

Catalyst: Influence

Annual report on behalf of the Quaternary research community in New Zealand with regard to international membership of the International Union for Quaternary Research (INQUA)

Author: David J. Lowe, University of Waikato

Date: 10 March, 2018

Note: this initial report includes Appendix A (attached)

Supported international union membership:	International Union for Quaternary Research (INQUA)
New Zealand national delegate:	Professor David J. Lowe, University of Waikato FRSNZ, FNZSSS, Hon Fellow INQUA
Affiliated New Zealand organisation/national committee:	Ad hoc group of New Zealand Quaternary researchers, some in leadership roles associated with INQUA-funded projects and/or international focus groups (IFGs) as noted in the report below. Most are members of the active Australasian Quaternary Association (AQUA), which is affiliated with INQUA, and various other science associations/societies in NZ.
President/Chair of New Zealand organisation or national committee:	Dr Helen Bostock (NIWA) – Immediate Past-President, Australasian Quaternary Association (AQUA)
Reporting year:	1 Dec 2016-31 Dec 2017
Report due date:	10 March 2018

It is anticipated that this report has been discussed in some form with the national committee or organisation identified above and provides the wider view of this network.

I have discussed the report with some of the leading New Zealand Quaternarists and/or leaders of several INQUA-funded projects/IFGs (names are listed on p. 7). I attach a 17-page document (**Appendix A**) that summarises Quaternary-related research in New Zealand and the relationship of research to the International Union for Quaternary Research (INQUA) and the associated focus groups and projects. It is referred to in the report below.

Citation: Lowe, D.J. 2018. Quaternary research in New Zealand and relationship to the International Union for Quaternary Research (INQUA). *Annual Report for 'Catalyst Fund: Influence' for 2017 (with Appendix)*. School of Science, University of Waikato, Hamilton, 24 pp.

1. Catalyst: Influence assessment criteria

- 1.1. Please comment on how the supported union membership involves recognised global science and innovation leaders, the connection with whom could benefit New Zealand in a substantive manner.

Many of the top Quaternary science specialists globally are members of the *International Union for Quaternary Research* (INQUA), and a number of New Zealand Quaternary scientists arguably are in that elite category. Membership of INQUA provides access to this international knowledge base and the latest developments in the discipline, as described below and in Appendix A, which includes examples of the international recognition of New Zealand Quaternary geological archives as globally important or unique, and of New Zealand participation and leadership in (a) globally-significant research and (b) in decision making at the international level through INQUA and through associated activities/outlets involving Quaternary research and its dissemination.

Most of New Zealand's Quaternary researchers have been involved with INQUA-led projects or research groups, referred to as international focus groups (IFGs), that enable them to tackle globally-relevant research questions in the disciplines encompassed by the Quaternary (see Appendix A). Key questions about climate change in the past are a main focus because understanding the causes and timing spatially and through time requires a global and multi-disciplinary approach, with a Southern Hemisphere perspective especially important because of the general paucity of data in much of the hemisphere to compare with that from the Northern Hemisphere. Future models of changing climate are largely contingent upon robust paleoenvironmental data, dated at high precision, being obtained from a range of archives throughout New Zealand and surrounding marine sediments by Quaternary scientists. Increasingly, high-resolution past-environmental data are needed as are improved chronologies, to enable questions of leads and lags in past climate systems to be answered at a range of scales (both regionally and globally).

INQUA's five broad *commissions* (Appendix A) provide seed funding to IFGs and projects annually to enable new and especially collaborative research to be undertaken on important topics that may incorporate revised or new methodologies. Many early career researchers (ECRs) especially have benefitted from the funding provided by INQUA through support to attend and participate in meetings and conferences through travel grants. In addition, the New Zealand and Australian Quaternary research communities have forged closer relationships over the past decade under the umbrella of the *Australasian Quaternary Association* (AQUA), which is affiliated with INQUA. AQUA members have been very active with biennial conferences hosted in New Zealand and Australia, the publication of biannual newsletters, and financial and in-kind support for the INQUA-led IFGs and projects.

- 1.2. Please comment on how the International Union membership has advanced New Zealand's research, science and technology reputation over the last year and/or presented new opportunities for collaboration in research fields of strategic importance to New Zealand.

From 1 December 2016 to 31 December 2017, the New Zealand Quaternary research community, with strong support from Australian counterparts, made significant advances in three main ways, in part catalyzed through membership of INQUA:

(a) by showcasing completed research important both to New Zealand and globally in key disciplines of (i) paleoclimatic studies and (ii) the use of volcanic-ash (tephra) layers as correlating and dating tools (tephrochronology) via publication of **three 'special issues' of three international journals** *Climate of the Past*, *Journal of Quaternary Science*, and *Quaternary Geochronology* (Lorrey and Newnham 2017b; Lane et al. 2017b; Lorrey et al. 2017) (references are given at the end of Appendix A);

(b) by continuing and maintaining collaborative national and international opportunities for presenting and discussing new research and networking at four conferences/workshops held in this period by leaders of INQUA-

funded IFGs and project – the key IFGs and projects in New Zealand currently supported by INQUA include SHAPE (ongoing IFG), INTAV (ongoing IFG), EXTRAS (project), and SHeMax (project) (defined in Appendix A); and

(c) by mentoring and developing ECRs through provision of opportunity for them to participate in conferences or workshops using funds provided by INQUA and AQUA to support travel or to offset registration costs.

The development of several key IFGs and projects, led in part by New Zealand Quaternary researchers, has been critical in improving and bringing together researchers with widely varying interests to tackle difficult problems and ‘big’ topics such as climate change that are essential to help obtain a global understanding of environmental change past, present, and future. Further details are given below in section 2 and Appendix A.

- 1.3. *Please comment on what the New Zealand research sector, aligned with the International Union membership, can offer to international researchers, with a view to creating potential partnership, or cement New Zealand’s involvement, in the activity over the long-term.*

Very strong partnerships have been developed by New Zealand and Australian researchers through the IFGs and projects that are supported by INQUA. As noted elsewhere, the advent of the Australasian INTIMATE project led to the more-or-less entire Quaternary communities of New Zealand and Australia becoming involved to develop new ideas and to publish benchmark papers and interpretations and a new template for interpreting climate change from c. 30,000 years ago through to c. 8000 years ago. Although centered on Australasia, the myriad of connections between New Zealand and Australian researchers and counterparts all around the world means that international partnerships are strong and durable. For example, the INTAV executive comprises representatives from New Zealand, Canada, UK, Japan, and Switzerland. And every four years the global Quaternary research community assembles for the full INQUA congress (held in Japan in 2015 and to be held in Eire (Republic of Ireland) in 2019), with New Zealand an important voice on the International Council and with numerous scientific sessions being convened by New Zealand and other scientists, i.e. the INQUA community provides one of the best examples of strongly connected and productive relationships in science that is tackling globally-relevant problems. New Zealand Quaternary scientists are extremely productive and effective given the small size of our community.

- 1.4. *Please comment on what has been planned for New Zealand to leverage off the opportunities identified in 1.2 or 1.3. If these are ongoing activities, please comment on the progress since last year’s report.*

As evident below and in Appendix A, the current IFGs and projects being undertaken currently in New Zealand are set to run until the INQUA congress in Dublin in 2019. Consequently, conferences and other activities for these are being planned for 2018. For example, SHAPE members held a workshop at Wollongong in February 2018, INTAV members are holding an international tephra conference in Romania in June 2018, and SHeMax members are running a workshop in Australia in June 2018. AQUA is holding its biennial meeting in Canberra in December 2018. Each of these meetings/workshops provides further opportunity for new research and collaborations and for ECRs to engage with the Quaternary community.

2. Information relevant to the research community in the previous year

- 2.1. *Please list any New Zealander(s) participating in International Union work programmes and/or the Union council(s), and several notable achievements of 2017 pertaining to Quaternary research in New Zealand*

Prof David Lowe (University of Waikato):

- (i) New Zealand representative of RSNZ (and the New Zealand Quaternary science community) on the International Council of INQUA

- (ii) One of only four New Zealanders to be awarded an honorary life fellowship of INQUA (in July 2015)
- (iii) Formal advisor to SACCOM, INQUA
- (iv) Immediate Past-President on the executive of INTAV, under the aegis of which the executive has proposed three tephra-focussed sessions for the full INQUA congress in Dublin, 2019
- (v) Leader of the ongoing EXTRAS project of INTAV
- (vi) Co-editor of INTAV special issue of *Quaternary Geochronology* (Lane et al. 2017b)
- (vii) Co-organiser of the “Crossing New Frontiers” tephra meeting planned for Romania, June 2018
- (viii) Member of advisory editorial boards of *Quaternary International*, *Journal of Quaternary Science*, *Quaternary*, *Quaternary Geochronology*

Dr Andrew Lorrey (NIWA):

- (i) New Zealand early career researcher representative on SACCOM, INQUA
- (ii) Co-leader of SHAPE, under the aegis of which the executive has proposed a SHAPE session for the full INQUA congress in Dublin, 2019
- (iii) Co-editor of two SHAPE special issues in *Climate of the Past* (Lorrey et al. 2017) and *Journal of Quaternary Science* (Lorrey and Newnham 2017b)

Dr Lynda Petherick (Victoria University of Wellington):

- (i) Leader of SHeMax

Prof Rewi Newnham (Victoria University of Wellington):

- (i) New Zealand representative on formal subdivision of the Holocene series/epoch
- (ii) Regional Editor (Asia and Australasia), *Journal of Quaternary Science*
- (iii) Member of advisory editorial board of *The Holocene*
- (iv) Co-editor of SHAPE special issue of *Journal of Quaternary Science* (Lorrey and Newnham 2017b)

Prof Andrew Mackintosh (Victoria University of Wellington):

- (i) Lead Author, Intergovernmental Panel on Climate Change (IPCC) “Special report on the ocean and cryosphere in a changing climate” (in preparation)
- (ii) Review Editor and member of advisory editorial board of *Frontiers in Cryospheric Sciences*

Dr Helen Bostock (NIWA):

- (i) Immediate Past-President (New Zealand) of the Australasian Quaternary Association (AQUA) and member *ex officio* of AQUA committee (2012-2018)
- (ii) Co-editor of the SHAPE special issue of *Climate of the Past* (Lorrey et al. 2017)

Dr Carol Smith (Lincoln Univ.):

- (i) Co-editor of *Quaternary Australasia* (newsletter of AQUA)

Dr Andrew Rees (Victoria University of Wellington):

- (i) Member of AQUA committee (2016-2018)

Associate Prof Alan Hogg (Radiocarbon Dating Laboratory, University of Waikato):

- (i) Member of editorial advisory board of *Quaternary Geochronology*

Prof Jamie Shulmeister (University of Queensland, Brisbane):

- (i) Editor of book on the New Zealand Quaternary (published by Springer/Atlantis Press) in 2017: “Landscape and Quaternary Environmental Change in New Zealand”

Emeritus Prof Paul Williams (University of Auckland):

- (i) Author of textbook on the geomorphology of New Zealand including its Quaternary record (published by Elsevier) in 2017: “New Zealand Landscape: Behind the Scene”.

2.2. Please list International Union activities over the last year of relevance to your research community and describe how these have been communicated.

INTAV

- (a) A skill enhancement grant to INTAV of €5000 (~\$8500), awarded by SACCOM, INQUA, in 2017 enabled 10 early career researchers, and Prof David Lowe (University of Waikato) (awarded a separate grant of \$3000 from the State University of New York at Buffalo, USA), to attend a specialist tephra workshop “Best practices in tephra collection, analysis, and reporting: leading toward better tephra databases” on 19 August 2017 in Portland, Oregon, USA. That workshop involved around 10 New Zealand participants out of a total of 50
- (b) EXTRAS project: a special volume of tephra-focussed papers relating to the EXTRAS project was published in the international journal *Quaternary Geochronology* by Lane et al. (2017b) and comprised 12 papers and 2 editorials including Lane et al. (2017a). Also, a substantial invited review paper on tephra correlation and statistical methods was published in the international journal *Quaternary Science Reviews* as an output of both EXTRAS and SHAPE (Lowe et al. 2017)
- (c) A number of INTAV members including David Lowe were involved in the New Zealand three-group paleoclimates workshop in Wellington 27-28 August 2017 (noted also for SHAPE and SHeMax below)
- (d) INTAV executive including David Lowe are organizing an international tephra meeting “Crossing New Frontiers: Tephra Hunt in Transylvania”, 24-29 June, 2018, to be held near Brasov, Transylvania, Romania

SHAPE

SHAPE was awarded €6000 (~\$10,200) by PALCOM, INQUA, to enable the leaders including Dr Drew Lorrey (NIWA) to build networks across the Southern Hemisphere to undertake new paleoclimate research in the hemisphere as described in Appendix A. The funding supported two workshops of SHAPE as follows:

- (a) New Zealand paleoclimates workshop held in Wellington from 27-28 Aug 2017 with around 40 participants, mainly from New Zealand but with several from Australia. The workshop, as well as showcasing current research, led to the proposal for two review articles (on past climate proxies and geochronologies) to be developed over the next few years, these reviews being led by Dr Shaun Eaves (VUW) and Dr Andrew Rees (VUW)
- (b) An Australian paleoclimates workshop was held in Wollongong 2-3 February 2018 with around 30 participants from both New Zealand and Australia
- (c) SHAPE members in 2017 also produced two special volumes, one in the international journal *Journal of Quaternary Science* edited by Lorrey and Newnham (2017b) (15 papers and an editorial) and a second in the international journal *Climate of the Past* (Lorrey et al. 2017).

SHeMax

SHeMax leaders were awarded €4000 per year for 2016 and 2017 (i.e. €8000 total, about \$13,600) to undertake new collaborative research on the Last Glacial Maximum in the Southern Hemisphere. SHeMax leaders organized

- (a) a two-day workshop in Auckland 3-4 December 2016 and then took part in the New Zealand paleoclimates workshop in Wellington 27-28 August 2017
- (b) Another SHeMax workshop, led by Dr Lynda Petherick, is to be held 28-29 June 2018 at the Moreton Bay Research Station of the University of Queensland on North Stradbroke Island.

Communication in all of these programmes has been made via published papers in the international literature as well as via notices and reports in newsletters including *Quaternary Australasia* (AQUA) and *Quaternary Perspectives* (INQUA), multiple Facebook sites, and individual organisational (focus group or project) webmail services. David Lowe also reported to the New Zealand Quaternary community several times in 2016 and 2017 (also once so far in 2018) with brief updates on activities and issues via an email list (~60 names) of the main active Quaternary researchers. These emails are also copied to Australian INQUA representative Dr Jessica Reeves (Federation University Australia).

3. Additional comments

3.1. *Additional comments relevant to the International Union membership that you would like to share with the Society, MBIE, and/or the research community.*

The fee paid annually to INQUA, CHF2370 (~\$3500 NZD) represents very good 'value for money' in the sense that (a) New Zealand is paying the second lowest membership rate to INQUA, and (b) the New Zealand and (in part) Australia Quaternary research communities received considerably more in return from INQUA in the form of grants to the focus groups and projects of ~\$35,300 for the year Dec 2016 to Dec 2017, approximately a ten-fold difference.

Signature:



Delegate: (David J. Lowe)

Date submitted to the Society: 10 March 2018

Please return this form to the Royal Society Te Apārangi by email using the email address International.Unions@royalsociety.org.nz. For transparency reasons, we would appreciate if the report is additionally cc'ed to the President/Chair of the affiliated New Zealand organisation/national committee.

Acknowledgement:

I am very grateful to the following colleagues for information or insightful comments that improved the report:

Associate Prof Peter Almond (Lincoln Univ., Lincoln)

Dr Helen Bostock (NIWA, Wellington)

Dr Andrew Lorrey (NIWA, Auckland)

Prof Rewi Newnham (VUW, Wellington)

Dr Lynda Petherick (VUW, Wellington)

Dr Marcus Vandergoes (GNS Science, Lower Hutt)

Note that all or parts of this report may be made assessable to the public on the Royal Society Te Apārangi Catalyst: Influence website and through a Catalyst: Influence newsletter.

Appendix A: Summary of Quaternary-related research in New Zealand and relationship to International Union for Quaternary Research (INQUA)



Introduction

INQUA is a long-standing, reputable, and very active organization that represents a global community of scientists and others involved with research on all aspects of Earth history covering the time of the current ice age – that is, from about 2.58 million years ago (Ma) to the present. This period, the Quaternary, encompasses the Pleistocene (from 2.58 Ma to 11,700 years ago) and the Holocene (from 11,700 years ago to present day). It is characterised by dramatic and frequent changes in global climate, with multiple cold glaciations alternating with warm interglaciations alongside numerous associated changes and developments including the evolution and dispersal of hominins and humans (e.g. Walker and Lowe 2007).

INQUA, founded 90 years ago in 1928 (<https://www.inqua.org/>), comprises nearly 50 member countries and is committed to global collaboration to improve understanding of environmental change during the Quaternary through interdisciplinary research including both fundamental and applied aspects. It places emphasis on assisting the involvement of early career researchers (ECRs) as well as encouraging collaboration with researchers in developing countries. For example, at the INQUA Congress in Nagoya in 2015, 145 ECRs were supported financially to help enable their attendance, and a grant of €28,000 was provided to support participation of scientists from low GDP countries.

Because the Quaternary includes all aspects of Earth and hominin/human history since ~2.6 Ma, the range of topics able to be studied is effectively limitless. The massive, four-volume “Encyclopaedia of Quaternary Science”, published in 2013, attests to this wide scope (Elias and Mock, 2013). Consequently, INQUA has been organised into five broad, over-arching research areas, so-called ‘commissions’, with leaders elected on four-yearly cycles that coincide with the frequency that full INQUA congresses are held:

- Palaeoclimates (PALCOM)
- Coastal and marine processes (CMP)
- Stratigraphy and chronology (SACCOM)
- Humans and biosphere (HABCOM)
- Terrestrial processes, deposits and history (TERPRO)

Within these commissions are numerous (i) international focus groups (IFGs), (ii) projects, and (iii) skill-enhancement events (typically workshops). These formal groups/projects/workshops are eligible to receive funding from INQUA through competitive bids, as exemplified below and in the annual report. Each commission hosts website and Facebooks sites as do many IFGs. INQUA publishes a biannual newsletter, *Quaternary Perspectives* (<https://www.inqua.org/publications/quaternary-perspectives>). INQUA’s flagship publication is the journal *Quaternary International* (QI), which it owns. QI is published by Elsevier for INQUA and, along with fees from member countries, helps provide income for INQUA’s activities. Such activities include funding IFGs and projects (e.g. in 2016, €105,000 was spent on these).



New Zealand

New Zealand has an active and productive group of Quaternary scientists (Bostock et al. 2012). A wide array of topics is currently being investigated including many cross-disciplinary and multi-disciplinary projects, via the groupings/projects/workshops along with complementary projects funded locally. Some examples, chosen to highlight their diversity, include reconstructing past climates at a range of spatial and temporal scales and using a wide range of proxies; human evolution and dispersal; sea-level change past, present and future; tsunamis; paleoecology; identifying and using volcanic ash layers as a connecting and dating tool (tephrochronology); glacier modelling over time and space; tree-ring studies (dendrochronology); archaeology and paleoanthropology; paleontology; ancient DNA studies; advances in radiometric dating techniques; the Geological Time Scale and the advent of the Anthropocene; ice-core research; deep-sea marine research (paleoceanography); lake records and past environments including impacts of humans (paleolimnology); biodiversity and change; ancient soils (paleopedology); cave deposits (speleothems); natural hazards and their identification and mitigation; climate modelling; impact of volcanism on climate; past earthquakes and modelling (paleoseismology); neotectonic studies; global carbon budgets; and so on.

Topics and issues highly relevant to New Zealand and involvement of New Zealand scientists with INQUA, and benefits

New Zealand provides a unique and dynamic 'natural laboratory' for undertaking internationally relevant studies on volcanism, climate change, past vegetation, glaciation/glacierisation, sea-level change, ancient DNA, and the impact of humans during the Quaternary (e.g. Lorrey and Bostock 2017; Shulmeister 2017a; Wood et al. 2017). In a nutshell, this uniqueness stems from the location of New Zealand as an isolated archipelago that stretches from the sub-tropics to sub-polar regions in the mid-latitudes of the Southern Hemisphere astride a complex, obliquely convergent plate boundary (Newnham et al. 1999; Graham 2015; Shulmeister 2017b; Williams 2017). These features have generated a range of styles of volcanism and tectonic events, the development of a mountainous terrain sufficiently high in South Island to allow an ice cap to develop during glacials, and which lies athwart prevailing westerlies creating markedly contrasting climates. The dynamic evolving landscape helped generate unique fauna and flora: some are descendants from ancient Gondwanan times but most were either blown or washed here or derived from repeated environmental changes and tectonic and volcanic events in New Zealand during the Quaternary (e.g. Gibbs 2016). Research from New Zealand, one of the few landmasses in the southern mid-latitudes, can thus be used to examine and test explanatory models of global climate change and the links to the south westerly winds and Southern Ocean.

The very late arrival of humans to New Zealand (the last substantial landmass in the world outside the polar regions to be colonised) from eastern Polynesia in the mid- to late- 13th century means that most changes in the environment can be readily ascribed to natural (non-human) causes until very late in the geological record. Another 'ace' held by New Zealand Quaternary researchers is the well-dated inventory of volcanic-ash or tephra deposits that has been developed: the inventory enables different sorts of paleoenvironmental records (and archaeological deposits) firstly to be connected using the tephra layers as isochronous marker beds, and secondly it enables dates obtained on the tephra to be transferred from one environmental setting to another (i.e. via tephrochronology: Lowe 2011).

A key consideration in examining the rate and magnitude of climate change and global warming, and potential societal responses, is that projected models are reliant on two main sources of information: (i) actual measurements and (ii) inferred changes in climatic and other environmental parameters through time derived from analyses of proxies (such as pollen) extracted from dated archives (such as lake sediments). Measurements are limited to the instrumental record, which in New Zealand barely extends ~150 years, and so the use of estimated numerical data from Quaternary proxy studies, supported by the best chronology able to be constructed, becomes essential in underpinning robust

modelling of climatic change that takes into account both short- and long-term changes temporally and spatially. Such data form an important basis for the **Intergovernmental Panel on Climate Change (IPCC) Assessment Reports (ARs)**. Supported now by the United Nations, these reports began in 1988. The 5th Assessment Report was published in 2014, involving >800 authors; the first working group (WG-1) provided part 1 of the report “The physical science basis”. New Zealand climate and Quaternary scientists have been involved with the reports as writers or as leaders, with Prof Tim Naish (VUW) (full affiliations demarked by these abbreviations are given at the end of this document) being a Lead Author for WG-1 of Assessment Report 5, and Prof Andrew Mackintosh (VUW) a Lead Author for “Special report on the ocean and cryosphere in a changing climate” (SROCC) (scheduled for completion in September 2019).

Quaternary topics recently or actively investigated in New Zealand include:

1. Nature, scale, and tempo of climate and environmental change (past, present, and future), including the causes and timing of abrupt climate change such as those from 30,000 years ago, using a range of proxies, such as chironomid (midge) remains, pollen (palynology), or stable isotopic measurements, and various archives including ice cores, peat bogs, lake sediments, speleothems, tree-rings, and marine sediments
2. Mapping and modelling glaciers and ice sheets through time and evaluating potential drivers, especially during the last glacial maximum and the last glacial-interglacial transition
3. Determining and interpreting short-term climatic change such as El Nino-Southern Oscillation conditions using tree rings and other proxies
4. Measuring and modelling crustal deformation through time including neotectonics (e.g. Alpine Fault drilling project)
5. Understanding volcanoes and their composition, eruption history, and products.
6. Developing very high-resolution records of climate change through (for example) tree-ring studies of fossil kauri (e.g. Lorrey et al. 2018), annually-layered (varved) lake sediments (e.g. Lake Ohau project), corals, and ice cores
7. Modelling climate change and impacts, and contributing to IPCC reports
8. Impacts of humans on ecosystems such as on water and soil quality (e.g. MBIE funded Lakes 380 project), loss of biodiversity, soil carbon flux through time and space, and definitively separating human from natural drivers
9. Natural hazards, including volcanism, earthquakes, sea-level rise and coastal erosion, landsliding, flooding, and their mitigation (includes considerable research being supported by regional councils and MBIE Hikurangi Margin paleoseismicity project)
10. Developing and improving dating and stratigraphic methods for the Quaternary such as enhancing the calibration of the radiocarbon (¹⁴C) time scale (e.g. through the **International Calibration project INTCAL**, e.g. Hogg et al. 2013), utilizing U-Th/(He) zircon- or cosmogenic ³He-dating and luminescence dating, using Bayesian age-modelling methods (e.g. Vandergoes et al. 2013), and improving methods for identifying and statistically correlating volcanic-ash (tephra) beds (e.g. Lowe et al. 2017)
11. Timing and environmental impacts of Polynesian settlement, adaptations to environmental change spatially and temporally, and development of the Maori culture (e.g. Anderson 2016)
12. Using ancient DNA to understand New Zealand’s past environments and life
13. Contributing to the global geochronological framework encompassed by the Geologic Time Scale and contributing to the subdivision of the Holocene and the timing of the newly-endorsed Anthropocene Era

New Zealand’s active Quaternary scientists *per se* number about 50 or 60 in total. But many more ‘specialist’ scientists such as isotope geochemists, radiometric dating specialists, IT and GIS specialists, climate and numerical modellers, soil scientists, archaeologists, anthropologists, and environmental historians are engaged with research on the Quaternary – anyone working on deposits or processes

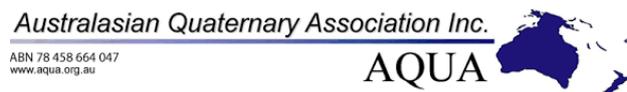
dating from ~2.6 Ma in New Zealand is effectively engaged with the topics above and many others. Such scientists and others are largely centred in CRIs including GNS science, NIWA, and Landcare Research, the universities, and regional councils.

Quaternary Techniques short course

A number of leading Quaternary researchers come together annually to participate in the GNS Science-led short course for graduates, “*Quaternary Techniques: Measuring Change and Reconstructing Past Environments*”. The QT course is run at the National Isotope Centre, GNS Science, Lower Hutt, for two days in mid-May every year. It attracts around 50 graduates/postgraduates from many of the New Zealand universities, and some from Australia. The mix of lectures, labs, and hands-on exercises covers a range of topics and practices that underpin Quaternary research methods and applications, and the meeting provides an opportunity for senior Quaternary researchers (e.g. Dr Marcus Vandergoes, GNS Science; Prof Rewi Newnham, VUW; A/prof Andrew McIntosh, VUW; Dr Chris Moys, UoO; Dr Drew Lorrey, NIWA; Dr Helen Bostock, NIWA; Dr Shaun Eaves, VUW; Prof Gary Wilson, UoO; Dr Nic Rawlence, UoO; Prof Troy Baisden, UoW; Dr Karyne Rogers, GNS Science; Prof David Lowe, UoW) to renew contact and, critically, to help encourage and mentor the next generation in the discipline and to develop thesis-based collaborative research projects.

Involvement and opportunity with AQUA community, and INQUA projects/focus groups

The majority of New Zealand Quaternary scientists are members of **AQUA: the Australasian Quaternary Association**.



AQUA lies under the umbrella of INQUA. It has been in existence since 1982 and is steered by elected office holders from New Zealand and Australia. As well as running a very active Facebook page and a website (<http://aqua.org.au/>), AQUA produces a high-quality newsletter, *Quaternary Australasia* (currently two issues per year), holds meetings every two years (the most recent being in Auckland in early December 2016 – see report), and supports ECRs and Quaternary scientists in various ways with scholarships and travel grants.



Fig. 1. Some of the AQUA participants at the INQUA Congress in Nagoya 2015 (photo: AQUA)

In 2007, AQUA hosted the full INQUA Congress in Cairns which attracted around 1000 participants from around the world (including >30 from New Zealand). This was only the third time the congress

had been held in the Southern Hemisphere (the first was in Christchurch in 1973, then Durban in 1999). Most recently, the Australia-New Zealand contingent (representing AQUA) was the 4th largest group at the Nagoya Congress in Japan in 2015 (Fig. 1; Lowe 2015). This strong showing reflects the remarkable resurgence in Quaternary studies in Australasia, in part a legacy from the outstanding Cairns congress and partly because of the advent of ‘closer collegial relations’ from 2003 when the globally-significant Australasian INTIMATE project (described below) began in New Zealand and Australia under the aegis of INQUA. The AUS-INTIMATE project galvanised the entire Quaternary research communities of both countries. As noted elsewhere, the most recent AQUA meeting in Auckland in late 2016 attracted ~120 participants, attesting to the vibrancy currently pervading the Quaternary community. AQUA also seeks to encourage research by younger workers in particular, by helping them to attend meetings and conferences and promote their work and the region. AQUA also encourages early career researchers to get involved with running the organisation and there are several ECRs on the committee.

International INQUA-funded projects/IFGs led by and involving Quaternary researchers in New Zealand, and benefits to New Zealand

In the past ~15 years or so, international projects led or co-led by New Zealand Quaternarists have been strongly supported by INQUA and represent a significant return on the much appreciated annual investment made by MBIE (or predecessor) via RSNZ to INQUA.

(1) Australasian-INTIMATE project (INTEgration of Ice-core, MARine and TERrestrial records since 30,000 years ago), led initially by Dr Brent Alloway (UoA/VUW), Prof Jamie Shulmeister (UoC, now UoQ), and Prof Rewi Newnham (UOP, now VUW) (2003-2007) and then by Dr Peter Almond (LINC), Dr Marcus Vandergoes (GNS Science), and Dr Andrew Lorrey (NIWA) (2008-2011), was within INQUA’s Paleoclimate Commission (PALCOM). Various people led different specific aspects of the project. The project began simultaneously in New Zealand (NZ-INTIMATE) and Australia (OZ-INTIMATE) effectively in 2004 with a series of annual meetings and workshops for NZ-INTIMATE involving most of the New Zealand paleoclimate community as well as geochronologists. The project culminated in publication in the international literature of a climate event stratigraphy, a newly developed tephrochronological framework, and various other papers on past vegetation patterns, etc (e.g. Barrell et al. 2005, 2013; Alloway et al. 2007; Lowe et al. 2008, 2013; Bostock et al. 2013; Newnham et al. 2013). The paper by Alloway et al. (2007) involved 56 co-authors. Funding support from the INQUA parent body towards the NZ-INTIMATE Project was in the order of \$3000 per year on average to help support costs for workshops and to help support emerging scientists attend such meetings.

(2) SHAPE project/IFG (Southern Hemisphere Assessment of PalaeoEnvironments). This project/IFG effectively took up where the AUS-INTIMATE project finished, being formed initially as a project within INQUA’s PALCOM (2013-2015).



It was then granted the status of a full International Focus Group (2016-2019). Initiated and led by Dr Andrew Lorrey (NIWA) and Dr Stephen Phipps (UNSW, now at IMAS), and supported by several other leading New Zealand, Australian, and South African Quaternary researchers, SHAPE continued some of the goals of AUS-INTIMATE, such as production of high resolution palaeoclimate records during the late Quaternary.

However, it has a wider spatial scope, incorporating New Zealand, Australia, the Pacific islands, South America, South Africa, Antarctica and the Southern Ocean. In addition, the time scale extends back to 60,000 years. As well as using proxy-based reconstructions to compare with climate model simulations to determine distinct circulation and climate modes of the past, SHAPE additionally aims to reconstruct atmospheric and oceanic circulation patterns for three critical

periods in the Late Quaternary – 32,000, 21,000, and 6000 years ago – to improve understanding of Southern Hemisphere climate and environmental changes. These reconstructions will be compared with the PMIP3 (Paleoclimate Modelling Intercomparison Project) and CMIP5 (Coupled Model Intercomparison Project) multi-model ensemble for these same time periods and a transient simulation for the last 8000 years. Integration with climate model simulations are helping to enable the formulation of new hypotheses about triggers of climate change, climate dynamics, and mechanisms of inter-hemispheric climate teleconnections.

Training is another key SHAPE activity. It is focussing on using new tools designed for palaeoclimate research, including the Past Interpretation of Climate Tool (PICT) to generate targets for Southern Hemisphere circulation patterns based on Australasian data, and other areas of the Southern Hemisphere, to assist in interpreting hydroclimatic and circulation conditions linked to a wide array of climate drivers. Proxy reconstructions, and understanding of local responses to circulation changes, will also help improve the interpretation of proxy data.

SHAPE activities over the past year are given in the annual report. They include publication of two special issues of papers on new Southern Hemisphere paleoclimatic records (Lorrey et al. 2017; Lorrey and Newnham 2017a, 2017b). The 26 papers in these issues derive from research in New Zealand (including subantarctic islands), Australia, Chile (including Patagonia), Papua New Guinea, South Georgia, South Africa, Madagascar, and from oceanographic research.

- (3) INTAV, the International Focus Group on Tephrochronology and Volcanism.** This IFG was established in its present form in 2007 within INQUA's Stratigraphy and Chronology Commission (SACCOM), although equivalent tephra-focussed groups associated with INQUA date back to 1961 (the history is summarised in Lowe et al. 2011b and Lane et al. 2017a).



INTAV has a website (<http://www.comp.tmu.ac.jp/tephra/intavtmu/pg772.html>) and operates an active Facebook site and also uses JISCMail-Tephra for international communication. It has an executive of four formally elected members including Prof David Lowe (since 2007; other New Zealand tephra specialists A/prof Victoria Smith (UoOx) and A/prof Phil Shane have been executive members of INTAV as well in the past decade. Currently Prof David Lowe (UoW) is immediate past-president, and Prof Takehiko Suzuki (TMU) is president. INTAV (and earlier equivalent groups) has organised a series of international field conferences and workshops over the past decades including in 1990 (Mammoth, USA), 1994 (Hamilton, New Zealand), 1998 (Le Puy, France), 2005 (Dawson, Yukon Territory, Canada), and 2010 (Kirishima, Japan). All resulted in publication of papers in special tephra-focussed volumes. Also, INTAV led an interlaboratory comparison exercise for the analysis of glass shards using the electron microprobe that involved New Zealand laboratory participation (Kuehn et al. 2011).

- (4) INTREPID project** (Enhancing Tephrochronology as a global research tool, parts I and II) was led by Prof David Lowe. The project was an initiative of INTAV and began in 2009 and finished in 2015. Funding from INQUA was received annually from 2009 amounting to around \$8000 per year to support activities relating to the aims of INTREPID. In 2010, INTREPID grants (about \$1200 each) from INQUA enabled three New Zealand geoscientists to attend the international tephra meeting, "Active Tephra in Kyushu", held in Kirishima, Japan. A volume of papers, including New Zealand articles, from that meeting was published by Lowe et al. (2011a). In 2014, a skills-based workshop "Tephra 2014" was funded by a grant to INTAV from INQUA (~\$8000) that supported ECRs, including several from New Zealand, to attend the workshop in Portland, USA.

(5) EXTRAS Project (EXTending TephRAS as a global geoscientific research tool stratigraphically, spatially, analytically, and temporally), led by David Lowe, is another initiative of INTAV and runs from 2016-2019. It follows directly on from INTREPID. To meet its aim (encapsulated in the title 'Extending TephRAS'), EXTRAS is addressing seven core objectives ('the magnificent seven'):

- (a) To evaluate and apply new and emerging technologies to identify and map proximal-to-distal tephras, and cryptotephra deposits, and to establish their spatial and stratigraphic interrelationships to facilitate their use as chronostratigraphic units and as a basis for documenting volcanic eruption histories.
- (b) To develop and evaluate new and emerging methods to characterize tephra and cryptotephra constituents mineralogically and geochemically (including isotopically) using formalised protocols that enhance data quality and quantity.
- (c) To develop improved age models for tephra and cryptotephra deposits and hence to improve existing age models for key palaeoclimatic, archaeological, and other sequences using tephra and cryptotephras as appropriate.
- (d) To evaluate and develop objective ways of correlating tephra and cryptotephra deposits from place to place using statistical techniques and numerical measures of (un)certainty of correlation.
- (e) To develop regional and ultimately global databases of high-quality mineral, geochemical, and other data (stratigraphic, chronologic, spatial) for tephra and cryptotephra deposits.
- (f) To maintain and enhance the global capability of tephrochronology for future research through mentoring and training of emerging researchers in the discipline.
- (g) To improve education to the wider community (outreach) about tephrochronology and its application and relevance.

Activities in the past year of EXTRAS are given in the annual report. They include publication of a special issue on tephras (Lane et al. 2017b) arising from papers presented in tephra sessions at the Nagoya INQUA Congress in 2015. EXTRAS objectives form the core of sessions being planned for a forthcoming international tephra meeting, "Crossing New Frontiers: Tephra Hunt in Transylvania", being held near Brasov, Romania, in June 2018.

(6) SHeMax project (The Last Glacial Maximum in the Southern Hemisphere). SHeMax is a project within INQUA's PALCOM commission running from 2016-2019. Led by Dr Lynda Petherick (VUW), with close support from several other New Zealand and Australian Quaternary scientists, SHeMax seeks to develop a greater understanding of the timing and nature of the LGM in the Southern Hemisphere.



In order to achieve this, proxy data archived in marine and terrestrial records from different settings in the Southern Hemisphere are being analysed for the period 35,000 to 15,000 years ago, encompassing the termination of the last glacial cycle, and the traditionally-accepted timing of the global Last Glacial Maximum (LGM) ~24,000 to 18,000 years ago. Emerging evidence suggests that instead of being a relatively short event centered on 21,000 years ago, the LGM in the Southern Hemisphere may have been an extended period of time, with an early onset at 35,000-30,000 years ago. It has also been suggested that the LGM was not uniformly cool and dry, but may have been characterized by millennial-scale variability, as indicated by the earlier findings of the NZ-INTIMATE project (Barrell et al. 2013).

In SHeMax, records from high-resolution marine and coastal sediments, lake sediments, speleothems, ice cores, glacial moraines, dunes and fluvial systems will be compared to produce a

synthesis of climatic variability and explore the premise of an extended LGM in the Southern Hemisphere. The spatial focus will be ~20-80° S, which will allow investigation into teleconnections between the mid- and high-latitudes. In addition to the synthesis of environmental conditions, suggested drivers and/or triggers of climatic variability are being evaluated. A significant component of the SHeMax project is the comparison of proxy data with model simulations for the LGM, e.g. PMIP, SynTRACE-21. The project will also investigate the response of humans during the LGM to climatic variability, in terms of settlement, migration and cultural development.

Activities of SHeMax for the past year are given in the annual report.

(7) Six examples of international recognition of New Zealand Quaternary geological archives as globally-significant or unique, and New Zealand leadership and participation in globally-important research and decision making

(a) Whanganui Basin (text below taken from Pillans 2017)

Whanganui Basin is a unique New Zealand (and global) archive. Nowhere else in the world is there yet documented a shallow marine basinal sequence, exposed on land, which spans the entire Quaternary. Furthermore, marginal, slow uplift of the basin has resulted in a sequence of marine terraces that spans much of the Middle and Upper Quaternary. Thus, coeval shoreline and inner shelf marine sediments are preserved within the basin (Fig. 2). Proximity of the basin to the Taupo Volcanic Zone also means that the basin contains many rhyolitic (silica-rich) tephras, which allow correlation and dating both within the basin and throughout the New Zealand region, including deep-sea cores.

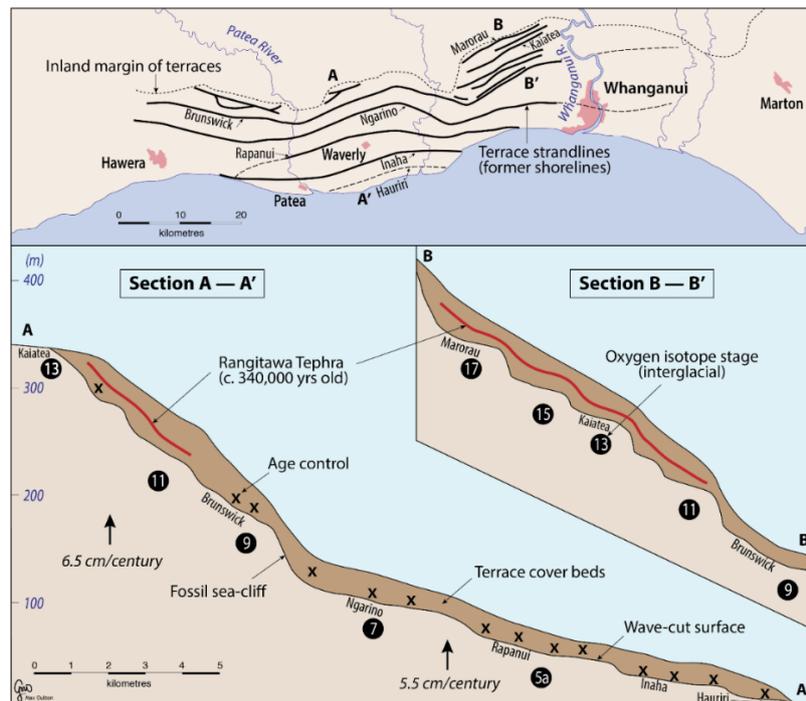


Fig. 2. Two N-S oriented cross sections in the Whanganui region showing a series of wave-cut coastal terraces that reflect progressive tectonic uplift, becoming higher and older inland (after Carter 2015, p. 281, based mainly on Pillans 1983).

The richly fossiliferous marine sediments of Whanganui Basin provide the basis for definition of the younger stages of the New Zealand geological timescale: the stratotype sections and points (SSPs) of the Haveran, Castlecliffian, Nukumaruan and Mangapanian Stages are all located within

Whanganui Basin. A particularly significant feature of the Whanganui Basin is the potential for marine-terrestrial correlation. This arises because of the intricate stratigraphic relationships between marine and non-marine deposits in the basin, best illustrated by the marine terraces and their coverbeds. Quaternary eustatic sea-level fluctuations, because of global ice-volume changes, are directly recorded as shorelines and cyclic shelf sediments (Fig. 3). Associated paleoclimatic changes are recorded in loess deposits and floral and faunal assemblages, which can be stratigraphically related to shoreline (sea-level) changes. Tephras and magnetostratigraphy provide the chronological framework.

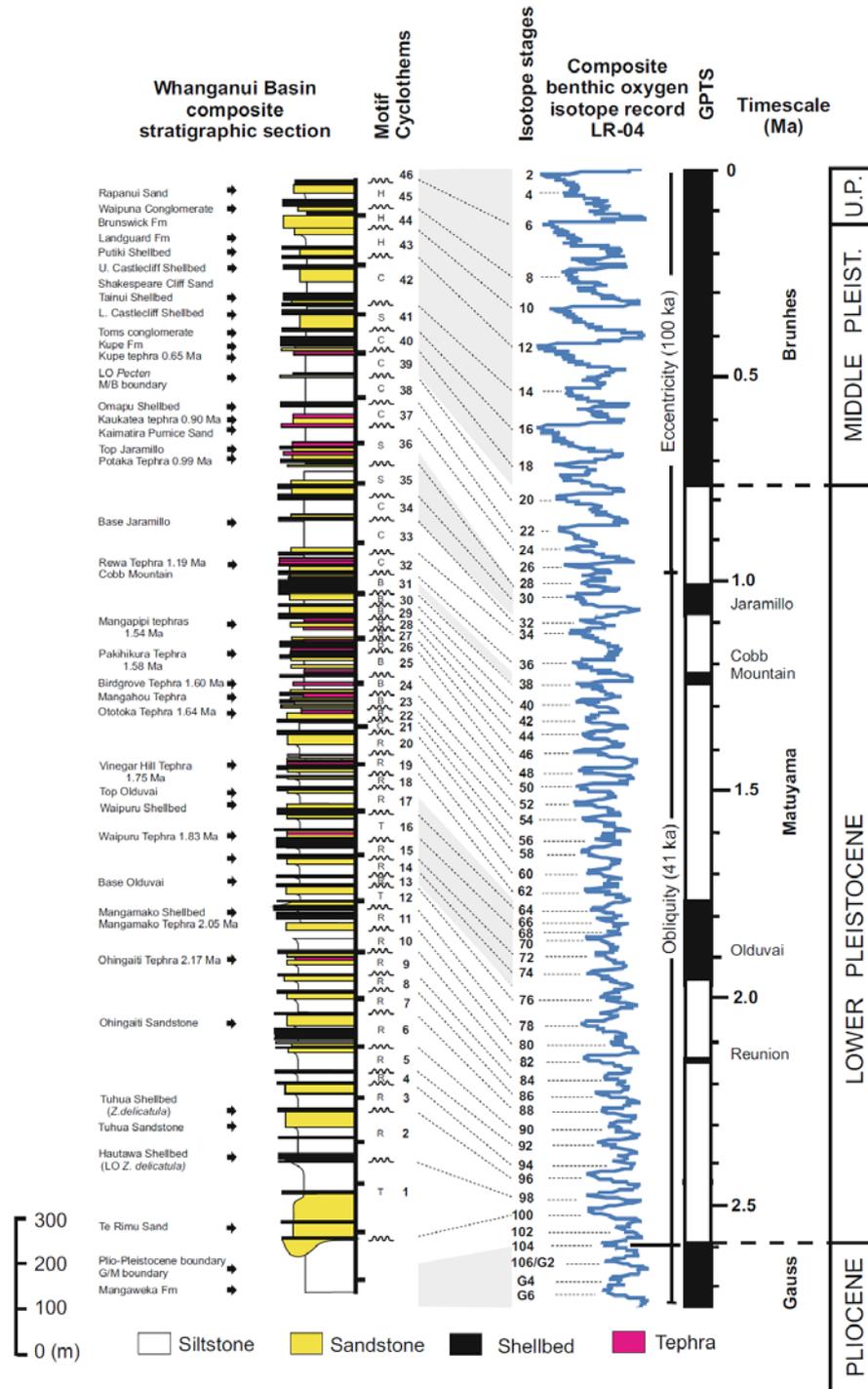


Fig. 3. Composite cyclostratigraphy for the last 2.6 Ma of the Whanganui Basin (from Pillans 2017, p. 144). H Hawera, B Birdgrove, T Turakina, S Seafeld, C Castlecliff, R Rangitikei, GPTS Geomagnetic Polarity Time Scale

Whanganui Basin has been a fertile testing ground for sequence stratigraphic models, originally developed by the petroleum industry to interpret deep seismic data from sedimentary basins in terms of sea level and sedimentary architecture. The Plio-Pleistocene is the only part of the stratigraphic record for which there is an independent high-resolution proxy sea-level record (from the oxygen isotope record in deep-sea sediments). Whanganui Basin is one of the few on-land unconformity-bounded, shallow marine sedimentary sequences in the world that provides sufficient outcrop to test the sequence stratigraphic model against known sea-level changes.

(b) Base of the Holocene and its subdivision

The boundary between the Pleistocene and the Holocene is now defined in a Greenland ice core. This type location is supported by five reference sites called parastratotypes (global auxiliary stratotypes) around the world. The Australasian region is represented by sediments in Lake Maratoto (Fig. 4). The boundary is marked by a distinct Egmont-derived tephra layer (Konini bed-b) aged ~11,800 years. Maratoto lies about 10 km south of Hamilton and is ~22,000 years old and empounded by volcanogenic alluvium overlain by thick peat (Walker et al. 2009). The proposal for the tephra-bearing Lake Maratoto sediments to be the parastratotype was made by Profs Rewi Newnham (VUW) and David Lowe (UoW).



Fig. 4. Lake Maratoto in which the Pleistocene-Holocene boundary for Australasia is defined (photo: David Lowe).

Prof Newnham is also the only Southern Hemisphere representative on the international panel charged with developing a proposal for formal subdivision of the Holocene that can be applied at the global scale (see item d below) (Walker et al. 2012; Head et al. 2017).

(c) Kauri tree rings

In northern New Zealand, lowland forests grew continuously through the full interglacial-glacial-interglacial cycle from 125,000 years ago, unlike the rest of New Zealand or land elsewhere in the world that had no forest during the glacial period. The northern forest included *Agathis australis* (kauri), albeit in diminished proportions during glaciations in comparisons with its relative abundance during interglaciations. Wetlands or 'swamps' (many now drained) contain large amounts of preserved subfossil kauri from long-lived trees (Fig. 5), and these provide a globally unique scientific resource – a 'world class paleoarchive' – of huge potential for multiple scientific endeavours of international significance as reported by Lorrey et al. (2018):

- (i) Swamp kauri tree-ring chronologies are temporally unique, and secondary analyses (such as radiocarbon and isotopic analyses) have value for improving understanding of Earth's recent geologic history and pre-instrumental climate history (e.g. Palmer et al. 2016).
- (ii) Swamp kauri deposits that span the last interglacial-glacial cycle show potential to yield 'ultra-long' multi-millennia tree-ring chronologies, and composite records spanning large parts of Marine Oxygen Isotope Stage 3 (and most of the Holocene) may be possible.
- (iii) High-precision radiocarbon dating of swamp kauri chronologies can improve the resolution of the global radiocarbon calibration curve (INTCAL) (see item d below), while testing age modelling and chronologic alignment of other independent long-term high-resolution proxy records (e.g. Turney et al. 2016).
- (iv) Swamp kauri also has the potential to facilitate absolute dating and verification of cosmogenic events found in long Northern Hemisphere tree-ring chronologies.



Fig. 5. Quaternary researchers from New Zealand and Australia join forces on an AQUA Auckland conference field trip in December 2016 alongside a large, ancient kauri stump in Northland. Dendrochronologist and trip leader Dr Drew Lorrey (NIWA) standing fifth from left (wearing brown top). See also Fig. 6.

(d) International Radiocarbon Calibration (INTCAL)

The University of Waikato Radiocarbon dating Laboratory, directed by A/prof Alan Hogg, has been involved with the INTCAL project for several decades, and has led the development of the Southern Hemisphere (SH) ¹⁴C calibration curve (SHCal). Although the ¹⁴C calibration curves from the Northern Hemisphere (NH) and SH are broadly similar, there are subtle differences between the structural forms of each curve. For this reason, calibration, and especially ¹⁴C wiggle-matching, are best achieved using dendrochronologically secure calibration data sets derived from the appropriate hemisphere. Such work has been undertaken by collaborating geochronologists and Quaternary scientists including dendrochronologists, and the results are published approximately every four years or so as new data are acquired, modelled, discussed and agreed by international protocol. The most recent INTCAL papers were published in 2013 (e.g. Hogg et al. 2013; Reimer et al. 2013). These papers are hugely influential: for example, Reimer et al. (2013) has been cited >4677 times and Hogg et al. (2013) >798 times (Google Scholar data 26 Feb 2018).

The development of the SH calibration curve, including using kauri, has been important in many applications such as dating the famous Taupo eruption to $AD\ 232 \pm 10$ (Hogg et al. 2012) and dating (for the first time) $p\bar{a}$ palisade posts (Hogg et al. 2017). The work at Waikato has also led to revisions and corrections of the NH calibration curves as well as deepening understanding of the mechanisms and drivers involved in the natural carbon isotope system through time (e.g. Hogg et al, 2016; Turney et al. 2016, 2017a, 2017b).



Fig. 6. Slab of kauri for use in calibrating the radiocarbon time scale in the Southern Hemisphere at the Waikato Radiocarbon Dating Lab, UoW (photo: Alan Hogg)

(e) Defining the Anthropocene

A group of New Zealand and Australian Quaternarists (Bostock et al. 2015) led a survey of AQUA members regarding the feasibility and potential timing (start) of the proposed new geological period, the Anthropocene (Malhi 2017). They wrote up the findings as a report for the international group (the Anthropocene Working Group) charged with the revising the Geological Time Scale (Zalasiewicz et al. 2017) (Fig. 7).

Recently, new trans-Tasman research by AQUA members proposed that the start of the Anthropocene be 1965 AD on the basis of a ‘bomb peak’ atmospheric radiocarbon fallout signal identified and dated precisely (to October–December 1965) by dendrochronology in an exotic Sitka spruce tree (dubbed ‘the loneliest tree in the world’) on subantarctic Campbell Island (Fig. 8; (Turney et al. 2018). The ‘bomb peak’ in this remote and pristine location is broadly coincident with many environmental changes associated with the post-World War II ‘Great Acceleration’ in industrial capacity and consumption (e.g. Zalasiewicz et al. 2017), and the authors thus claim that the findings provide a precisely-resolved potential Global Stratotype Section and Point (GSSP) or ‘golden spike’, marking the onset of the Anthropocene Epoch (Fig. 9).

Eonothem / Eon		Erathem / Era		System / Period		Series / Epoch		Subseries / Subepoch		Stage / Age		GSSP		Numerical age (Ma)			
Phanerozoic	Cenozoic	Quaternary	Anthropocene	to be named									present				
					U/L	Meghalayan								mid-20th century			
					M	Northgrippian									0.0042		
					L/E	Greenlandian									0.0082		
							U/L	to be named							0.0117		
							M	to be named							0.126		
							L/E	Calabrian							0.773		
								Gelasian							1.80		
															2.58		

Fig. 7. The Quaternary time scale as currently preferred by the Anthropocene Working Group, with the Anthropocene shown at the rank of series/epoch. Black type indicates names officially approved and ratified by the International Commission on Stratigraphy (ICS)/Executive Committee of the International Union of Geological Sciences (IUGS EC). Names or Global boundary Stratotype Section and Point (GSSP) designations in grey type or as grey 'spikes' have yet to be officially sanctioned by ICS/IUGS EC, but stage names and subseries for the Holocene were approved by the Subcommittee on Quaternary Stratigraphy (Zalasiewicz et al. 2017).

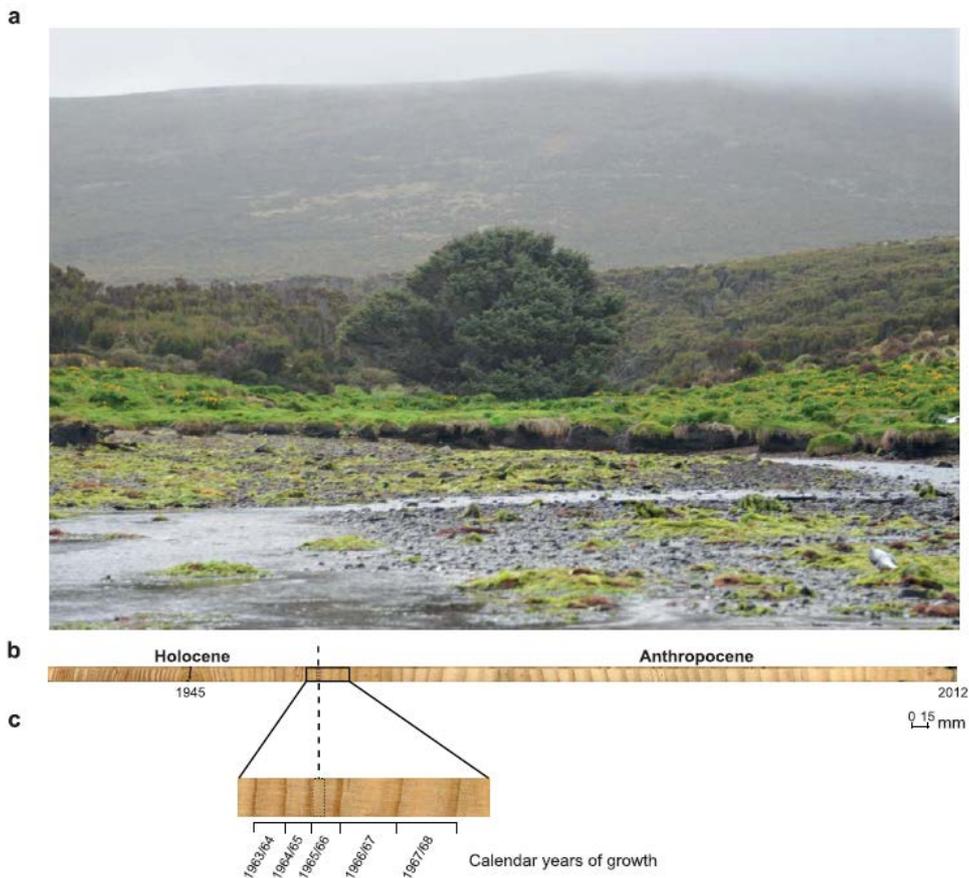


Fig. 8. The “Loneliest Tree in the World”. The subantarctic Campbell Island Sitka spruce (*Picea sitchensis*) surrounded by open *Dracophyllum* sp. scrub (panel a) with visual image of tree-ring growth (panel b) and enlargement of the proposed transition between the Holocene and Anthropocene (panel c) (Turney et al. 2018).

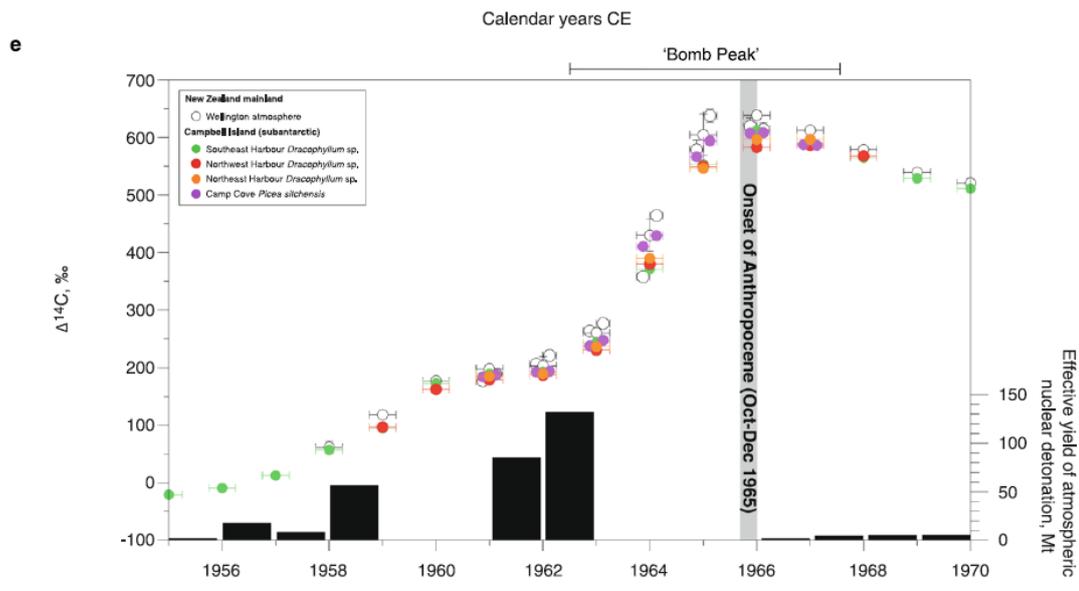
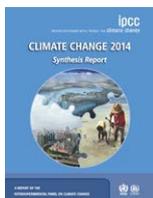


Fig. 9. Bomb carbon measured for the period 1955–1970. The peak in the Campbell Island Sitka spruce (*Picea sitchensis*) ^{14}C (filled purple circles) during the austral spring (October-December) of 1965 matches the signal measured at Lower Hutt (open circles) and demonstrates a regionally-representative signal that falls within the period of the Northern Hemisphere bomb peak (Turney et al. 2018).

(f) Involvement with Intergovernmental Panel on Climate Change (IPCC) Assessment Reports and recognition with Nobel Peace Prize



Several New Zealand climate/Quaternary scientists have been involved with the IPCC Assessment Reports. For example, as noted earlier, Prof Tim Naish (VUW) was a Lead Author for Working Group-1 of the 5th IPCC Assessment Report 5 (2013), and Prof Andrew Mackintosh (VUW) is Lead Author for “Special report on the ocean and cryosphere in a changing climate” (in preparation). Dr David C. Lowe (no relation to author of this Catalyst report) was a Lead Author for Working Group-1 of Assessment Report 4 (2007), which also involved (past or present) NIWA staff Drs James Renwick, Jim Salinger, David Wratt, Martin Manning, and Andy Reisinger. These scientists shared in the award of the Nobel Peace Prize for the authors of IPCC Assessment Report 4.

Syntheses of each report are provided as summaries (e.g. IPCC 2014).

Summary of benefits

The benefits of New Zealand’s membership of INQUA include (but are not limited to) the following:

- (a) to give New Zealand a voice and vote in the activities of the world’s leading group of scientist (INQUA) dealing with climate change, tectonism, volcanism, human evolution and environmental impacts, and numerous other topics relating to the Quaternary period, including the present day, and projected future changes through IPCC reporting;

- (b) to provide an overarching organisation to foster research projects through commissions, with the INTIMATE project being an outstanding success that engaged and stimulated essentially the entire Quaternary community in New Zealand to new levels of internationally and nationally acclaimed research; INTAV has also been very successful and helped to put New Zealand research, including use of unique features, and leadership on to the global stage;
- (c) to provide direct financial support to the IFGs SHAPE and INTAV, and the SHeMax and EXTRAS projects, that amounts to about a ten-fold return on the annual fee paid to INQUA, and of direct benefit to many New Zealand Quaternarists, especially younger, emerging scientists through travel and conference grants; and
- (d) fostered much closer ties and established and maintained strong networks through AQUA and projects such as INTIMATE and SHAPE with Australian and international colleagues, with INQUA sponsorship providing leverage for in-kind support for meetings and analytical services.

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Abbreviations

GNS Science, Institute of Geological and Nuclear Sciences
 IMAS, Institute for Marine and Antarctic Studies, University of Tasmania
 LINC, Lincoln University
 NIWA, National Institute of Water and Atmospheric Research
 UNSW, University of New South Wales
 UoA, University of Auckland
 UoC, University of Canterbury
 UoO, University of Otago
 UoOx, University of Oxford
 UoP, University of Plymouth (UK)
 UoQ, University of Queensland
 UoW, University of Waikato
 VUW, Victoria University of Wellington