after the conference hangover has lifted.

Finally take the time to stand at your poster during the session. Maybe you won't have as many visitors as the 'Megafauna Extinction' poster but every person you get to talk to makes the difference. Have a quick 3 minute spiel pre-planned in case your audience wants to know more.

ASSOCIATION

Finding people at an international conference can be tricky. Luckily the AQUA community will be well represented at Dublin (Figure 1 shows the AQUA contingent at the 2015 Nagoya INQUA Congress). So make sure you find out about events happening after hours. There is also a range of Commission Meetings, including the INQUA ECR Commission who will be arranging a number of social events and practice sessions, which will be posted on the facebook site and the INQUA website. Each INQUA commission has a social media page with updates leading up to the conference. Make sure you join so you don't miss out.

Figure 1: The Australasian contingent at the Nagoya 2015 INQUA Congress.

GLOBAL MARKERS OF THE ANTHROPOCENE – WORKSHOP REPORT

Larissa Schneider[1,2] and Simon Haberle[1,2]

1. Archaeology and Natural History, School of Culture, History and Language, College of Asia and Pacific, Australian National University. 2601 Acton, Canberra, ACT – Australia.

2. CABAH – ARC Centre of Excellence for Australian Biodiversity and Heritage. Australian National University

Corresponding author: Larissa Schneider. Archaeology and Natural History, School of Culture, History and Language, College of Asia and Pacific, Australian National University. 2601 Acton, Canberra, ACT – Australia. Larissa.Schneider@anu.edu.au

Abstract: The Max Planck Institute for the Science of Human History organised a workshop on the global markers of the Anthropocene held at the Haus der Kulturen der Welt in Berlin, 28-29 February, 2019. Participants at the workshop (16 researchers from worldwide research institutes) discussed the importance of multidisciplinary research and the application of markers of the Anthropocene to revolutionise archaeological studies. This report provides a brief description of the participants, presentations and discussions generated during the workshop, while highlighting the importance of interdisciplinary forums such as this for the generation of new ideas and approaches to the big questions around human impact on planet earth.

The term "Anthropocene" refers to a not yet formalized epoch of geologic time during which geologic processes have been dominated by human impact. This impact, in many forms (e.g. biological, physical and chemical), is recorded in natural archives either as new fossil assemblages (neobiotas), anthropogenic deposits or a wide variety of contaminants emitted to the environment. With the current efforts by the scientific community to formalise the Anthropocene Epoch, a meeting was organised by the Max Planck Institute, held in Berlin in 28-29 February, 2019 to discuss the possible markers and methods to study the Anthropocene and how these markers may be applied in the practice of archaeology (Figure 1). This article reports on the discussions held at this meeting.

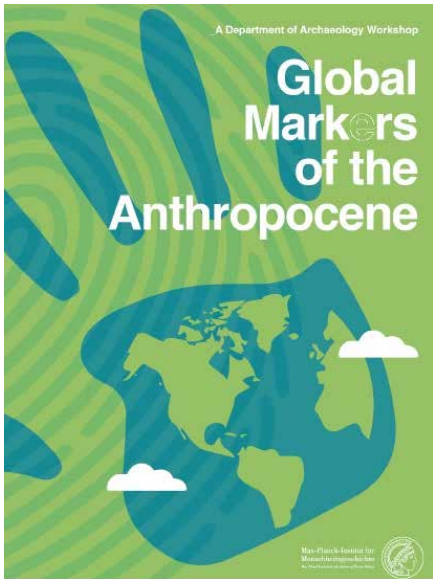

Figure 1: Global Markers of the Anthropocene Workshop Max Planck Institute held in Berlin in 28-29 February 2019.

The impetus for organising a workshop was driven by a key question of 'Can the markers of the Anthropocene be integrated into archaeological research methodologies in order to better reconstruct the human past?' The workshop, organised by Nicole Boivin from the Max Planck Institute for the Science of Human History, was composed of participants from a wide range of disciplines to discuss the integration of methods and approaches that could be applied to the study of the Anthropocene in archaeological context.

The workshop was composed of 16 participants from 10 research institutions worldwide (Figure 2), spanning a range of disciplines within the social, biological and physical sciences.

A multi-disciplinary approach to study the Anthropocene is expected to bring several benefits to archaeological research. First, multi-disciplinary research breaks up typical bias' and trends in single disciplinary research, which is often driven by a tendency for researchers to focus on particular questions, cases and variables for reasons of convenience or data availability; rather than broader relevance or construct validity. Second, a multi-disciplinary approach encourages the use of non-traditional archives to study the past. This creates a link between archaeology and modern research, which allows a more complete and precise measurement of the significant environmental changes that mark the Anthropocene. Third, the use of multi-disciplinary markers with long and more recent range enables the development of new techniques which will transform the way we measure and scale the Anthropocene.

Figure 2: Participants of the Global Markers of the Anthropocene Workshop on the footsteps of the Haus der Kulturen der Welt in Berlin, representing 10 worldwide research institutions, spamming from a range of disciplines within the social, biological and physical sciences.

THE GLOBAL MARKERS OF THE ANTHROPOCENE

The main objective of the Global Markers of the Anthropocene Workshop was to raise and discuss potential global markers and methods from various disciplines that could be applied in a global area and allow international collaboration. As such, a marker should be well distributed globally and be cost effective to allow international participation.

The Global Markers of the Anthropocene workshop did not focus on arguments around establishing the start date of the Anthropocene Epoch. Instead, it was focused on the nature and applicability of the markers themselves across a range of time scales, from the evolution of humans and long-term markers of anthropogenic activity through to the Great Acceleration and markers of the Anthropocene. As was noted at the workshop it is most likely that 1950 AD will be designated as the beginning of the Anthropocene by the Anthropocene Working Group. On the first day of the workshop, the group approached long term markers of anthropogenic activity, spanning the Pleistocene through to Holocene period (Table 1) while on the second day, the markers of the Anthropocene focused on the last ~200 years, correlated to the Industrial Revolution and Great Acceleration (Table 2).

CAN THE MARKERS OF THE ANTHROPOCENE BE INTEGRATED INTO ARCHAEOLOGICAL RESEARCH METHODOLOGIES IN ORDER TO BETTER RECONSTRUCT HUMAN PAST?

Systematically measuring and quantifying human impacts through time is integral to a range of disciplines studying deep-time through to human history to the modern period. Exploring ways of linking these disciplines through the application of markers of the Anthropocene to archaeological problems was a primary focus of discussions at the workshop. For instance, steroid markers may be used in archaeological sites that have already been studied by archaeologists to test if they can add to a more comprehensive understanding of human impacts and environmental changes. The transformation of archaeological excavation techniques to include an analysis of everything up to the surface (not ignoring sediment with modern plastics or other markers of the Anthropocene) is a high priority (on a global scale), so that information on contemporary site impacts can be incorporated into the data on the timing and nature of the transition to the Anthropocene Epoch.

Table 1: Long-term markers of Anthropogenic Activity.

MARKER	PRESENTER	DESCRIPTION
Radioactive isotopic proxies (IsoMemo)	Ricardo Fernandes (Max Planck Institute for the Science of Human History	Application of stable and radioactive isotopic proxies to assess human-driven environmental impacts. A Big Data approach to the large amounts of available isotopic data is now in place through the IsoMemo, within the fields of archaeology, ecology, and environmental and life sciences. It offers Bayesian statistical tools to map human and environmental histories at wide spatial and temporal scales.
Archaeological assessment of global land use through mapping (ArchaeoGLOBE)	Erle Ellis (University of Maryland)	ArchaeoGLOBE, a collaborative mapping of global land use from 10,000 BP to 1850 CE, provide a detailed and precise understanding of how human use of land transformed the biosphere and the Earth system.
Archaeological approaches to longterm agricultural diversity and its distribution	Dorian Q Fuller (University College London)	Proposal for new approaches to simple, recurrent, coarse scale sampling and dating to study domestication of plants and animals and the creation of agricultural ecosystems.
Anthropogenic species introductions	Torben Rick (Smithsonian Institution)	Archaeological record of ancient biological introductions serves as an important global marker of human activities in the Anthropocene. These records allow a truly understand of their impact and influence in the Anthropocene
Species dispersals and extirpations	Anneke Janzen (Max Planck Institute for the Science of Human History	Proposal of using ZooMS (Zooarchaeology by Mass Spectrometry) as a tool for producing secure taxonomic identifications from extremely fragmentary faunal material for relatively little cost. Using collagen peptide fingerprints it is possible to identify a range of vertebrates.
Hominins in the Pleistocene	Michael Petraglia (Max Planck Insitute for the Science of Human History	Pleistocene hominins and hunter-gatherer communities should not be viewed as passive actors on the landscape, but rather as active agents in contributing to the formation of landscapes and faunal and floral distributions.
Pollen, charcoal and dung spherulites	Simon Haberle (Australian National University)	Long and high-resolution pollen and charcoal records indicate changes in plant community composition and disturbance regimes over the late 20th and 21st century. Dung fungi is a proxy for pastoralism and the onset of ecosystem change in the late 20th and 21st century.
Phytoliths	Julio Mercader (University of Calgary)	Phytoliths track the boundary between ecosystems, ecological disturbance, and the evolutionary backdrop of human occupation.
Land use	Jed O. Kaplan (Department of Earth Sciences, University of Hong Kong)	A proposal that understanding land use change in the past and its importance for the Anthropocene must go beyond deforestation and consider the range of ways in which humans have shaped the global environment since we emerged as a species.

The workshop led to a number of initiatives being discussed:

1. A pilot project that will explore how we can effectively bring together analyses of deep-time markers of anthropogenic activity and markers of the Anthropocene in archaeological deposits. This project is now under development for implementation in Nicole Boivin (Max Planck Institute) and Torben Rick's (Smithsonian Institute) field projects, beginning in July 2019.
2. Joint publications involving the members of the workshop and other interested participants, including one paper that explores the development of an archaeological coring approach involving multiple markers of anthropogenic impact in an archaeological context.
3. Given the opportunity for networking during the workshop, additional projects are expected to come up, drawing on existing samples and datasets with a possible follow-up workshop at Ringberg Castle next year to evaluate the pilot project outputs.

Table 2: Markers of the Anthropocene.

CHRONOMARKER	PRESENTER	DESCRIPTION
Steroid faecal biomarkers	Thomas Larsen and Patrick Roberts (Max Planck Institute for the Science of Human History)	Use of steroid faecal biomarkers, a type of lipid derived from cholesterol, as a proxy for palaeodemography. It is an affordable technique for studying past human and animal population sizes, applicable over millennia and to different contexts both within and beyond settlements.
Biogeochemical markers	Gerd Gleixner (Max Planck Institute for Biogeochemistry)	Explore key processes in global biogeochemical cycles at the molecular level by using biomarkers and their isotopic content. Lipids can persist for a long time in the environment, and can be used to develop profiles that can identify individuals or groups of organisms as well as environmental conditions including salinity, anoxia, and desiccation.
Varve microfacies and nitrogen isotopes in lake sediments	Birgit Plessen (German Research Centre for Geosciences, GFZ)	Lacustrine records of δ_5N reveal human impact by extensive land use, sewage, fertilizer, and atmospheric pollution. The δ_5N record testify the anthropogenic nitrogen input over the past 1000 years with dramatic changes since the last 200 years.
Metal contamination	Larissa Schneider (Australian National University)	The dramatic increase in metals usage in the Great Acceleration has left a discernible concentration peak in dated stratigraphic materials which allows the use of metals as a synchronous global signal of the Anthropocene. One of the solid candidates for signals of the Anthropocene is mercury due to its ability to travel long distances and conducive to wide-spread application.
Fly-ash particles and PCBs	Neil Rose (University College London)	Fly-ash particles (specifically the carbonaceous component – spheroidal carbonaceous particles or SCPs) and persistent organic pollutants (POPs) had a rapid increase in accumulation in a range of natural archives in the 1950s. Both markers are good indicators of the start of the Anthropocene at the start of the Great Acceleration.
Plastic pollution	Juliana Ivar do Sul (Leibniz Institute for Baltic Sea Research Warnemünde)	Microplastics have appeared since the 1950s. Microplastic slow deposition within sediment layers and its potential to be preserved in the geological time scale make them good markers of the Anthropocene.
Atomic bomb isotopes	Sue Trumbore (Max Planck Institute for Biogeochemistry)	Atmospheric testing of nuclear weapons created a suite of radioisotopes. These 'bomb' isotopes have been proposed as one of the potential global indicators of the Anthropocene.

THESIS ABSTRACTS

Late Quaternary stream channel adjustment in hydrologically variable catchments, subtropical Australia.

James S. Daley (PhD)

Griffith Centre for Coastal Management, Griffith University, Australia.

In regions of high climate and hydrological variability, alluvial rivers exhibit complex arrangements between channel characteristics and flow regimes. Along the eastern margin of Australia, hydrologic variability is highest in the subtropics of Southeast Queensland (SEQ). Many alluvial rivers in this area have entrenched channels, termed 'macrochannels'. They accommodate large floods and include a suite of inset alluvial units. However, the formation of the macrochannels and their relation to hydrological regimes remains largely unresolved. This study investigates whether the macrochannels of SEQ are related to the contemporary and variable flow regimes or are inherited late Quaternary landforms. The aim of this thesis is to address the nature of channel entrenchment and relationships with adjacent alluvium and flood hydrology. Geomorphological, hydraulic and chronostratigraphic data are evaluated from alluvial settings within SEQ, with a detailed site investigation presented in the mid-reaches of Lockyer Creek.

This research examines the hydrology and geometry of 65 gauging stations in alluvial reaches within SEQ. No common bankfull inundation frequency was found and annual exceedance probabilities (AEPs) range from approximately 1.5 – >100 years, with a median of 9.75 years. Channel entrenchment appears prevalent throughout the region, with >50% of alluvial rivers analysed exhibiting a bankfull capacity that exceeds the 10-year AEP. Macrochannel bankfull frequencies are broadly distributed, with a peak in the distribution at the 20-year recurrence interval but an overall median of 45 years and some adjacent alluvial surfaces not inundated in historical times. At a regional level, macrochannel dimensions scale with catchment area but highly variable geometries bear little relationship to the modern flow regime or slope. Entrenchment has mostly occurred in dryer, western catchments that have a higher degree of hydrological variability, despite no statistically significant correlation between flow variability and the degree of entrenchment. Nonetheless, their presence serves to constrain most contemporary river flows.

Despite high hydrological variability throughout the region and considerable variation in macrochannel capacities, 95% of streams feature active 'inner' river channels constructing and inundating adjacent alluvial units at the mean annual flood (MAF). However, only 25% of streams analysed engage the main valley floor surface as their primary floodplain. Holocene alluvium is mostly present as either a narrow, depositional wedge in the form of inset floodplains and benches or as a drape overtopping buried terraces. Over 90% of entrenched streams have compound forms featuring inset alluvial units which range from several metres to 150 m wide within the macrochannel.

In the Lockyer Creek catchment, downstream macrochannel geometry is highly variable at the reach scale and in part has been influenced by antecedent structural/lithological controls and the presence of resistant valley fills. Abrupt morphological changes and variation in macrochannel geometry coincide with changes in alignmetn and confinement against the valley margin. However, an overall downstream decrease in macrochannel area are apparent in all sub-catchments and correspond with increased terrace preservation. Extensive fill terraces occupy 70-95% of valley floors in the mid to lower catchments.

Terrace sediments are spatially variable but consist of 5-12 m of highly weathered heavy clays to fine-sandy clay loams. Radiocarbon and single grain optically stimulated luminescence (OSL) dating indicate a large proportion of the valley fill reflects a significant phase of aggradation of fine-grained alluvium from ca. 35 ka throughout the Last Glacial Cold Period (LGCP) that overlies older Pleistocene basal sediments. Subsequent channel incision up to 10 m is well-constrained in the mid-reaches of the Lockyer by upper terrace ages of 9.25 ± 0.84 ka to 11.5 ± 1.29 ka at four sites and basal floodplain ages of 10.08 ± 1.02 – 7.97 ± 1.03 ka. Surficial ages of terraces adjacent to macrochannels in three other key catchments across SEQ indicate synchronous, regional incision of Pleistocene alluvial fills at 9.24 ± 0.93 ka, with all age ranges within 1σ errors. Correlation with other regional chronologies and climate proxy records suggest the current entrenched river systems within SEQ formed in response to changes in late Quaternary climate, related to an early Holocene pluvial episode identified elsewhere in eastern Australia.

Holocene floodplains set within the entrenched Pleistocene valley floor have basal ages that are ca. 7.5 ka but whose proximal margins are still actively accreting. This Holocene fill has primarily accreted over the mid – to late-Holocene but overlaps with the contemporary hydrological regime. The dominance of the macrochannel form appears to be related to persistent inherited controls in the form of bedrock and terrace constriction, coupled with low rates of sediment supply and ongoing high hydrological variability. Fine-grained, mechanically resistant Pleistocene alluvium has imposed substantial controls on the formation of the widely distributed macrochannels of SEQ.

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Reconstructing Australia's late Quaternary climate from the geochemistry of lake sediments and snail shells

Georgina Falster (PhD)

Earth Sciences, School of Physical Sciences, The University of Adelaide, SA, Australia

Australia's climate is influenced by ocean-atmosphere interactions in the adjacent Indian, Pacific, and Southern oceans, as well as major atmospheric circulation patterns. Australian climates exhibit high inter-annual variability, arising in part from complex interactions between these drivers. Understanding the nature and drivers of Australian climate variability is not only important for land use and management, but also has global relevance, due to Australia's contribution to the global terrestrial carbon budget. Measurements of Australian temperature and rainfall only extend back to the early 20th century, and hence do not capture the full range of natural climate variability. Proxy-based climate reconstructions are therefore required to understand Australian climate variability on long (centennial to millennial) time scales. The late Quaternary—defined in the thesis as 30 to 10 thousand years before the year 1950 (ka BP)—is a particularly informative interval. It encompasses large changes in global climate dynamics, including both the global Last Glacial Maximum (LGM; 23 to 19 ka BP) and subsequent deglaciation, allowing assessment of the Australian climate response to global change. However, the arid to semi-arid nature of most the continent is not conducive to sedimentary record accumulation, limiting spatial and temporal resolution of existing late Quaternary climate reconstructions.

The thesis therefore presents both new late Quaternary palaeoclimate data and new methods for inferring past climate across the Australian continent, through the following research components:

1. A record of late Quaternary moisture balance, inferred from highly resolved x-ray fluorescence and organic carbon isotope measurements of a sedimentary sequence from Lake Surprise in south-eastern Australia (Chapter 3). The regional significance of this record is assessed using a Monte Carlo Empirical Orthogonal Function approach.
2. The high-resolution record is supported by three discrete quantitative temperature estimates, based on the clumped isotope composition (Δ_{47}) of freshwater snail shells from Blanche Cave, also in south-eastern Australia (Chapter 6). Δ_{47} analysis allows calculation of the growth temperature of carbonate minerals (e.g. snail shells), independent of organism, carbonate phase, or formation water geochemistry. Carbonate Δ_{47} analysis therefore offers a uniquely direct estimate of past temperatures, that has not previously been applied in Australian palaeoclimate studies.
3. Clumped isotope analysis is highly susceptible to contamination, so the thesis provides a new pretreatment method for obtaining precise and accurate data from carbonates preserved within an organic-rich matrix (Chapter 2).
4. The influence of remote drivers of Australian climate often manifests in distinct spatial patterns of temperature or rainfall. However, the low spatial resolution of existing palaeoclimate records across the continent inhibits detection of spatio-temporal climate trends that would facilitate inference of these drivers. The thesis therefore evaluates the climate proxy potential

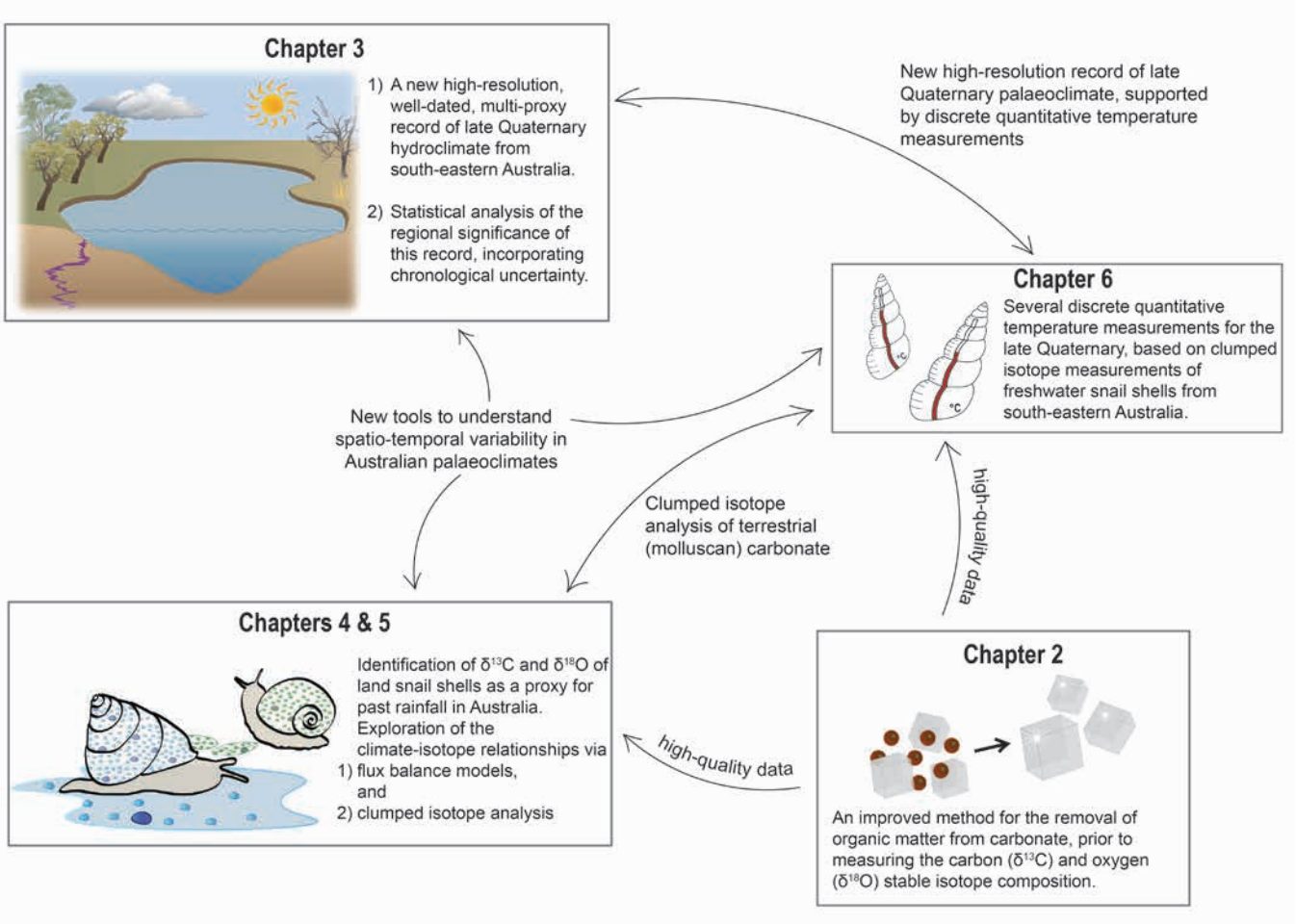
of land snail shells in Australia, by combining flux balance models with clumped and stable isotope measurements of modern shells collected from a wide spatial and climatic gradient across the continent (Chapters 4 and 5).

The palaeoclimate reconstructions provide a coherent record of climate variability prior to and throughout the late Quaternary, and suggest that drivers of south-eastern Australian climate have varied on multi-millennial time scales in response to major shifts in global circulation. Δ_{47} analysis of freshwater snail shells suggests that between ~41 and 32 ka BP, mean annual air temperatures at Blanche Cave decreased from approximately 12 ± 3.2 °C to 5 ± 4.4 °C i.e. almost ten degrees cooler than modern. These relatively low temperatures preceded a period of regional aridity between 28 and 18.5 ka BP as recorded at Lake Surprise. Together, the data suggest that the south-east Australian climate was probably responding to very different drivers to those that affect the modern climate, possibly dominated by cold Southern Ocean processes. Centennial – to millennial-scale hydroclimate variability was maintained throughout the 28–18.5 ka BP interval. Peak aridity between 21 and 18.5 ka BP probably represents the local expression of the global LGM.

A rapid deglacial climate shift occurred between ~18.5 and 16 ka BP, culminating in warmer (15.5 ± 3.6 °C) and wetter conditions probably more like those of the present.

The stable isotope geochemistry of modern land snail shells records precipitation amount via two mechanisms: (1) its influence on the $\delta^{18}O$ of precipitation (a wet season signal), and (2) its effect on vegetation $\delta^{13}C$ (an annual to multi-annual signal). Unlike freshwater snails, land snail Δ_{47} growth temperatures do not have a straightforward relationship with average air temperatures, but rather are useful for extracting the temperature influence from snail shell $\delta^{18}O$. This is the first study to report $\delta^{13}C$, $\delta^{18}O$, and Δ_{47} measurements from land snail shells spanning such a large climatic gradient, and also the first to investigate snail isotope-climate relationships across the variable and largely arid Australian environments. The isotope-climate relationships are robust irrespective of species or regional climatology. With land snails widely distributed in Australia, including in arid climates that lack other suitable proxies, these consistent relationships demonstrate that land snail shell isotopes will be a valuable tool for assessing spatio-temporal precipitation variability at a continental scale.

Figure 1: Conceptual flow diagram summarising the research components of the thesis.



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UPCOMING MEETINGS

JULY 2019

PALSEA: Using ecological and chronological data to improve proxy-based palaeo sea-level reconstructions.

Venue: Dublin Ireland

Dates 21-23 July, 2019

https://palseagroup.weebly.com

XX INQUA Congress

Venue: Dublin, Ireland

Date: 25-31 July 2019

www.inqua2019.org

AUGUST 2019

2019 Summer School on Speleothem Science (S4)

Venue: Cluj-Napoca, Romania

Date: 11-17 August, 2019

www.speleothemschool.com/

SEPTEMBER 2019

13th International Conference on Paleoceanography (ICP13)

Venue: University of New South Wales, Sydney, Australia

Date: 1-6 September 2019

www.icp13.com.au

AMS-15 The 15th International Conference on Accelorator Mass Spectrometry.

Venue: Sydney

Date: 7-11 September, 2019

https://events01.synchrotron.org.au/event/66/

International Symposium on Loess Deposits as Archives of Environmental Change in the Past. National Academy of Science of the Republic of Armenia

Venue: Yerevan, Armenia

Date: 15-22 September, 2019

loess2019@geology.am

OCTOBER 2019

Society of Vertebrate Palaeontology

Venue: Brisbane

Date: 9-12 October 2019

http://vertpaleo.org/Annual-Meeting/Annual-Meeting-Home.aspx

ADVANCE NOTICE

2020

Palaeo Down Under 3

Venue: Brisbane

SOCIETY OF VERTEBRATE PALEONTOLOGY MEETING 2019

BRISBANE QUEENSLAND, AUSTRALIA, 9-12 OCTOBER.

The Host Committee of the 79th Annual Meeting is delighted to welcome all participants to the Society of Vertebrate Paleontology's 2019 meeting in Brisbane, Queensland, Australia, 9-12 October. The meeting will take place at the Brisbane Convention and Exhibition Centre, ideally located in the unique riverside cultural and lifestyle precinct of South Brisbane.

Details: http://vertpaleo.org/Annual-Meeting/Annual-Meeting-home.aspx

The 79th meeting will be only the third SVP to be hosted outside of North America, and the first one in the Southern Hemisphere. The meeting is co-hosted by The University of Queensland and the Queensland Museum. Although vertebrate fossils were first recognised in Australia by Europeans in the 1830s, global interest in the continent's vertebrate fossil record was invigorated in the 1950s and 1960s following the fieldwork and research of American paleo-mammalogist, Dr Ruben Stirton, and his team of students including Richard Tedford and Michael Woodburne. Interest in Australian vertebrate paleontology grew considerably after that time, culminating in the inaugural Conference on Australasian Vertebrate Evolution, Palaeontology, and Systematics, an informal, voluntarily organised biennial meeting first held in Brisbane in 1987. The 79th SVP meeting represents a coming-of-age for Australian vertebrate paleontology.

Brisbane's location at the capital of Queensland's premier tourist region presents the ideal opportunity for delegates to enjoy a microcosm of Australia's iconic experiences. World Heritage-listed rainforests, amazing beaches, islands, wineries, and the internationally famous Australia Zoo – home of the 'Crocodile Hunter' – are all easily accessible within an hour of the city. It is even possible to do day trips to the Great Barrier Reef from Brisbane. The Queensland Museum's geoscience collection, based in the Brisbane suburb of Hendra, is the largest palaeontological collection in Australia and one of the largest in the Southern Hemisphere.

2019 represents the first SVP Annual Meeting held on a Gondwanan continent and provides a gateway to the major regions of global paleontological significance including other cities and regional locations around Australia, New Zealand, Antarctica, and Southeast Asia. Queensland in particular is home to:

- The Riversleigh World Heritage Area considered by Sir David Attenborough as one of the four most important fossil sites on Earth;
- A new and diverse suite of Cretaceous-aged dinosaur sites critical in the understanding of Gondwanan biogeography;
- The earliest known Carboniferous tetrapods in Gondwana;
- The youngest uncontested Australian Pleistocene megafauna site, Neds Gully, just a stone's throw from Brisbane;
- The earliest known crown-group marsupials along with some of the oldest evidence for echo-locating bats, song birds, and extant genera of frogs; and
- The Chinchilla Fauna, Australia's most extensive Pliocene vertebrate fossil locality and one that contains the forbearers to most modern Australian marsupials.

We invite everyone to attend the Welcome Reception at the Queensland Museum where we will highlight Queensland's rich heritage in vertebrate paleontology. We hope that you will enjoy all that Brisbane, Queensland, and Australia more broadly has to offer during the 79th Annual Meeting of the Society of Vertebrate Paleontology!

Gilbert Price, and on behalf of the 2019 Host Committe

Quaternary AUSTRALASIA

Quaternary Australasia publishes news, commentary, notices of upcoming events, travel, conference and research reports, post-graduate thesis abstracts and peer-reviewed research papers of interest to the Australasian Quaternary research community. Cartoons, sardonic memoirs and images of mystery fossils are also welcome.

The Australasian Quaternary Association (AQUA) is an informal group of people interested in the manifold phenomena of the Quaternary Period. It seeks to encourage research by younger workers in particular; to promote scientific communication between Australia, New Zealand and Oceania; and to inform members of current research and publications. It holds biennial meetings and publishes the journal Quaternary Australasia twice a year.

Full annual membership of AQUA with an electronic subscription to QA is AUD50, or AUD35 for students, unemployed or retired people. The AQUA website (www.aqua.org.au) has information about becoming a member; alternatively please contact the Treasurer (address below). Members joining after September gain membership for the following year. Existing members will be sent a reminder in December.

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A/Prof Tim Cohen
School of Earth and Environmental Sciences
University of Wollongong,
NSW 2522, Australia
PH: +61 (0)2 4239 2375
tcohen@uow.edu.au

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Dr. Lynda Petherick
School of Geography, Environment and Earth Sciences
Victoria University of Wellington
Kelburn Campus
Wellington, New Zealand
PH: +64 (0)4 4635844
lynda.petherick@vuw.ac.nz

SECRETARY

Alex Wall
School of Earth and Environmental Sciences
University of Wollongong
NSW, Australia
awall@uow.edu.au

TREASURER

Dr Heather Haines
Australian Rivers Institute,
Griffith University
QLD, Australia
PH: +61 (0)4 2828 0606
h.haines@griffithuni.edu.au

COMMUNICATIONS AND IT COORDINATORS

Haidee Cadd
Sprigg Geobiology Centre
Department of Earth Sciences
The University of Adelaide
SA, 5005, Australia
PH: +61 (0) 4 0459 9285
haidee.cadd@adelaide.edu.au

GENERAL MEMBERS

Dr Andrew Rees
School of Geography, Environment and Earth Sciences
Victoria University of Wellington
Kelburn Campus
Wellington, New Zealand
PH: +64 (0)4 463 8396
andrew.rees@vuw.ac.nz

Dr Jessica Reeves
Faculty of Science and Technology
Federation University Australia,
Gippsland Campus,
Churchill
VIC 3842, Australia
PH: +61 (0)3 53279049
j.reeves@federation.edu.au

A/Prof Peter Almond
Department of Soil and Physical Sciences
Lincoln University
PO Box 85084
Lincoln 7647, Canterbury,
New Zealand
PH: +64 (0)3 423 0768
peter.almond@lincoln.ac.nz

Dr Heather Haines
Australian Rivers Institute,
Griffith University
QLD, Australia
PH: +61 (0)4 2828 0606
h.haines@griffithuni.edu.au

Lillian Luk
School of Biological, Earth and Environmental Sciences
University of New South Wales, NSW 2052, Australia
l.luk@unsw.edu.au

QUATERNARY AUSTRALASIA EDITORS

Dr Carol Smith
Department of Soil and Physical Sciences
Lincoln University
PO Box 85084
Lincoln 7647, Canterbury,
New Zealand
PH: +64 (0)3 423 0791
editor@aqua.org.au

Dr Sanja van Huet
Deakin University
School of Life and Environmental Science
Victoria 3125, Australia
PH: +61 (0)3 924 68529
editor@aqua.org.au