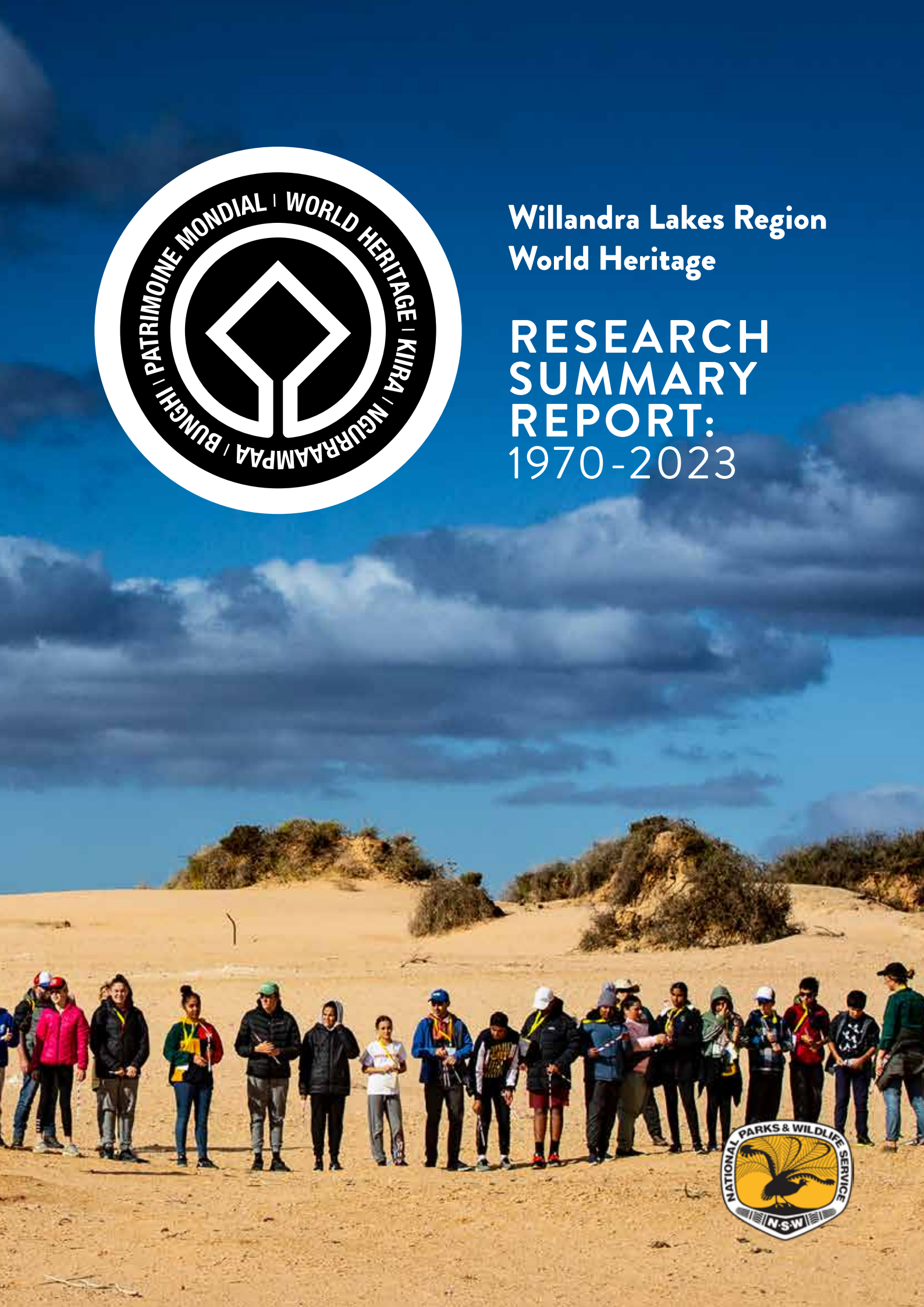
Willandra Lakes Region
World Heritage

RESEARCH SUMMARY REPORT: 1970-2023



CRITERIA FOR LISTING THE WILLANDRA LAKES REGION

ON THE WORLD HERITAGE LIST AND NATIONAL HERITAGE REGISTER

(Commonwealth of Australia Gazette, No. S99, 21 May 2007).

LISTING	CRITERION	DESCRIPTION
World Heritage	(iii)	to bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared
World Heritage	(viii)	to be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features
National Heritage	(a)	the place has outstanding heritage value to the nation because of the place's importance in the course, or pattern, of Australia's natural or cultural history
National Heritage	(b)	the place has outstanding heritage value to the nation because of the place's possession of uncommon, rare or endangered aspects of Australia's natural or cultural history;
National Heritage	(c)	the place has outstanding heritage value to the nation because of the place's potential to yield information that will contribute to an understanding of Australia's natural or cultural history
National Heritage	(g)	the place has outstanding heritage value to the nation because of the place's strong or special association with a particular community or cultural group for social, cultural or spiritual reasons

United Nations Educational, Scientific and Cultural Organization

Willandra Lakes Region Inscribed on the World Heritage List in 1981

Cover Photo: *Students at the Mungo Youth Project.*
Photo credit: *Paul Jones, Centre of Excellence for Australian Biodiversity and Heritage*

CONTENTS

INTRODUCTION

What research is happening in the Willandra Lakes Region World Heritage property? This world-famous cultural landscape is synonymous with archaeological and geological research and yet there is surprisingly little understanding of the type and extent of research that has been, and is being, carried out in the World Heritage property.

The purpose of this summary is to enhance awareness about the quantity and scope of research in the Willandra Lakes Region which is supported by or developed with the properties Aboriginal Advisory Group. Researchers who commenced or completed their research from 2015, the year the Aboriginal Advisory Group was established, were invited to contribute to this summary. All submissions received are presented in the following pages. The detailed bibliography at the end of this publication captures additional projects, where researchers were unable to provide summaries. To the best of our knowledge, the bibliography also captures all research outputs pre-2015.

The summary is divided into two types of research program, the first section is for all research carried out as part of the Mungo Archaeological Project. A multi-disciplinary project that ran for 10 years from 2007 to 2017 that saw the completion of numerous research projects. As all research under the Mungo Archaeological Project were researching a common theme, we clumped them together. The second part is for Individual Projects. These projects are often more focused, and smaller in nature and generally do not involve multiple research teams.

Research is a priority

Between the years 2015 and 2022, the Willandra Lakes Region World Heritage Aboriginal Advisory Group considered 115 agenda items relating to research. These items included requests to initiate new research, summaries of proposed publications, project updates and requests to apply for research funding to start new research projects. Approximately one-third of all meetings were spent reviewing, supporting and developing research in the Willandra.

Developing a Research Database

To prepare this summary, National Parks and Wildlife Service (NPWS) worked with La Trobe University's Mungo Archaeology Project, to develop a research database to document research outputs from the Willandra Lakes Region.

The aim of the database is to:

- facilitate the analysis of research carried out in the Willandra Lakes Region World Heritage property between 1969 and 2022,
- compile archival records to facilitate future updating and analysis and
- generate baseline information for identifying research gaps and to inform the development of a future research strategy and endeavours.

Research gaps will be identified by analysing the research database against the new research themes, identified within the Willandra Lakes Region World Heritage Research Prospectus developed by the Willandra Lakes Region World Heritage Advisory Committee. These themes include:

- Changing Cultural Landscapes;
- Enhancing the continuity of connection to Country;
- Sharing and archiving information;
- Language and Lore and Traditional Knowledge and skills;
- Sustaining the health of Country and its cultural and natural values

Research Themes

Below we summarise initial outcomes from analysis of the database. The database illustrates a continuity of research outcomes since the late 1960s with 251 primary research outputs identified (Table 1 summarises the different types of outputs). Since 1969, up to ten primary research outputs have been published or completed every year, although in most years, the number ranges from one to four. While research has been consistent since the late 1960s, there have been two major projects Australian National University field program (1969-1979) and the La Trobe University Mungo Archaeological Project (2007-2017). Interestingly, publications in the database do not correspond to these time periods due to the time it takes to analyse and write up results. Many of the publications from these projects were published years later.

See Table 1 and Figure 1

Table 1. Primary research outputs.

Record type	#	%
Journal article – peer reviewed	126	50
Book chapter – peer reviewed	28	11
PhD thesis	17	7
Master/Honours thesis	32	13
Government reports	11	4
Consulting reports	37	15
Total	**251**	**100**

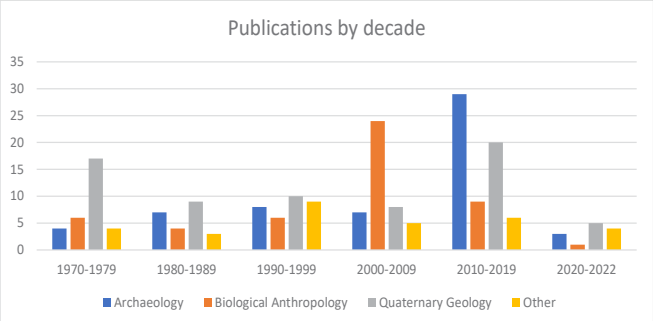


Figure 1. Decade by decade summary of the number of primary research outputs in Quaternary geology, archaeology, biological anthropology and other disciplines.

What influence has World Heritage Listing had on research?

Research to date has aligned closely with the criteria for the listing of this World Heritage property (Figures 1 and 2). The property was inscribed in 1981 for its outstanding cultural and natural values; specifically for 'bearing exceptional testimony to a past civilisation' (criterion iii), which was updated in 2007 to include 'cultural traditions as well as civilisations that are living or which have disappeared' and as 'an outstanding example of a landscape illustrating a significant stage in human history' (criterion viii). The disciplines most closely related to these world heritage criteria have dominated the primary research outputs over the past 40 years.

What are the research interests?

Ten disciplines are represented in the database and the majority of these relate to research in Quaternary geology, biological anthropology and archaeology, and of these, Quaternary geology predominates.

The disciplines include:

- biological anthropology
  - morphological analysis: 43%
  - trace fossils: 17%
  - geochronology: 17%
- Quaternary geology
  - palaeoenvironments: 45%
  - geochronology: 36%
- Archaeology:
  - stone artefacts: 30%
  - landscape archaeology: 20%
  - faunal analysis: 14%
  - the study of open sites: 12%

The database shows that there are four predominate subdisciplines, Geochronology (17%), Palaeoenvironments (15%), Ancestral remains and morphological studies (12%) and stone artefact studies (11%). Another 28 sub-disciplines contributed less than 10% of the primary research outputs, and a further 22 sub-disciplines which each contributed 1%. Faunal studies designed to generate information about diet and foraging activities contributed to only 5% of primary research outputs.

Where is the research happening?

The Willandra Lakes Region is made up of some 13 main lakes and is most well-known for Lake Mungo. It is therefore no surprise that 47% of the primary research outputs that directly related to a site occurred in Lake Mungo. Only 22% of location specific research took place in other parts of the Willandra Lakes system.

The academic Impact

The academic impact of the Willandra Lakes Region is far reaching and not just for researchers with a local interest. Information learnt from the Willandra has had a broad and lasting impact to national and international narratives of human history. Six percent of the primary research outputs in this database build into this broader discussion. Over half of this is focused on biological anthropology. This emphasises the impact the Willandra Lakes has had on global academic narratives.

Below are a series of charts and graphs that illustrate how the database can be used to gain a better understanding of research in the Willandra Lakes.

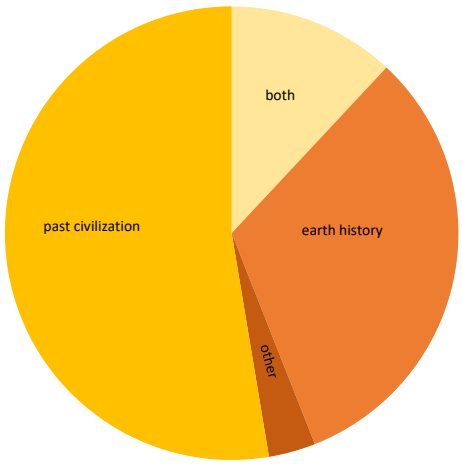


Figure 2. Proportion of publications representing the two key criteria for heritage listing

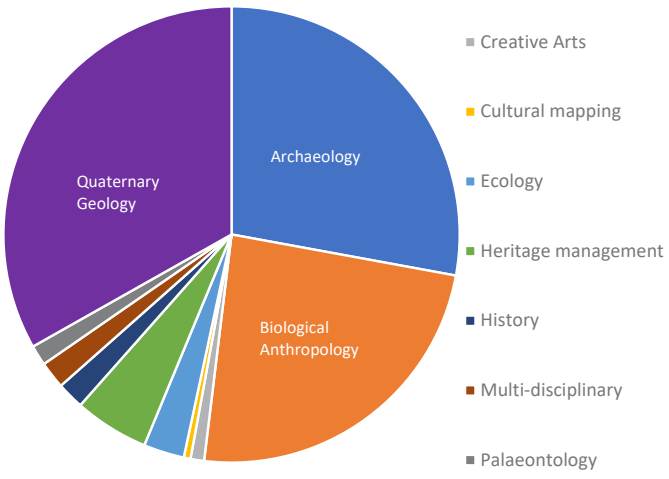
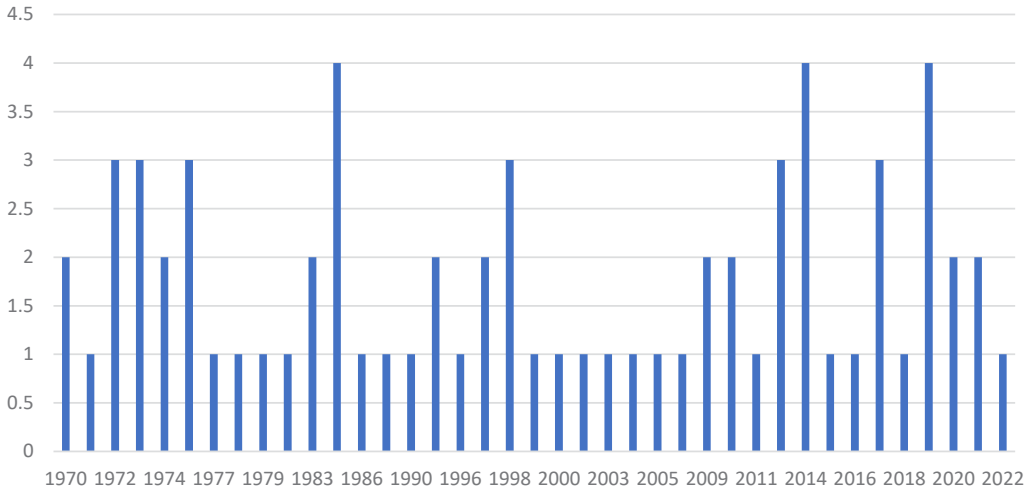


Figure 3. Disciplines represented in the primary research outputs

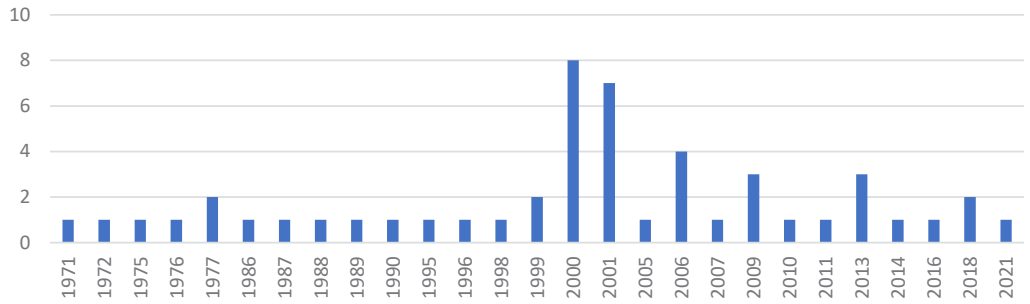
RESEARCH OUTPUTS FROM QUATERNARY GEOLOGY

Quaternary geology: years in which research outputs were produced and number of research outputs for those years



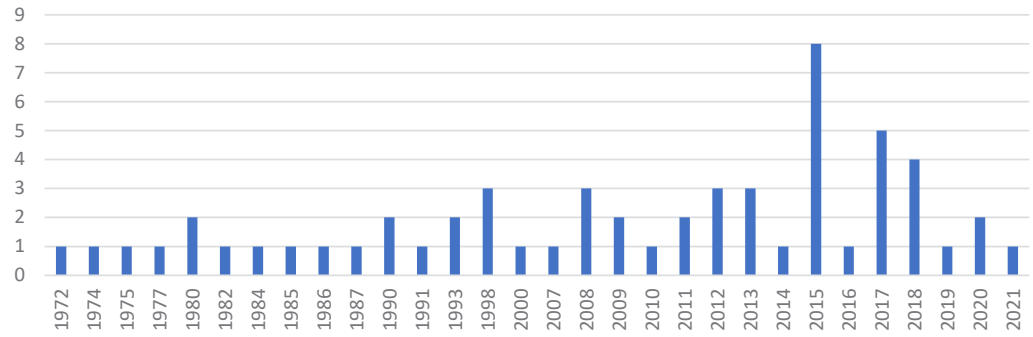
RESEARCH OUTPUTS FROM BIOLOGICAL ANTHROPOLOGY

Biological anthropology: years in which research outputs were produced & number of outputs for those years



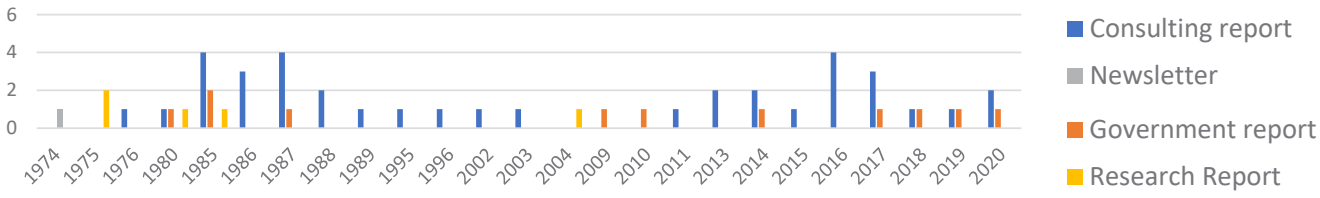
RESEARCH OUTPUTS FROM ARCHAEOLOGY

Archaeology: years in which research outputs were produced and number of outputs for those years



ALL REPORTS

Reports (government, consulting & other): years in which reports were produced and number of different types of reports



MUNGO ARCHAEOLOGY PROJECT

LA TROBE UNIVERSITY

UOW AUSTRALIA

Australian National University

THE CHANGING CULTURAL LANDSCAPES OF THE WILLANDRA LAKES REGION: PERSPECTIVES FROM THE ARCHAEOLOGY AND GEOLOGY OF LAKE MUNGO

Nicola Stern

MUNGO ARCHAEOLOGY PROJECT

Cultural Heritage Officers: Cally Doyle, 2007-9; Daryl Pappin, 2007-14 (La Trobe University)

OSL dating & depositional history: Kathryn Fitzsimmons (Tübingen University), Zenobia Jacobs, Nathan Jankowski, (University of Wollongong)

Isotope geochemistry: Rainer Grün, Kelsie Long, Ian Williams (Australian National University)

Landscape archaeology: Nicola Stern, Jacqueline Tumney (La Trobe University)

The cultural landscape during the Last Glacial Maximum: Elizabeth Foley (La Trobe University)

Stone technology & raw material sources: Jacqueline Tumney, Caroline Spry, Rebekah Kurpiel, Elizabeth Foley (La Trobe University)

Amino Acid Racemization: Colin Murray-Wallace (University of Wollongong), Maddison Crombie (La Trobe University)

Residues and use wear: Richard Fullagar, Elspeth Hayes (University of Wollongong), Birgitta Stephenson (In the Groove Analysis), Judith Field (University of NSW)

Shell and bone technology: Erica Weston, Elizabeth Foley (La Trobe University), Kat Szabo (University of Wollongong), Michelle Langley (Griffith University)

Hearth micro-stratigraphy: Lauren Prossor, Tim Denham (ANU), Meg Ensor (University of Wollongong)

Faunal analysis: Jillian Garvey, Chris Silvester, Chris Biagi, Elizabeth Foley (La Trobe University)

Experimental and participatory GIS: Katherine Thomas (La Trobe University)

Surveying, remote sensing & erosion monitoring: Simon McClusky (ANU), Rudy Frank, Paul Penzo-Kajewski (La Trobe University)

Duration: 2007 to current

Institution: La Trobe University

RESEARCH GOALS

Embedded within the living cultural landscape of the Barkindji/Pakaantyi, Mutthi Mutthi and Ngiyampaa Nations is a remarkable archive of changing land use and occupancy stretching back more than 50,000 years. A long and detailed history of environmental change has been captured in the channels and floodplains, lakebeds and lunettes, sand plains and dune-fields that make up this landscape. Traces of people's activities were incorporated into these landforms as they formed. The Mungo Archaeology Project is investigating what these can reveal about the changing cultural landscapes of the Willandra Lakes Region through detailed archaeological and geological studies of the Lake Mungo lunette.

The lunettes are a focus of research because their sediments span a long period of time Their alternating layers of sand and clay reflect the hydrological conditions that prevailed in the adjacent lakes and the build-up of sediment on the lunettes was more continuous than on other landforms. The archaeological features preserved in the Lake Mungo lunette are the material traces of individual events: cooking fires and associated scatters of food remains, patches of tool-making debris, a shell tool or a cache of unworked shells, a grindstone stashed for future use, or a broken bone projectile point discarded on the dune. Each is preserved in sediments that record information about prevailing lake conditions, which have been linked to regional and global shifts in climate. These evocative material traces have the potential to provide unique insights into the changes in diet and foraging activities, technologies, and social networks that have taken place over the past 50,000 years, and thus, contribute to a dynamic history of Australia's First Nations.

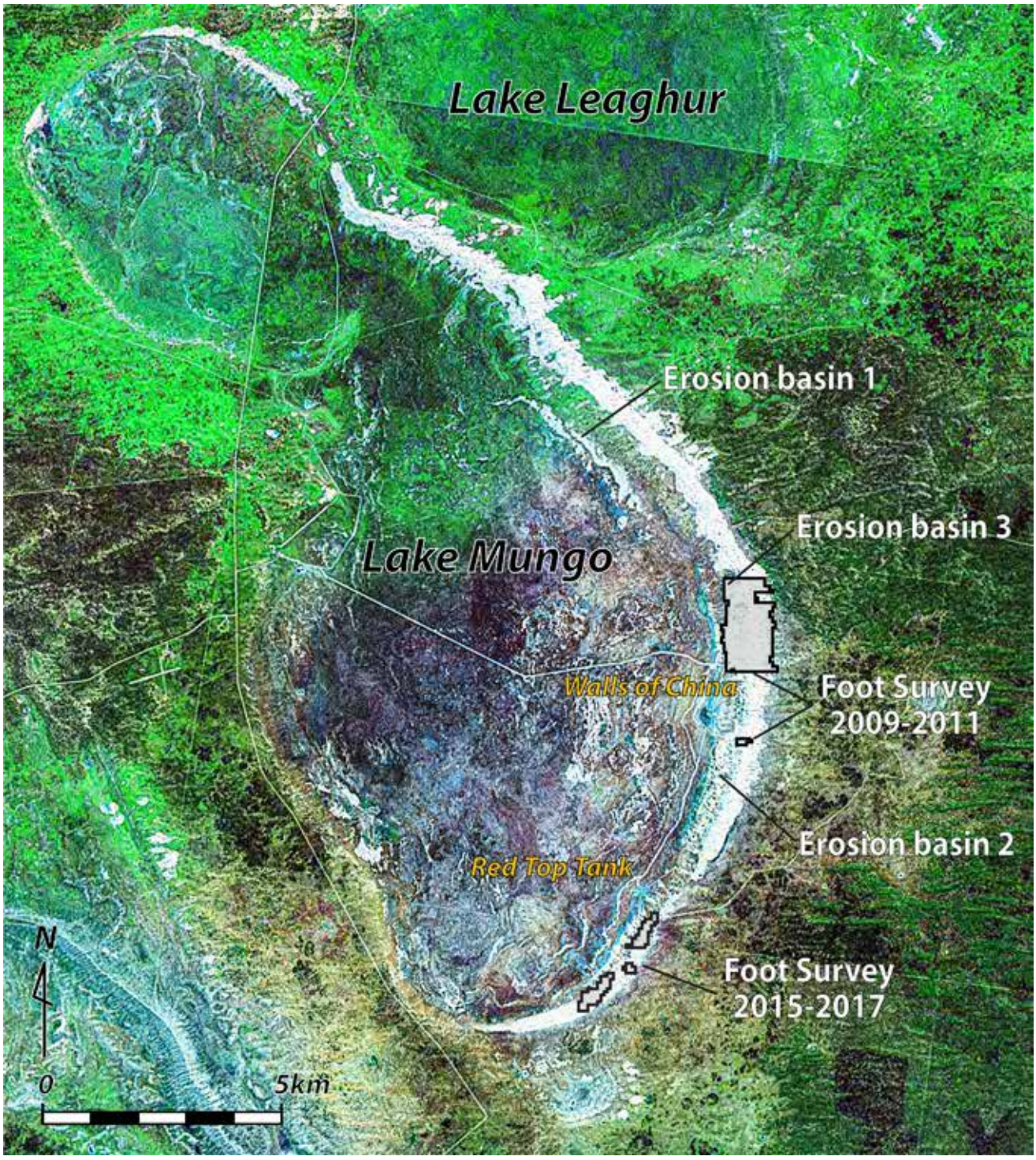


Figure 1: NASA satellite image of the Mungo Basin showing the locations of the Mungo Archaeology Project's detailed geological and archaeological study areas.

KEY OUTCOMES

The approach developed to study the history of land use and occupancy at Lake Mungo is tailored to the unique features of this archive and the opportunity it provides for generating commensurate behavioural and palaeoenvironmental information. Fulfilling this potential requires tight integration of archaeological and geological data, in the field and during analysis. Three components of the research contributed to the development of this approach:

1. detailed studies of 3 erosional basins and the archaeological traces found in different sedimentary and topographic settings within those basins (including Tumney this volume); this laid the foundation for larger scale geological and archaeological studies;

2. systematic documentation of the contents and context of cultural features eroding out onto the surface of selected portions of the lunette, combined with

Figure 2: Plate illustrating the foot survey work in progress and some of the cultural features documented during this work (Photos: Nicola Stern, Rudy Frank, Caroline Spry, Mungo Archaeology Project).

systematic geological mapping: this permits study of the abundance and types of activity traces preserved in different sedimentary envelopes, formed under different palaeoenvironmental conditions (also see Jankowski, this volume);

3. detailed study of selected finds and cultural features, including the collection of refitting sets of artefacts (Spry, Foley this volume), bone and shell tools (Langley this volume), grindstones (Hayes this volume), and the excavation of selected hearth features with their associated scatters of animal bone and stone tools (Foley this volume)

The results of this research allow us to disentangle the activities and technologies depicted in Giovanni Caselli's classic image of 'life at Lake Mungo 32,000 years ago' which includes everything, of every age, ever found in sites on the lunette. Instead, the focus is on identifying the changes in diet and foraging activities, technologies, and social networks that have taken place over the last 50,000 years.

Some of the key outcomes of this research include the following.

- Hearths, food remains, tools and tool-making debris are found throughout the sequence, including the sediments that accumulated after the final drying of Lake Mungo, about 15,000 years ago.

- Archaeological traces are more abundant and more varied during periods when lake levels were low but fluctuated in response to frequent flood pulses, suggesting that people visited the lunette more often and/or in greater numbers and/or for longer when the biological productivity of the system had been recharged.

- Changes in the food remains preserved in sediments of different age and correspondingly different environmental conditions point to shifts in foraging activities, although terrestrial resources were the main constituent of the protein diet when people camped on the lunette.

- Although present in the lake until it dried out, shellfish were collected primarily during the early part of the last glacial maximum, and fish, during its latter phases; during this time, Lake Mungo was considerably reduced in size.

- Residues and wear traces on the grindstones provide rare insight into the processing of plant foods (Hayes this volume).

- Subtle changes in the composition of chipped stone artefact assemblages reflect changes in the quantity of raw material carried onto the lunette, how many tools were made for use on the lunette or for carrying away, as well as the way people moved through the landscape (Tumney this volume, Spry this volume, Foley this volume).

- Pleistocene shell tools with deeply incised notches differ from the shell tools described in the ethno-historic literature, providing additional insight into the way technologies have changed over time.

PUBLICATIONS

Thomas, K. 2023. Biocultural mapping: unpacking the myth of an unsuitable Country in the arid zone, Willandra Lakes Region World Heritage Area, Australia. Environmental Systems Research 2023: 12-23.

Turnbull, M, Parker A and Jankowski, N. 2023. The history of phytolith research in Australasian archaeology and palaeoecology. Vegetation History and Archaeobotany https://doi.org/10.1007/s00334-023-00922-4

Thomas, K. 2022. Exploratory GIS: modelling past land use and occupancy with functional connectivity, Willandra Lakes Region World Heritage Area, NSW, Australia. Journal of Computer Applications in Archaeology, 5(1), 188–214. DOI: https://doi.org/10.5334/jcaa.98

Prossor, L., Denham, T., Brink, F., Troitzsch, U., & Stern, N. 2022. The microstratigraphic investigation of hearth features at Lake Mungo, Australia. Journal of Archaeological Science: Reports, 46. doi:10.1016/j.jasrep.2022.103711

Long, K., D. Heslop, and EJ. Rohling. 2021. Quantitative assessment of the oxygen isotope composition of fish otoliths from Lake Mungo, Australia. Quaternary Research 102: 234-246. https://doi.org/10.1017/qua.2020.121

Barrows, TT., KE. Fitzsimmons, S. Mills, J. Tumney, D.Pappin and N. Stern. 2020. Late Pleistocene lake level history of Lake Mungo, Australia, Quaternary Science Reviews 238, 106338 https://doi.org/10.1016/j.quascirev.2020.106338 0277-3791

Jankowski, N., N. Stern, T. Lachlan and Z. Jacobs, . 2020. A high-resolution late Quaternary depositional history and chronology for the southern portion of the Lake Mungo lunette, semi-arid Australia. Quaternary Science Reviews 233, 106224. https://doi.org/10.1016/j.quascirev.2020.106224

Fitzsimmons, K., N. Stern and C. Spry. 2019. Holocene and recent aeolian reactivation of the Willandra Lakes lunettes, semi-arid southeastern Australia. The Holocene 29: 606-621. https://doi.org/10.1177/0959683618824790

Kurpiel, R., R. Pickering, R. Maas and N. Stern. 2019. Lead (Pb) isotope signatures for silcrete sources from the Willandra Lakes region, Australia: a pilot study of a new method for provenancing silcrete artefacts. Journal of Archaeological Science: Reports 23: 62-71. https://doi.org/10.1016/j.jasrep.2018.10.031

Tumney, J. 2018. Identifying and characterising different types of stone artefact accumulations on the surface of the Lake Mungo lunette, southwest New South Wales, Australia. Journal of Archaeological Science: Reports 21: 380–388. https://doi.org/10.1016/j.jasrep.2018.08.007

Stern N. 2018. Lake Mungo, Archaeology of. In C. Smith (ed.) Encyclopedia of Global Archaeology. Springer, Cham. https://doi.org/10.1007/978-3-319-51726-1_699-2

Long, K, R. Wood, I. Williams, J. Kalish, N. Stern, and R. Grün. 2018. Fish otolith microchemistry: snapshots of lake conditions during early human occupation of Lake Mungo, Australia. Quaternary International 463: 29-43. https://doi.org/10.1016/j.quaint.2016.10.026

Hayes, E., C. Pardoe and R. Fullagar. 2018. Sandstone grinding/pounding tools: Use-trace reference libraries and Australian archaeological applications. Journal of Archaeological Science: Reports Vol.20, pp.97-114. https://doi.org/10.1016/j.jasrep.2018.04.021

Fitzsimmons, K.E. 2017. Reconstructing palaeoenvironments on desert margins: new perspectives from Eurasian loess and Australian dry lake shorelines. Quaternary Science Reviews vol. 171, pp.1-19. https://doi.org/10.1016/j.quascirev.2017.05.018

Foley, E., C. Spry and N. Stern. 2017. Establishing the integrity and stratigraphic origin of stone artefact scatters on the surface of the Lake Mungo lunette in south-eastern Australia. Journal of Archaeological Science: Reports 13: 547–557. https://doi.org/10.1016/j.jasrep.2017.05.002

Weston, E., K. Szabo and N. Stern. 2017. Pleistocene shell tools from the Lake Mungo Lunette, Australia: identification and interpretation drawing on experimental archaeology. Quaternary International 427: 229-242. https://doi.org/10.1016/j.quaint.2015.11.048

Spry, C., and N. Stern. 2016. Technological organization. In J. Jackson (ed.), Oxford Bibliographies in Anthropology. Oxford University Press, New York. DOI: https://doi.org/10.1093/obo/9780199766567-0158

Doerschner, N., Hernandez, M., Fitzsimmons, K.E. 2016. Sources of variability in single grain dose recovery experiments: insights from Moroccan and Australian samples. Ancient TL 34(1), 14-25.

Stern, N. 2015. The archaeology of the Willandra: its empirical structure and narrative potential. In A. McGrath and M.A. Jebb (eds), Long History, Deep Time. ANU Press, Canberra. Pp. 221-240. http://doi.org/10.22459/LHDT.05.2015

Fullagar, R., E. Hayes, B. Stephenson, J. Field, C. Matheson, N. Stern and K. Fitzsimmons. 2015. The scale of seed grinding at Lake Mungo. Archaeology in Oceania 50: 177-179. https://www.jstor.org/stable/44078477

Fitzsimmons, KE., N. Stern, C. V. Murray-Wallace, W. Truscott and C. Pop. 2015. The Mungo mega-lake event, semi-arid Australia: non-linear descent into the last ice age, implications for human behavior. PLOS ONE 10(6), e0127008. https://doi.org/10.1371/journal.pone.0127008

Fullagar, R., E. Hayes, B. Stephenson, J. Field, C. Matheson, N. Stern and K. Fitzsimmons. 2015. Evidence for Pleistocene seed grinding at Lake Mungo, southeastern Australia, Archaeology in Oceania 50: 3-18. https://doi.org/10.1002/arco.5053

Long, K., N. Stern, IS. Williams, L. Kinsley, R. Wood, K. Sporic, T. Smith, S. Fallon, H. Kokkonen, I. Moffat and R. Grün. 2014. Fish otolith geochemistry, environmental conditions and human occupation at Lake Mungo, Australia. Quaternary Science Reviews 88: 82-95. http://dx.doi.org/10.1016/j.quascirev.2014.01.012

Stern, N. 2014. The archaeology of Lake Mungo. In C. Smith (ed.), Encyclopedia of Global Archaeology. Springer, New York. Pp.4364-4375. https://doi.org/10.1007/978-3-030-30018-0

Fitsimmons, K., N. Stern and C. Murray-Wallace. 2014. Depositional history and archaeology of the central Mungo lunette, Willandra Lakes, southeast Australia. Journal of Archaeological Science 41: 349-364. http://dx.doi.org/10.1016/j.jas.2013.08.004

Stern, N., J. Tumney, K. Fitzsimmons and P. Kajewski. 2013. Strategies for investigating human responses to changes in environment at Lake Mungo in the Willandra Lakes, southeast Australia. In D. Frankel, J. Webb and S. Lawrence (eds), Archaeology in Technology and Environment. Routledge, London. Pp.31-50.

Petherick, L., H. Bostock,TJ. Cohen, KE. Fitzsimmons, J. Tibby, P. Moss,TT. Barrows, J. Reeves, J. Kemp, J. Jansen, G. Nanson, P. De Deckker, M. Fletcher, A. Dossetoand OZ-INTIMATE members. 2013. Climatic records over the past 30 ka from temperate Australia – a synthesis from the OZ-INTIMATE workgroup. Quaternary Science Reviews 74, 58-77. https://doi.org/10.1016/j.quascirev.2012.12.012

Tumney, J. 2012. Sand, stone and software: landscape archaeology in the Willandra Lakes World Heritage Area. Journal of Historical and European Studies 3: 89-110.

Fitzsimmons, KE. 2011. An assessment of the luminescence sensitivity of Australian quartz with respect to sediment history. Geochronometria 38(3), 199-208. https://doi.org/10.2478/s13386-011-0030-9

Fitzsimmons, KE., EJ. Rhodes andTT. Barrows 2010. OSL dating of southeast Australian quartz: A preliminary assessment of luminescence characteristics and behaviour. Quaternary Geochronology 5, 91-95. https://doi.org/10.1016/j.quageo.2009.02.009

MANUSCRIPTS UNDER REVIEW

Faulkner, P., N. Stern and J. Balme. n.d. Utilisation by Aboriginal People. Chapter 15 in Ponder, W, Hallan, A. and M. Klunzinger (eds), Australian Freshwater Molluscs: Biology, Ecology, Conservation, and Diversity. CSIRO Publishing.

UNPUBLISHED PHD THESES

Foley, E. 2021 The Cultural Landscape at Lake Mungo during the Last Glacial Maximum . Department of Archaeology and History, La Trobe University

Thomas, K. 2020 Participatory and Experimental GIS in the Willandra Lakes Region World Heritage Area, NSW. PhD thesis, Department of Archaeology and History, La Trobe University.

Smith, Tegan, E. 2019. Depositional History and Palaeoenvironments of the Lake Mulurulu Lunette, Willandra Lakes World Heritage Area, New South Wales. PhD Thesis, Research School of Earth Sciences, Australian National University.

Kurpiel, R. 2017. Stone Sources In The Willandra Lakes Region, In South-Eastern Australia: A Study Of Source Characterisation And Raw Material Procurement, Ph.D thesis, Department of Archaeology and History, La Trobe University.

Long, K. 2018. Fish Otoliths And Palaeoenvironments. Research School of Earth Sciences, Australian National University.

Hayes, E. 2015. What Was Ground: A Functional Analysis of Grinding Stones from Madjedbebe and Lake Mungo, Australia. Centre for Archaeological Science, University of Wollongong.

Spry, C. 2014. Refitting A Past: A Comparison Of Late Pleistocene And Terminal Pleistoene/Early Holocene Stone Tool Technology At Lake Mungo, Southwest New South Wales, Australia. Department of Archaeology and History, La Trobe University.

Tumney, J. 2011. Environment, Landscape And Stone Technology At Lake Mungo, Southwest New South Wales, Australia. Ph.D thesis, Department of Archaeology and History, La Trobe University.

UNPUBLISHED MASTERS BY RESEARCH THESES

Crombie, M. 2021. Just Cracking the Surface: Amino-Acid Racemization in Archaeological Emu Eggshell. Master of Science by Research Thesis (Chemistry), Department of Archaeology and History, La Trobe University.

Prossor, L. 2015. Lake Mungo Hearths: A Multi-Scale, Mixed Method Geoarcheological Investigation Of Burning Features At Lake Mungo, NSW, Australia. Master of Archaeological Science Thesis, School of Archaeology and Anthropology, Australian National University.

UNPUBLISHED HONOURS THESES

Geiberras, H. 2021. Bettongs for Dinner. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Ensor, M. 2019. Geoarchaeological and Chronological Investigations of Combustion Features at Lake Mungo, NSW. Providing Fine Grained Detail to Burning Questions. B.Sc. Honours Thesis, School of Earth and Atmospheric Sciences, University of Wollongong.

Stephenson-Gordon, 2018. The Inconspicuous Tool. An Experimental Study of Use-Wear on Fine-Grained Silcrete Flakes and Case Study of Hearth Sites at Lake Mungo. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Bandurski, C. 2018. A technological study of stone artefact assemblages from the Lower Mungo unit, Lake Mungo, Southwest New South Wales, Australia. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Tranter-Edwards, L. 2017. Traces of Past Human Activity at an Inter-lake Clay Pan in the Willandra Lake Region: their Context and Significance. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Johnson, R. 2017. Fire and Fragmentation: A Taphonomic Analysis of Bone Fragmentation. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Tickle, I. 2016. A Study Of Stone Artefacts Associated With Hearths On The Lake Mungo Lunette. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Lovell, C. 2015. Fish And Fishing At Site 1168. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Barker, D. 2015 A Study Of The Mineralogical Variation In Ochre From The Lake Mungo Lunette. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Dillon, E. 2014. A Geoarchaeological Study Of Location 969660, Lake Mungo. B.A. Honours thesis, School of Archaeology and Anthropology, Australian National University.

Roy, L. 2013. Reduced To Tools: A Technological Study Of Two Stone Artefact Assemblages From Lake Mungo, Australia. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Stammers, R. 2013. An Experimental Study Of The Effects Of Heat Treatment On Silcretes In The Willandra Lakes Region. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Long, K. 2012. An Ear To The Ground: Fish Otoliths, Chronology And Human Climate Interactions At Lake Mungo. B.A. Honours Thesis, Department of Archaeology and Anthropology Department, Australian National University.

Truscott, W. 2012. Erosion On The Mungo Lunette: The Effects Of Small And Large Scale Weather Events On Archaeological Materials. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Vick, S. 2012. Chibnalwood Beach Quarry: A Technological Study Of A Silcrete Source From The WLRWHA. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Weston, E. 2012. A Study Of Shell Tools From The Mungo Lunette. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Foley, E. 2011. Refitting Stone Artefacts At Lake Mungo: A Study Of The Integrity Of Chipped Stone Artefact Scatters On The Lunette Surface. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Kurpiel, R. 2010. Notched Artefacts From The Willandra Lakes World Heritage Area. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

Boljkovac, K. 2009. In Situ SHRIMP Δ18o And Laser Ablation ICP-MS Sr/Ca And 87Sr/86Sr Measurements In Fossil Otoliths For Palaeoclimate Reconstructions At The Willandra Lakes World Heritage Area. BSc Honours Thesis, Research School of Earth Sciences, Australian National University.

Kibble, M. 2008. The Study Of Surface Faunal Assemblages From Open Sites In The Willandra Lakes: A Case Study From Locality 969660. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

MacManus, T. 2008. Rocks In A Box: An Assessment Of Unprovenanced Artefact Collections From The Willandra Lakes World Heritage Area. B.A. Honours Thesis, Department of Archaeology and History, La Trobe University.

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ENVIRONMENT, LANDSCAPE AND STONE TECHNOLOGY AT LAKE MUNGO, SOUTHWEST NEW SOUTH WALES, AUSTRALIA

Jacqueline Tumney

MUNGO ARCHAEOLOGY PROJECT

Researcher: Jacqueline N. Tumney

Degree: PhD

Duration: 2007-2011

Institution: Department of Archaeology and History, La Trobe University

Discipline: Archaeology

RESEARCH GOALS

The challenges of interpreting assemblages of artefacts derived from surface or eroding contexts have long been recognised by archaeologists. Through ongoing erosion, many of the artefacts now sitting on the surface of the Lake Mungo lunette have moved away from the sedimentary layers in which they were originally buried. It is these sediments that allow us to determine the time at which different artefacts were used and discarded and that provide evidence about the environments in which people were living. For this reason, past investigations into stone assemblages commonly focussed on artefacts recovered from excavations where the sedimentary context was known. These assemblages were typically small, in contrast to the hundreds or even thousands of artefacts, in some locations, that can be observed on the surface of the lunette.

Consequently, at the commencement of this study very little was known about the way that people at Lake Mungo in the past were using stone – where it was from and how it was being worked, used, re-used and discarded – and whether there were changes during and after the severe environmental conditions of the Last Glacial Maximum (LGM). The main aim of this study, therefore, was to test a methodology for obtaining information about variability and change in human behaviour from the relatively low-density surface archaeological remains scattered across the large, complex and eroding landform that is the Mungo lunette.

This study focused on the stone artefacts exposed within a particular erosional setting, shallow erosion basins at the foot of the lunette, employing a combination of detailed surface mapping, distributional analysis and technological analysis to investigate whether useful information can be obtained from the concentrations of stone artefacts that often become exposed in these settings.

KEY OUTCOMES

This study contributed to the establishment of a framework to help identify the types of surface exposures/erosional settings within which stone artefacts can be subject to meaningful detailed investigation. Detailed analysis of stratigraphy, topography and size-patterning in the distribution of surface artefacts enabled the identification of different types of surface accumulation, enabling the designation of coherent assemblages from apparently undifferentiated surface material. Three assemblages from two study areas were defined, corresponding to lake-full and lake-fluctuating conditions during the LGM. Variable use of different raw materials indicated changes in mobility: people travelled widely and/or regularly (high mobility) when the lake was high; there was less travel with more time spent on the lake shore (low mobility) as the lake began to dry out and the water level oscillated; with a return to high mobility as the lakes dried out more permanently.

Figure 1: Detailed artefact recording and mapping. Stone artefacts are marked with blue flags. Surveying of each individual artefact location by Total Station is occurring at the far left and right, with detailed artefact attribute recording underway in the centre.

PUBLICATIONS

Barrows, T.T., Fitzsimmons, K.E., Mills, S.C., Tumney, J., Pappin, D. & Stern, N. 2020. Late Pleistocene lake level history of Lake Mungo, Australia. Quaternary Science Reviews 238: 106338. DOI: https://doi.org/10.1016/j.quascirev.2020.106338 0277-3791

Tumney, J. 2018. Identifying and characterising different types of stone artefact accumulations on the surface of the Lake Mungo lunette, southwest New South Wales, Australia. Journal of Archaeological Science: Reports 21: 380-388. DOI: https://doi.org/10.1016/j.jasrep.2018.08.007

Stern, N., Tumney, J., Fitzsimmons, K.E. and Kajewski, P. 2013. 'Strategies for investigating human responses to changes in landscape and climate at Lake Mungo in the Willandra Lakes, southeast Australia'. In D. Frankel, J.M. Webb & S. Lawrence (eds), Archaeology in technology and environment: intersections and transformations. Routledge, New York, pp. 31-50

Tumney, J. 2012. Sand, stone and software: landscape archaeology in the Willandra Lakes World Heritage Area. Journal of Historical and European Studies 3: 89-110

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Figure 2: Stone artefact cluster (marked with blue tags) on a relatively stable erosion platform (upper), with examples of silcrete and quartzite artefacts (lower).

REFITTING A PAST: A COMPARISON OF LATE PLEISTOCENE AND TERMINAL PLEISTOCENE/ EARLY HOLOCENE STONE TOOL TECHNOLOGY AT LAKE MUNGO

Caroline Spry

MUNGO ARCHAEOLOGY PROJECT

Degree: PhD

Duration: 2010-2014

Institution: Department of Archaeology and History, La Trobe University

Discipline: Archaeology

The primary aim of this study was to assess one method for obtaining useful behavioural information from surface stone artefact scatters that had eroded from the central Mungo lunette. Specifically, this study investigated people's technological responses to the palaeoenvironmental and palaeohydrological changes that occurred during two time periods: 21-15,000 years ago (Arumpo/Zanci units, height of the Last Glacial Maximum, lake levels fluctuating); and 15-

Figure 1: A silcrete steep-edged scraper refit on the Lake Mungo lunette, with Mutthi Mutthi man Daryl Pappin refitting stone artefacts that have eroded from the lunette in the background (Photo: Caroline Spry)

RESEARCH GOALS

8,000 years (post-lake unit, Lake Mungo permanently dry).

This study utilises the grouping and refitting of artefacts knapped from the same core (or tool), and spatial analysis of the distribution of these artefacts in relation to topographic and stratigraphic boundaries, to identify the stratigraphic unit of origin for surface stone artefact assemblages (i.e. Arumpo/Zanci or post-lake). These techniques are combined with attribute analysis of the artefacts to generate detailed information about the stone tool technology that people employed during each time period.

The specific questions addressed are: (1) Which stone-working activities occurred on the Mungo lunette? (2) What does this tell us about how people selected, procured, transported, worked, and discarded material? (3) Is there any evidence for differences in patterns of mobility between the two time periods? And (4) How does this information compare to previous models of land-use and descriptions of stone tool technology in the Willandra Lakes Region?

KEY OUTCOMES

This study established differences between the stone tool technology that people employed at Lake Mungo during the Arumpo/Zanci and post-lake time periods. These differences include an increase in people's mobility and foraging range, greater focus on carrying more portable and prepared cores, more efficient reduction of cores, and greater production of more efficient and versatile tool forms and portable toolkits after Lake Mungo had dried permanently.

This study also demonstrated the importance of investigating knapping groups and refits, and their distribution, to establish the stratigraphic integrity of surface stone artefact assemblages, and to generate detailed information about stone tool technology at a landscape scale. The approach to landscape archaeology developed by MAP (Stern, this volume), combined with technological analysis of high integrity artefact assemblages, enables demonstration of how stone tool technology changed over time.

PUBLICATIONS

Fitzsimmons, K., N. Stern and C. Spry. 2019. Holocene and recent aeolian reactivation of the Willandra Lakes lunettes, semi-arid southeastern Australia. The Holocene 29: 606-621. https://doi.org/10.1177/0959683618824790

Foley, E., C. Spry and N. Stern. 2017. Establishing the integrity and stratigraphic origin of stone artefact scatters on the surface of the Lake Mungo lunette in south-eastern Australia. J. Archaeological Science Reports 13: 547–557. https://doi.org/10.1016/j.jasrep.2017.05.002

Spry, C., and N. Stern. 2016. Technological organization. In J. Jackson (ed.), Oxford Bibliographies in Anthropology. Oxford University Press, New York. https://doi.org/10.1093/obo/9780199766567-0158

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Figure 2: Dr Caroline Spry, Daryl Pappin, Ryan McLean, and Elder Joan Slade studying stone artefacts that have eroded from the surface of the Lake Mungo lunette (Photo: Caroline Spry)

STONE SOURCES IN THE WILLANDRA LAKES REGION, IN SOUTH-EASTERN AUSTRALIA: A STUDY OF SOURCE CHARACTERISATION AND RAW MATERIAL PROCUREMENT

Rebekah Kurpiel

MUNGO ARCHAEOLOGY PROJECT

Degree: PhD

Duration: 2011-2018

Institution: Department of Archaeology & History, La Trobe University

Discipline: Archaeology

RESEARCH GOALS

Studying stone sources can help us understand the ways in which people organised their stone technology and how they moved raw material, cores and/or tools around the landscape.

The movement of stone across the landscape provides a record of the way people moved around, which means that it can provide information about shifts in mobility patterns and, sometimes, information about social and exchange networks. Understanding which sources people were using and how they were using them also helps us to interpret the stone artefacts we find elsewhere on the landscape.

The goals of this research were to:

- Provide information about where different types of stone resources can be found within the Willandra Lakes region.
- Determine if and how each of these localities were used as sources of raw material for toolmaking to better understand

Figure 1: Daryl Pappin and Jessica Pisana (Rebekah's daughter) recording artefacts (marked by the orange flags) at the Zanci silcrete source.

the strategies that people used for ensuring they had stone available when they needed it.

- Conduct laboratory analysis on geological samples of rock to establish whether geochemical techniques could be developed in the future to help link individual artefacts back to the source from which the raw material originated.

KEY OUTCOMES

As part of this research, 19 areas with potential to contain rock suitable for knapping were identified using geological maps, topography and information from local station managers. Archaeological surveys at these localities resulted in the identification of eight sources of silcrete and one source of orthoquartzite that showed clear signs of having been used by people to obtain stone for toolmaking. Most of the silcrete close to Lake Mungo was found to be of low-medium quality for the purpose of knapping, but high-quality silcrete was found near Lake Mulurulu, about 65km north of the Lake Mungo lunette. This means that people camped on the edge of Lake Mungo had to travel further to collect high-quality stone for making tools. Low to medium quality stone occurs at a number of locations within 20km of the Mungo lunette.

The artefacts found at the sources, together with the artefacts found at one of the erosion basins on the Lake Mungo lunette (the most central one studied by MAP, Stern this volume), show that people often carried cores, large flakes and unmodified nodules (rather than small, finished tools) with them when they left a stone source. These items were brought to other locations, including the edge of Lake Mungo. This strategy of provisioning places that do not have any naturally occurring sources of stone was a way of ensuring that people would always have stone available when they needed to make tools.

Geological samples from six of the silcrete sources were collected and subject to geochemical analysis. Some useful differences between sources were identified using both lead (Pb) isotope analysis and trace element analysis. Although some overlap in the signatures from closely spaced sources exists, these results show that there is potential for future studies to link artefacts with their geographical source of origin.

PUBLICATIONS

Kurpiel, R., Pickering, R., Maas, R. and Stern, N. 2019 Lead (Pb) isotope signatures for silcrete sources from the Willandra Lakes region, Australia: A pilot study of a new method for provenancing silcrete artefacts. Journal of Archaeological Science: Reports, vol. 23, pp. 62-71. https://www.sciencedirect.com/science/article/pii/S2352409X18304498

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Figure 2: High-quality silcrete was found near Lake Mulurulu

WHAT WAS GROUND? A FUNCTIONAL ANALYSIS OF GRINDING STONES FROM MADJEDBEBE AND LAKE MUNGO, AUSTRALIA

Elspeth Hayes

MUNGO ARCHAEOLOGY PROJECT

Degree: PhD

Duration: 2011-2015

Institution: Centre for Archaeological Science, School of Earth and Environmental Sciences, University of Wollongong

Discipline: Archaeology

RESEARCH GOALS

The main goal of this research project was to identify the function and use of grinding stones and fragments recovered from Pleistocene/early Holocene contexts at Lake Mungo through microscopic traces on the stone surfaces (Figure 1). In the past, the function of grinding tools has been inferred on the basis of tool morphology, and largely restricted to grass seed grinding, which is usually associated with deeply grooved, large sandstone dishes. Previous studies of grinding stones from the region have found little compelling evidence for seed grinding prior to the Pleistocene/Holocene boundary, in part because many grinding stones from Pleistocene contexts occur as fragments with no recurring form and no distinctive grinding grooves. Such tools are often referred to as "amorphous" grinding stones and their function is frequently assumed to be opportunistic, with little understanding of what materials were processed. However, earlier studies of Pleistocene grinding stones across Australia rarely included use-wear and residue analyses and therefore the function of these tools has remained relatively unexplored.

The specific goals of this research project were to:

1. Undertake a detailed functional analysis of 17 grinding stones and fragments through an integrated use-wear and residue analysis. This involved microscopic examination of tool surfaces to document use-wear as well as the removal and characterisation of adhering material (see Figure 2) to identify the processed material using optical and chemical techniques that were compared with experimental and ethnographic reference libraries;

2. Construct a sequence of grinding activities through-time based on tool function, tool stone selection and artefact life histories;

3. Evaluate the extent to which temporal and spatial variability of grinding stones is linked with site context, resource availability and environmental change.

KEY OUTCOMES

Functional analysis has indicated that most of the Mungo grinding stones were used for seed grinding activities, starting from 25,000 years ago. The presence of seed grinding tools from both Pleistocene and Holocene contexts at Lake Mungo indicates that seed processing was a consistently important activity and provides further evidence against the proposition that seed grinding technology was a late Holocene invention. The distinctive well-worn, dished and recycled grinding fragments indicate that the tools at Lake Mungo were often used until they were exhausted, likely related to the lack of locally available sandstone material. Thus, site context and resource availability are seen to play a significant role in determining grinding stone morphology.

PUBLICATIONS

Fullagar, R., E.H. Hayes, B. Stephenson, J. Field, C. Matheson, N. Stern and K. Fitzsimmons (2015) Evidence for Pleistocene seed grinding at Lake Mungo, south-eastern Australia. Archaeology in Oceania 50: 3–19.

Fullagar, R., E.H. Hayes, B. Stephenson, J. Field, C. Matheson, N. Stern and K. Fitzsimmons (2015) The scale of seed grinding at Lake Mungo. Archaeology in Oceania 50: 177–179.

Hayes, E.H., C. Pardoe and R. Fullagar (2018) Sandstone grinding/pounding tools: Use-trace reference libraries and Australian archaeological applications. Journal of Archaeological Science: Reports, 20: 97–114.

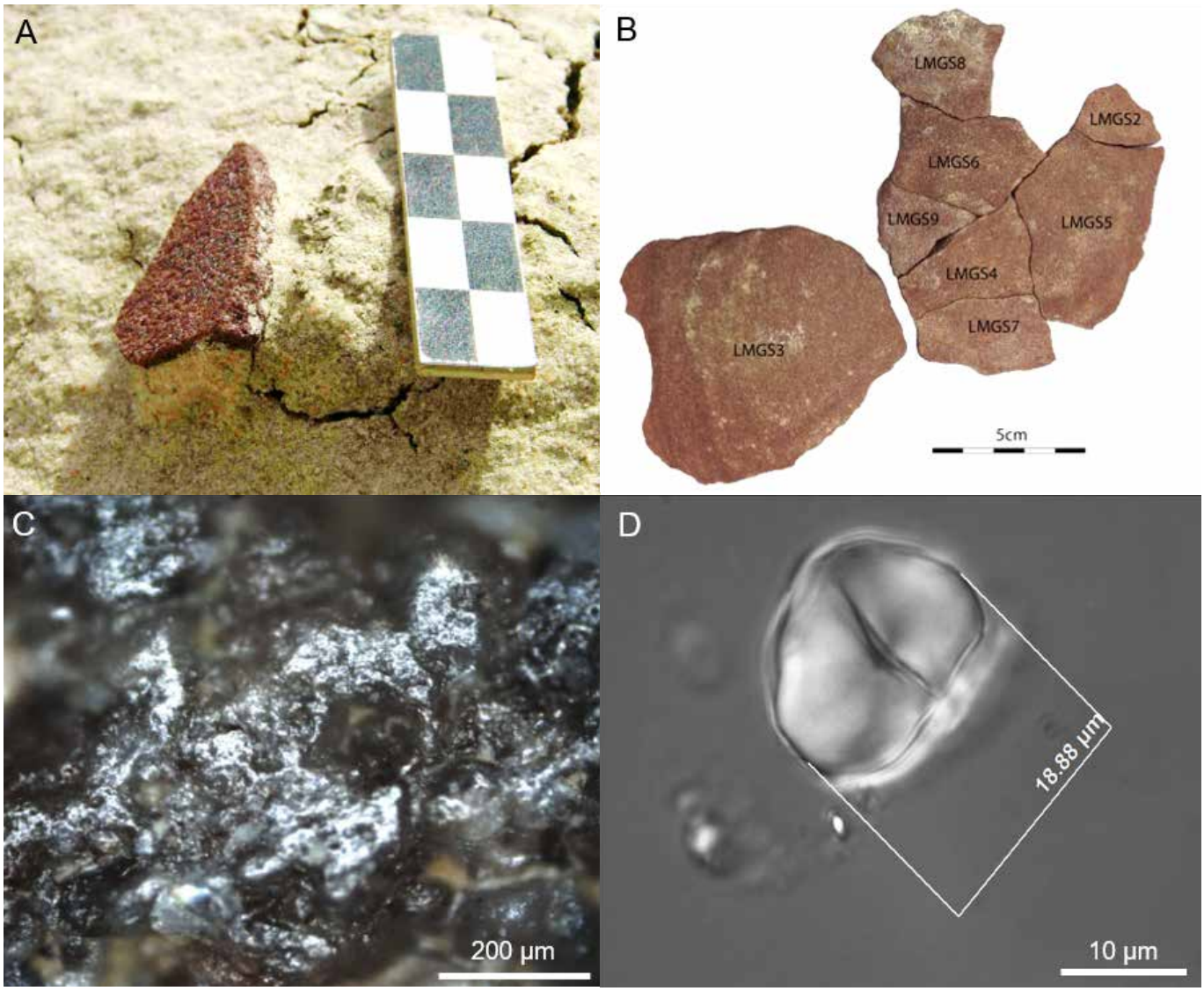

Figure 1: Grinding stone fragments from Lake Mungo and the examples of the microscopic traces documented on their surfaces. A) Sandstone grinding stone fragment analysed in this study (Photo: Nicola Stern); B) sandstone grinding stone fragments analysed as part of this study, refitted to show they comprised a single tool (Photo: Richard Fullagar); C) Use-wear documented on the surface of one of the analysed grinding stone fragments that indicates seed grinding (Photo: Elspeth Hayes); D) starch grain (plant residue) recovered from the surface of one of the analysed grinding stone fragments (Photo: Judith Field).

Link to Hayes Thesis: https://ro.uow.edu.au/cgi/viewcontent.cgi?referer=https://scholar.google.com.au/&httpsredir=1&article=5499&context=theses

COLLABORATORS

Functional analysis of the grinding stones and fragments was conducted in collaboration with Prof. Richard Fullagar (University of Wollongong), Dr Judith Field (University of New South Wales), Ms Birgitta Stephenson (In the Groove Analysis Pty Ltd), and Professor Carney Matheson (Griffith University).

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Figure 2: Ebbe Hayes taking a residue sample from a grinding stone at Lake Mungo. Photo: Richard Fullagar.

PARTICIPATORY AND EXPERIMENTAL GIS IN THE WILLANDRA LAKES REGION WORLD HERITAGE AREA, NSW

Kath Thomas

MUNGO ARCHAEOLOGY PROJECT

Research Project: Mungo Archaeology Project

Research Title: Participatory and Experimental GIS in the Willandra Lakes Region World Heritage Area, NSW

Researcher: Katherine Thomas

Degree: PhD

Duration: 2015-2019

Institution: Department of Archaeology and History, La Trobe University

Discipline: Archaeology

RESEARCH GOALS

This research project demonstrated the importance of listening to the testimonies of the Mutthi Mutthi, Ngyiampaa, and Barkindji/Paakantji about their experiences on Country. Oral histories transform the historical land use and occupancy mappings of Country. Land use and occupancy mapping is used by land managers and heritage advisors to assess and classify the archaeological and environmental record, typically within a Geographical Information System (GIS). This type of modelling is defined by scientific outcomes and does not incorporate crucial Traditional Ecological Knowledge (TEK) from descendent communities. Excluding the descendent communities from mapping Country is not a holistic approach to modelling the past cultural record.

Working with the First Nations communities of the Willandra Lakes within a participatory research framework is called Deep Mapping or Participatory GIS. Participatory GIS (pGIS) creates the pathway into mapping changing cultural contexts for the archaeological record. The GIS models were developed through the sharing of biocultural knowledge about culturally significant plant species and places of significance for individuals. Community members created memory map biographies of plant communities as both combined and individual expressions of the biocultural record. These pGIS models are complex and experimental, resulting in many different views of Country and the biocultural record of land use and occupancy. This research illustrates the need for multiple approaches to mapping and modelling the past with collaboration at the core of a research project.

KEY OUTCOMES

There are many benefits from working with all the key stakeholders to develop comprehensive models of land use and occupancy within the Willandra Lakes Region (WLR). This PhD demonstrates the importance of Deep Mapping and Participatory GIS for understanding land use and occupancy within the WLR. The oral histories, shared biocultural knowledge, provide the crucial cultural contexts for the GIS models of the archaeological record.

The work undertaken for this PhD illustrates that there is a distinction between modelling the material traces that comprise the archaeological record and the complex cultural signatures of land use and occupancy of the Traditional Owners. The complex cultural constructs of land use and occupancy at the point of European settlement cannot be achieved through the current practice of GIScience modelling of the archaeological record or potential ecological resource zones in isolation. The project also highlights the benefits of bringing GIScience modelling into a sub-branch of experimental archaeology. Complexity and human agency can be brought into our models of the past – this research demonstrates how we can do this in collaboration with First Nations communities on Country.

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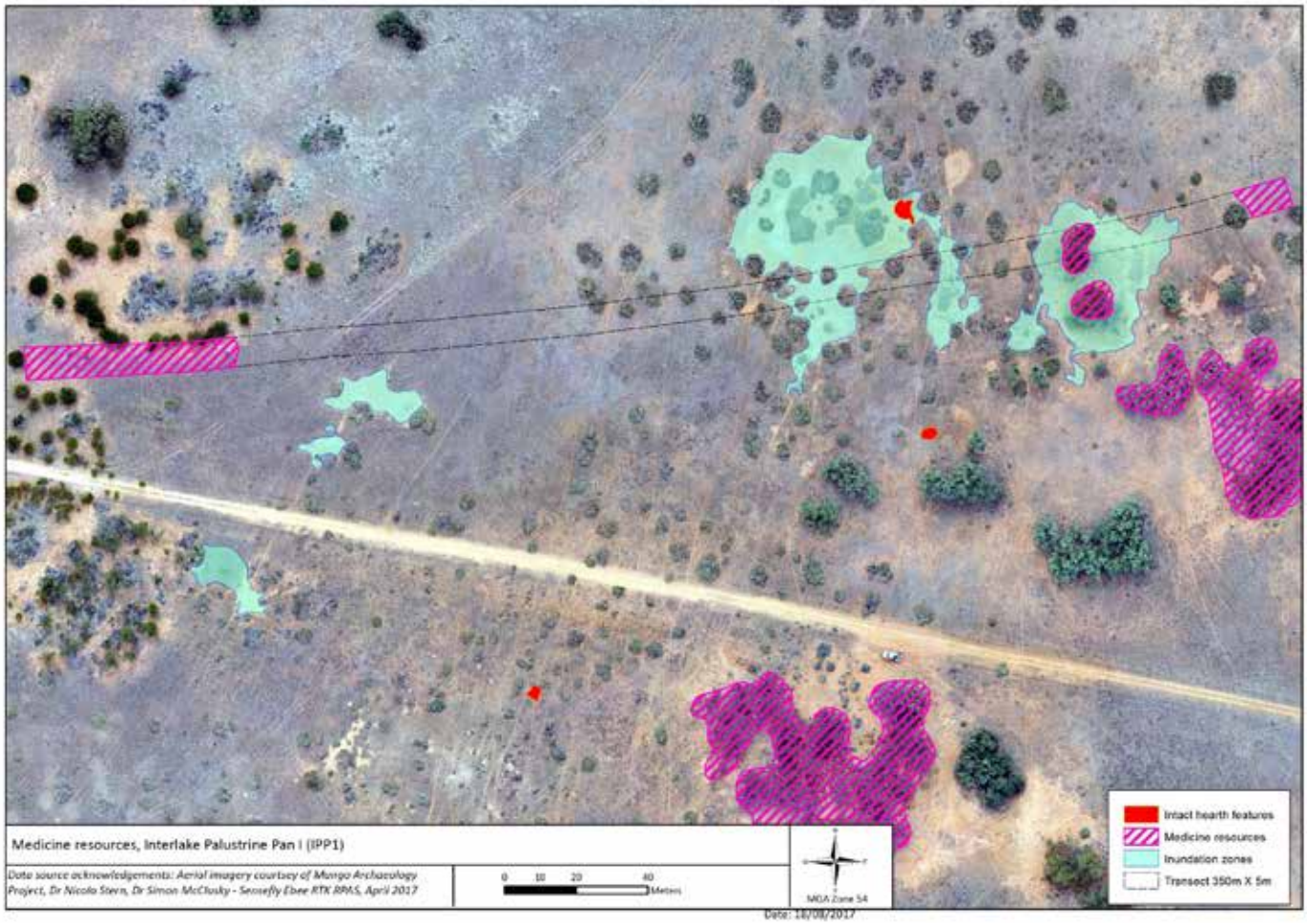

Figure 1

Plant names		Common names	Annual Wet or Dry, Saline? Y/N	Native s	Seed or Food, Medicine, or Weapon
Edge of Dune					
Enchylaena tomentosa		Ruby Saltbush	P	D	Food
Polycalymma sturtii		Poached egg daisy	A	D	Food
Inundation zone					
Chenopodium murale		Fat Hen	A	D	Food
Sonchus oleraceus		Sow Thistle	A	D	Food
Water					
Typha domingensis		Narrow-leaved Cum	A	W	Food
Cypress zone					
Polycalymma sturtii		Poached egg daisy	A	D	Food
Nicotiana velutina		Native tobacco	P	D	Medicine
Enchylaena tomentosa		Ruby Saltbush	P	D	Food
Callitris glaucophylla		White Cypress Pine	A	D	Food, Medicine, Weapons

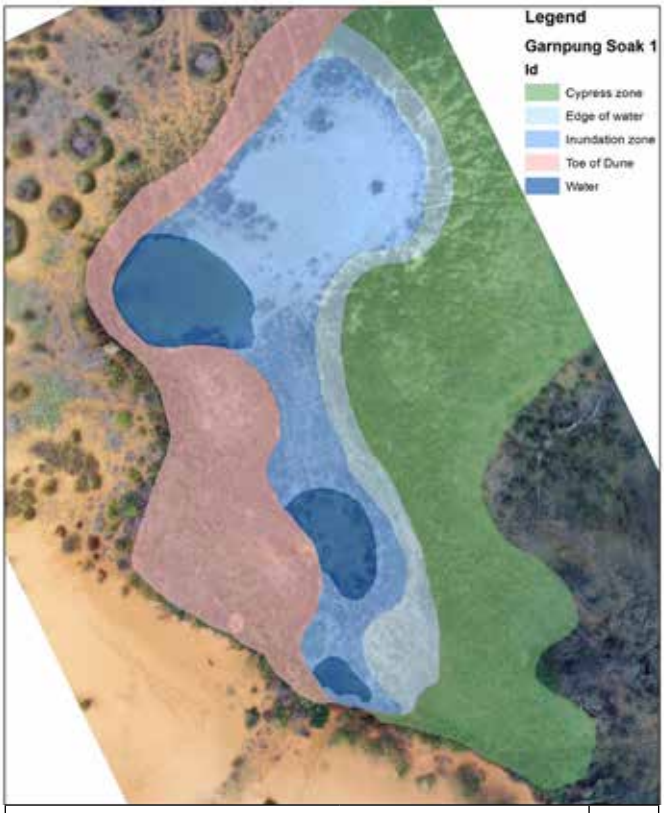

Figure 2

THE CULTURAL LANDSCAPE AT LAKE MUNGO DURING THE LAST GLACIAL MAXIMUM

Elizabeth Foley

MUNGO ARCHAEOLOGY PROJECT

Degree: PhD

Duration: 2015-2021

Institution: Department of Archaeology and History, La Trobe University

Discipline: Archaeology

RESEARCH GOALS

This research investigated the cultural landscape at Lake Mungo during the Last Glacial Maximum, a period approximately 20,000 years ago when the climate was cooler and more arid than it was at any other time in human history. Unlike the classic 'Ice Age' conditions of western Europe, most of Australia did not see snow, and fresh water would have been scarce, especially in the arid centre and its fringes, where rainfall was already low and unpredictable.

The lakes and rivers in western NSW would have held water, but the vast plains and dune fields of the region would have been very dry. The size of Lake Mungo was reduced, with occasional freshwater pulses (see Jankowski, Long, this volume), but there is plenty of evidence that the lake and the surrounding dunes remained an important part of the cultural landscape at this time (see Stern, this volume).

A range of archaeological features, each representing a single event or activity, were studied:

- Hearths, to provide insights into cooking, food processing and other fire-side activities
- The food remains from hearths, to investigate diet and foraging strategies
- Stone tools, found in clusters of knapping debris or scattered around hearths, to understand how stone was carried into, worked and used during the last glacial maximum
- Bone and shell tools, to gain additional insights into technology

KEY OUTCOMES

Analysis of the food remains recovered from the hearths shows that much of the protein component of the diet during the last glacial maximum was made up of small, burrowing or digging mammals, such as bettongs, hare-wallabies and small native mice. These animals would have built their nests and burrows in the Mungo lunette, promoting soil turnover and the growth of nutrient-rich plants. Some of these may have been processed using grindstones, which were also used on the Mungo lunette in this period (see Hayes, this volume).

Emu eggs were also part of the diet, collected from the nests of emus dug into the lunette during the winter months. Fish were also available periodically, suggesting that the dunes adjacent to lakes were important resource zones for people, at a time when water, plants and animals were less abundant and more dispersed in the surrounding sand plains.

The tools people used were made of bone, shell and stone; the stone was sourced from a range of silcrete and quartzite outcrops, both close to the lunette and further afield. Refitting of artefacts, and the contents of stone artefact clusters, suggest that stone was transported frequently over short distances, and in a form that allowed sharp-edged flakes to be made and used as-needed and with little modification. The technology facilitated the targeting of the lunette for its reliable suite of plant and animal foods during a period of unstable conditions, when the lake was small and dwindling.

PUBLICATION

Foley, E., C. Spry, and N. Stern 2017 Establishing the integrity and stratigraphic origin of stone artefact scatters on the surface of the Lake Mungo lunette in south-eastern Australia. Journal of Archaeological Science: Reports 13:547–557.

https://www.researchgate.net/profile/Elizabeth-Foley-5

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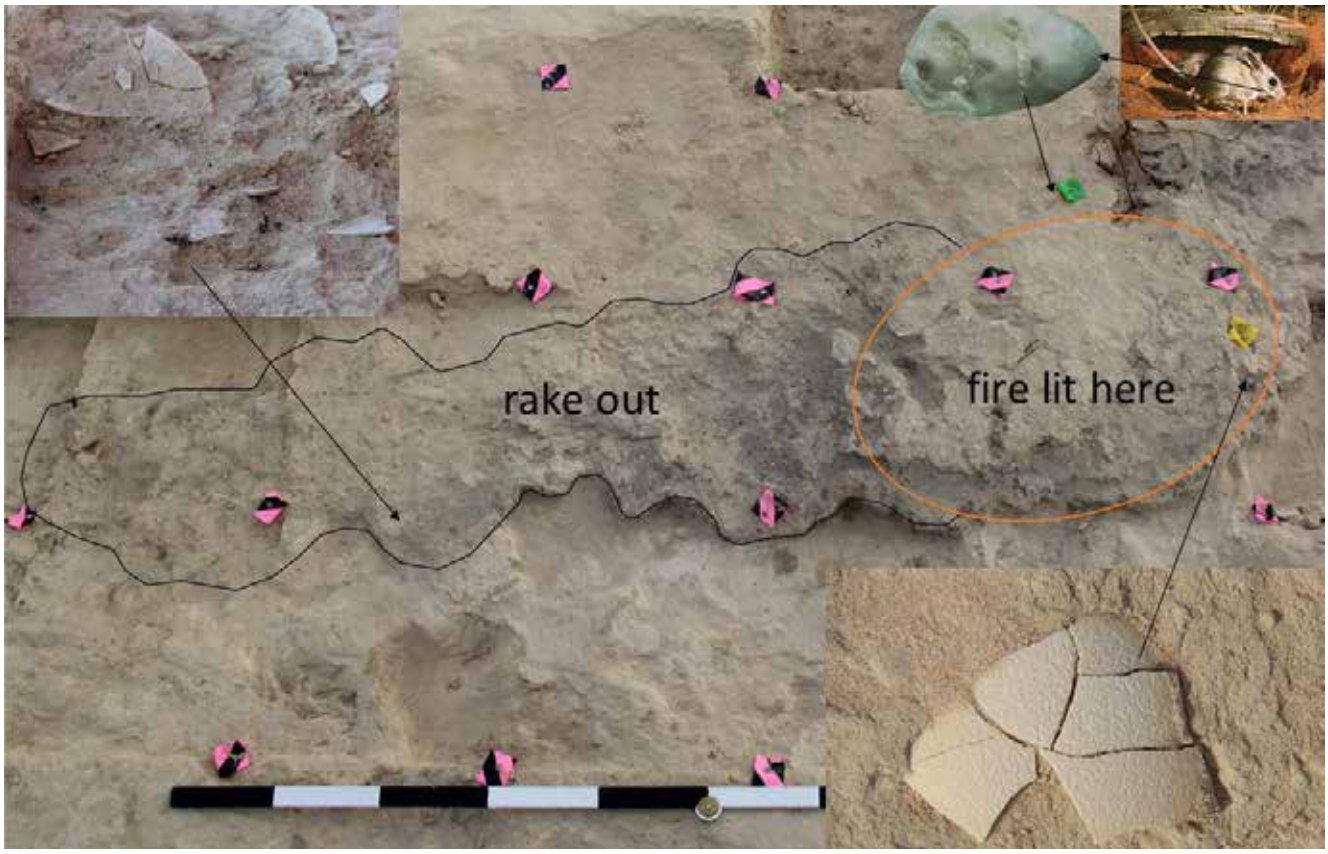

Figure 1: Remains of a fire place that was used to cook emu eggs and native mice. The eggs were cooked in a bed of ash and then dragged out of the fire where they were broken open to eat. A scatter of burned egg-shell, murid bone, and thick ash was left behind.

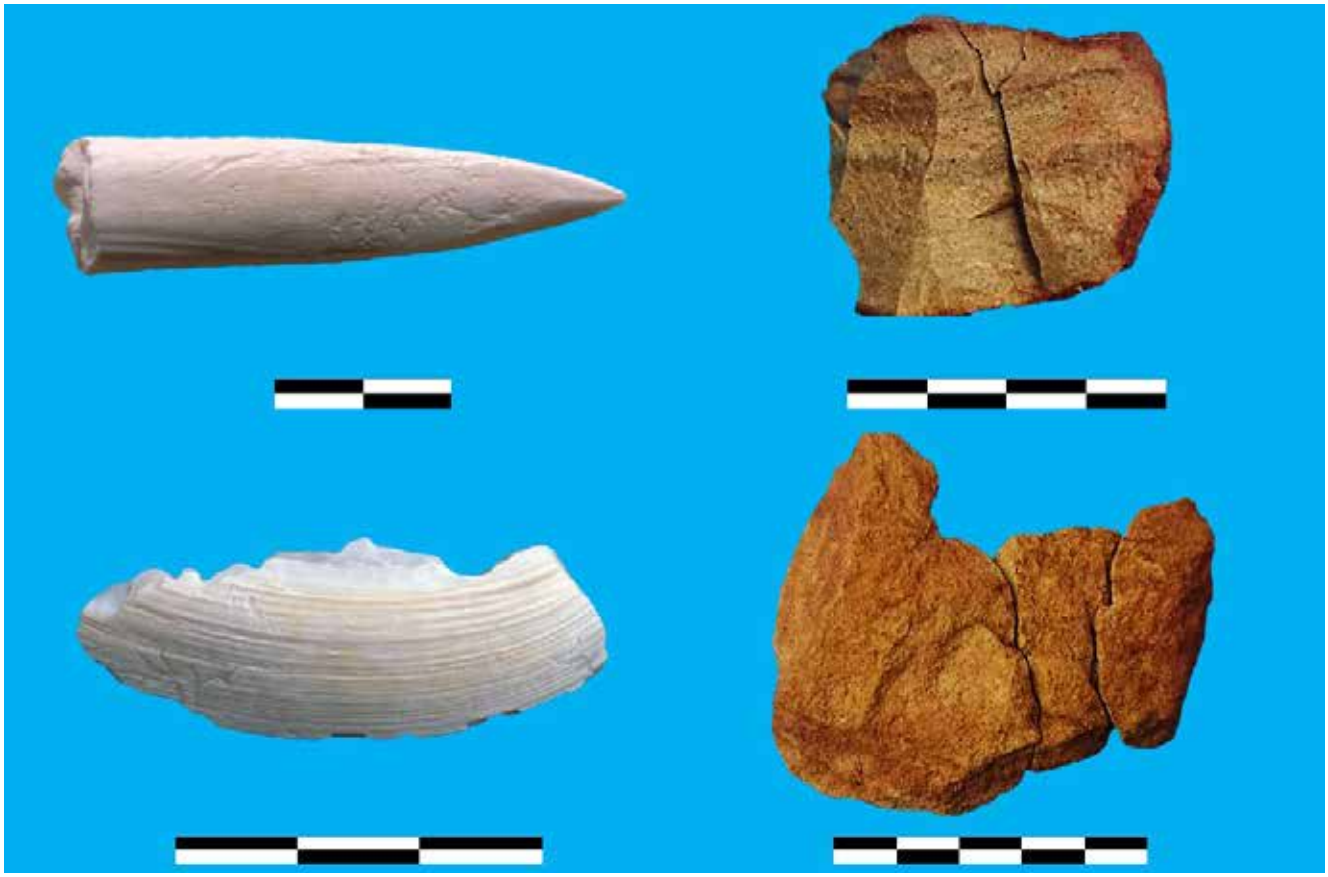

Figure 2: The tool-kit during the last glacial maximum included shaped and sharpened bone and notched shell (left, photos by Rudy Frank, Mungo Archaeology Project); thick flakes of fine-grained rock that were transported from place to place (top right), and larger nodules that were brought from nearby to the lunette, and stripped of any coarse material prior to use (bottom right). Scale bars are in 1cm increments.

GOLDEN PERCH (*MACQUARIA AMBIGUA*) OTOLITH MICROCHEMISTRY: MODERN VALIDATIONS AND ANCIENT APPLICATIONS

Kelsie Long

MUNGO ARCHAEOLOGY PROJECT

Degree: PhD

Duration: 2013-2019

Institution: Research School of Earth Sciences, Australian National University

Discipline: Archaeology

RESEARCH GOALS

This project investigated the potential of golden perch otoliths, which are found throughout the shoreline dunes of Lake Mungo (Figure 1), for providing information about lake level fluctuations and general environmental conditions. Fish otoliths are bone-like structures that form in the inner ears of bony fish. They develop by the incremental deposition of calcium carbonate onto an organic matrix, forming annual growth rings (Figure 2). As otoliths grow, they take up and preserve a record of the trace element and isotopic composition of the ambient water. Some of these chemical markers, like oxygen isotopes, are affected by temperature and by changes in water composition, such as salinity, with evaporation or flooding. This builds on the work of Katarina Sporcic (née Boljkovac), who for her Honours thesis in 2009 measured the geochemistry (oxygen isotopes, strontium isotopes, Sr/Ca and Ba/Ca ratios) across the age increments of otoliths and found fluctuations possibly linked to evaporation and flooding events.

The main goals were to:

- Validate the relationship between oxygen isotopes in golden perch otoliths and those of the water using modern fish from tanks and modern fish collected from an evaporating lake (Lake Pando Penunie-Lake Hope)
- Apply these geochemical methods to a collection of otoliths excavated from the shorelines of Lake Mungo in the 1970s to investigate changes in water conditions (flooding and drying events) through time. The otoliths were also radiocarbon dated to establish a more detailed chronology of the site.
- Construct a mass balance model using known size and shape of the lakes, modern evaporation rate and rainfall composition to test the effect of different filling and drying scenarios on the oxygen isotope composition of the lake water and hence the otoliths.

PUBLICATIONS

Kelsie Long, Rachel Wood, Ian S. Williams, John Kalish, Wilfred Shawcross, Nicola Stern, Rainer Grün, 2018, Fish otolith microchemistry: Snapshots of lake conditions during early human occupation of Lake Mungo, Australia, Quaternary International, Volume 463, Part A, pp 29-43

Kelsie Long, David Heslop, Eelco Rohling, 2021, Quantitative assessment of the oxygen isotope composition of fish otoliths from Lake Mungo, Australia, Quaternary Research, Volume 102, pp 234 - 246

https://scholar.google.com.au/citations?user=d51EQq8AAAAJ&hl=en

https://researchprofiles.anu.edu.au/en/persons/kelsie-long

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Figure 1: Golden perch otoliths and fish bones exposed on the surface of the Lake Mungo lunette (Photo: Nicola Stern, Mungo Archaeology Project)

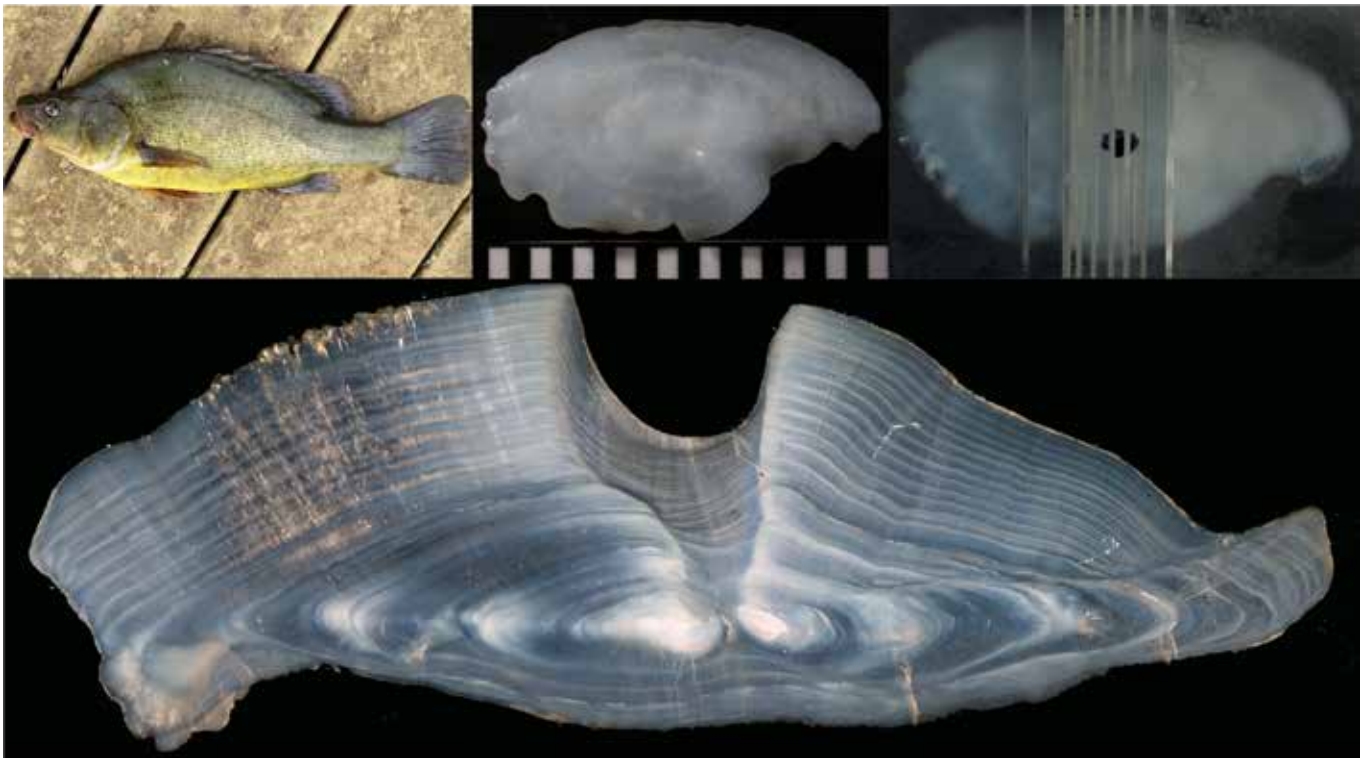

Figure 2: An image of a golden perch fish (top left, Photo: Ian Sutton https://www.flickr.com/photos/22616984@N07/15967142184), a modern golden perch otolith (top-middle), a modern golden perch otolith encased in resin and sectioned to expose the age increments (top-right) and a detailed image of one of the otolith cross sections showing the annual increments (bottom), tiny spots across the age increments on the right of the image are where the oxygen isotope analyses were taken.

DEPOSITIONAL ENVIRONMENTS AND CHRONOLOGY OF THE LAKE MUNGO LUNETTE, JOULNI STATION

Nathan Jankowski

MUNGO ARCHAEOLOGY PROJECT

Position: Post-Doctoral Research Fellow

Duration: 2017-current

Institution: Centre for Archaeological Science, School of Earth, Atmospheric & Life Sciences, University of Wollongong

Discipline: Geochronology and Geomorphology

RESEARCH GOALS

To understand the archaeological traces that are found within the Lake Mungo lunette we must first gain an understanding of the sediments themselves. The lunette's sediments hold valuable information about the environmental conditions that existed at Lake Mungo and the wider Willandra Lakes Region, and how these have changed over time. The goals of this ongoing work are to:

- Understand the depositional history for the Joulni section of the Lake Mungo lunette south of Red Top Tank;
- Define the sedimentary layers (strata) and characterise these sediments using field observation and microscopic analyses to better understand how the landscape developed over time (Figure 1);
- Determine the age of these sedimentary envelopes using optical dating of sand grains collected from within each layer;
- Redate a number of Bowler et al. (2003) original optical dating samples from the Mungo Man and Mungo Lady transects, the Shawcross (Mungo B) Trench, and Mungo Residual using current best-practice methods of optical dating. This redating allows us to compare the results of Bowler's studies of the southern tip of the lunette to the MAP studies further north.

KEY OUTCOMES

So far, 57 sediment sections have been recorded across 9 gullies and two large residuals that span ~2 km of the Lake Mungo lunette south from Red Top Tank. A total of 145 individual optical dating samples have been collected, and the sediments in 124 accompanying thin sections have been examined under the microscope. These measurements and analyses are ongoing, so our interpretations of past depositional histories and prevailing environmental conditions are also being refined as we accumulate further results. The following section summarizes the results we have published up to now.

We undertook a detailed study of the sedimentary layers within one naturally eroding gully located just south of the Mungo-Joulni boundary fence (labelled Gully 10; Figure 2). Here, 11 stratigraphic units were identified and 56 optical ages calculated from sampled sediment blocks. From these results we were able to define four broad time periods of sediment accumulation:

1. >100 thousand years ago – the environmental conditions for these sediments is difficult to determine because their original structure had been disrupted by deep and heavy soil formation processes.
2. 65–33 thousand years ago – these sediments are comprised mainly of sand and terminate with strong soil development indicative of lake full conditions and overall landscape stability.
3. 30–16 thousand years ago – conditions became increasingly unstable, and lake levels began to fluctuate significantly, before Lake Mungo dried out completely.
4. < 10 thousand years ago – only occasional reactivation of pre-existing lunette sediments until the present.

The redating of Bowler et al. (2003) samples from the southern end of the lunette have allowed us to better constrain the timing of deposition at the southern tip of the lunette. These new ages are in better agreement with the radiocarbon ages from the same sedimentary layers within the Shawcross (Mungo B) Trench excavations, reported in Long et al. (2017). Importantly, our redating has not changed the ages of Mungo Man or Mungo Lady beyond the statistical uncertainties presented by Bowler et al. (2003).

We are continuing to work on samples from Joulni with the ultimate goal of creating a geological map of the studied region that will allow the archaeological traces to be placed in their correct temporal and environmental context.

PUBLICATIONS

Jankowski, N.R., Stern, N., Lachlan, T.J., Jacobs, Z., 2020. A high-resolution late Quaternary depositional history and chronology for the southern portion of the Lake Mungo lunette, semi-arid Australia. Quaternary Science Reviews 233, 106224.

DOI: https://doi.org/10.1016/j.quascirev.2020.106224

http://www.sciencedirect.com/science/article/pii/S0277379119307449

Figure 1. The majority of the sedimentological work involves the detailed study of the sediments that are preserved in outcrops along the southern end of the Joulni MAP study area. The section shown here records two large free flowing sand dunes (black brackets) that were deposited before and after a period of landscape stability as indicated by a weak layer of soil development (black arrow).

Figure 2. Composite image showing the process of sampling sediments for analyses and dating (left to right). 1) The gully profile is cleaned back to reveal 'fresh' sediment surface that is recorded. 2) The position of sediment blocks are marked out, covered in plaster bandage, and then removed for sediment analysis in the laboratory. 3) Small tubes are then inserted into sediments to collect sediments for optical (sand grain) dating. 4) Final drawing of sedimentary profile for this section, where F = fine and C = coarse sediment, and circles represent the position of the dating samples. Optical ages are noted alongside the appropriate sample location with a 1σ uncertainty.

TESTING THE GREASY LUSTRE. AN ASSESSMENT OF MASS GLOSS ANALYSIS AS A NON-DESTRUCTIVE METHOD FOR IDENTIFYING HEAT TREATMENT IN SILCRETE FROM THE WILLANDRA LAKES

Rhiannon Stammers

MUNGO ARCHAEOLOGY PROJECT

Degree: Bachelor of Archaeology Honours

Duration: 2012-2013

Institution: Department of Archaeology and History, La Trobe University

Discipline: Archaeology

RESEARCH GOALS

Heat treatment involves using heat to modify the physical properties of stone to make it more amenable to knapping. Archaeological and ethno-historic evidence for heat treatment has been documented in many parts of the world, including Australia. In most cases, heat treatment has been identified by the presence of a 'greasy lustre' on the surface of artefacts and the presence of red artefacts. However, few studies have identified heat treatment using systematic scientific techniques rather than incidental observations and subjective approaches.

A variety of techniques have been suggested as ways of identifying the use of heat treatment to facilitate stone tool production, however, they are rarely used because they involve destruction of the samples being studied. Gloss Analysis is a quantitative, non-destructive, experimental technique, that was first used to study the heat treatment of fine grained silcrete from the southern Cape Coast of South Africa. Initial applications of the method proved promising; however, little work was undertaken to develop the technique and no investigation of its potential for studying coarser grained silcrete or other raw materials was undertaken. This study therefore aimed to:

1. Establish the viability of Gloss Analysis for detecting heat treatment of rocks with different textural characteristics.

2. Explore the application and usefulness of Gloss Analysis for identifying the heat treatment of silcrete in Australia.

3. Develop criteria for identifying the rock samples suitable for Gloss Analysis;

4. Investigate whether the Chibnalwood Lake Beach Quarry assemblage, studied by Vick in 2012, had been subject to heat treatment.

KEY OUTCOMES

This research showed that the composition of the rock is fundamental in determining whether Gloss Analysis is a useful method for identifying the heat treatment of silcrete. It appears that when crypto-crystalline and micro-crystalline silcretes are heated, the quartz grains they contain are homogenised permitting better refraction of the light beam and that the resulting glossiness of the rock surface means that it can be read using a Gloss meter. As a result, it was shown that the method is only somewhat useful for coarser grained silcretes like those found in the Willandra Lakes region. Consequently, the analysis of the Chibnalwood Lake Beach Quarry assemblage was inconclusive, but it is unlikely that it had been subject to heat treatment.

Additionally, it was shown that colour change is not a reliable method for identifying heat treatment. For colour change to occur, silcrete has to be heat treated in an oxygenated environment. When materials containing goethite are heated to more than 3000C in the presence of oxygen, their colour changes from yellow hues to red and green hues (Figure 1). However, when goethite is altered to haematite a change in colour does not always occur. The dehydration transformation is topotactic and may involve a direct transformation from goethite to hematite or a transformation that involves an intermediate superstructure phase before the final formation of hematite. Under a reducing environment, clay minerals form magnetite, which is grey in colour, whereas an oxygenating environment will produce both magnetite and pigmentary haematite, causing a reddening of the rock.

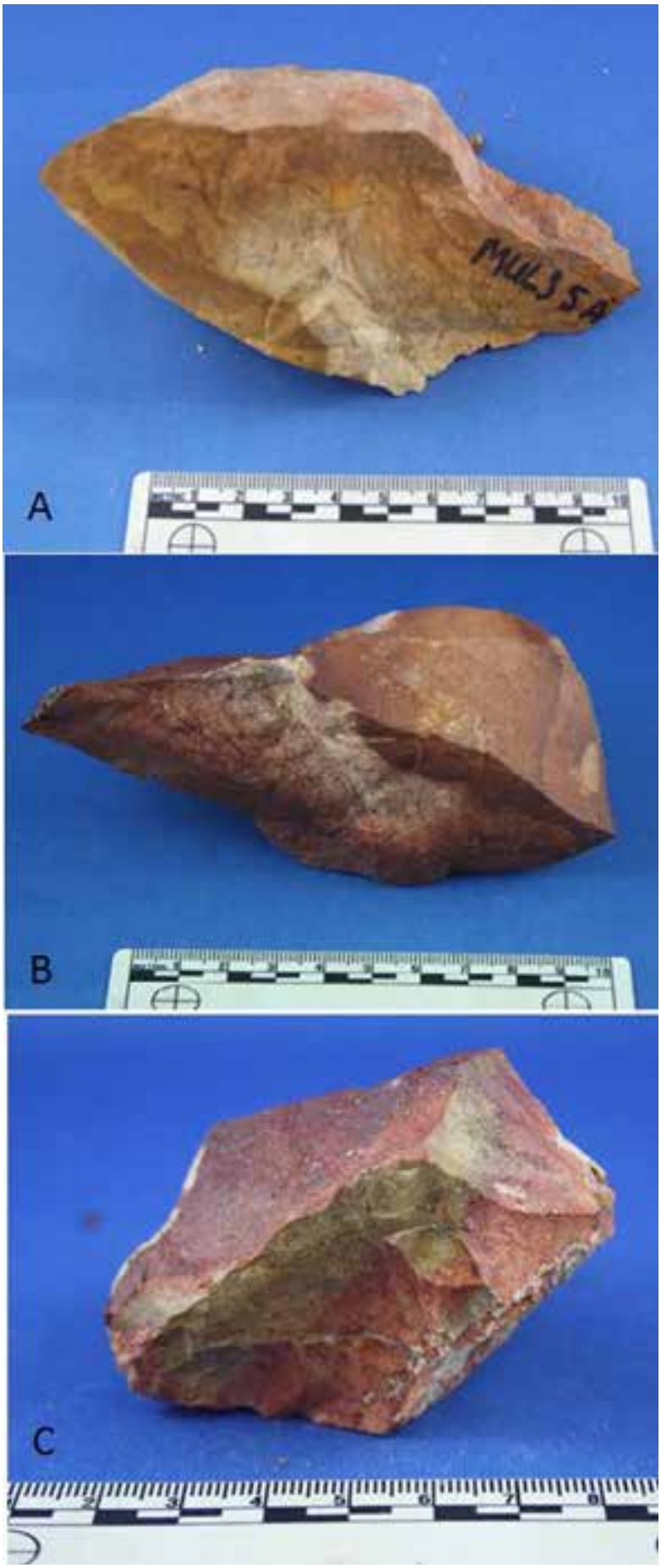

Figure 1: Silcrete from Mulurulu A) before heat treatment in an oxygenated environment, B) exterior after experiment 1 and C) flaked interior surface after experiment 1. Note that the colour change extends only a few millimetres into interior of the rock.

LAKE MUNGO HEARTHS: A MULTI-SCALE, MIXED METHOD GEOARCHAEOLOGICAL INVESTIGATION OF BURNING FEATURES AT LAKE MUNGO, NEW SOUTH WALES (NSW), AUSTRALIA

Lauren Nicole Prossor

MUNGO ARCHAEOLOGY PROJECT

Degree: Masters of Archaeological Science (Advanced) (Hons)

Duration: 2015-2015

Institution: School of Archaeology and Anthropology, Australian National University

Discipline: Archaeology

RESEARCH GOALS

Traces of people's activities were incorporated into the Lake Mungo lunette as it built up and these have been interpreted as the remains of single events, like the making of a stone tool or the lighting of a cooking fire (Stern, 2015). Hearths are the most abundant of the cultural features being exposed on the surface of the eroding lunette through ongoing erosion. Fires would have played an important role in people's lives, in cooking, heating, lighting, medicinal treatment, and ceremonial activities. The hearths found on the Lake Mungo lunette include the remains of heat-retainer ovens, as well as distinctive patches of cemented, organic-rich sediment and discrete clusters of burned bone. The field characteristics of both ovens and fireplaces vary considerably.

Six hearths that do not contain heat retainers were studied through description of sediment thin sections and QEM-EDS (Quantitative Evaluation of Minerals using Energy Dispersive Spectrometry), supported by X-ray diffraction (XRD): features 132, 190, 404, 486, 1132, 1139 and 1168 (Figure 1). Feature 132 was recorded and collected to study a bedding feature (not a hearth) but was recorded in the hearth database to document context. This study was designed to:

1. Enhance understanding of the relationship between the macroscopic field characteristics and microscopic features exhibited by these features.

2. Identify the types of cooking and food processing activities they represent (cooking fires, raking of ashes, processing locales).

3. Identify the effects of lighting a fire on a wet or dry substrate, and the impact of geomorphic processes on these features both during burial and after they were exposed on the modern ground surface.

KEY OUTCOMES

This research shows that the microstratigraphic study of hearth features is fundamental to understanding the activities which they represent, as well as the processes that contributed to their preservation. The most valuable inferences about the composition of the hearths and their microstratigraphy were obtained from the systematic descriptions of the thin sections (i.e., from the micromorphology) and these provided the primary basis for the interpretation of individual features. The QEM-EDS mineral maps facilitated visualization of the composition of the hearth samples and were particularly helpful in identifying variations in composition and supporting the thin section observations (Figure 2).

This study helped to link the macroscopic field characteristics of hearths represented in the record by discrete patches of cemented, organic-rich sediment ('baked sediment hearths') and/or burned bone to their microstratigraphic constituents and structure. In turn, this provided the basis for understanding what these hearth features represent in terms of cooking and food processing activities. Some features are interpreted as the remains of cooking fires (e.g., feature 486), while others represent the hot ash and foods raked out from a cooking fire (e.g., features 1319, 404, 190) and others represent the processing and discard of cooked food remains (e.g., feature 1168).

These methods employed in this study have the potential to furnish valuable data regarding temporal and geographical variations in cooking practices, alteration by post-

depositional processes and evaluating the appropriateness of different features for subsequent archaeobotanical, dating, palaeoecological or zooarchaeological analyses.

PUBLICATION

Prossor, L., Denham, T., Brink, F., Troitzsch, U., & Stern, N. 2022. The microstratigraphic investigation of hearth features at Lake Mungo, Australia. Journal of Archaeological Science: Reports, 46. doi:10.1016/j.jasrep.2022.103711

Figure 1: Multipanel showing photographs of the landscape and stratigraphic setting (1), close up (2) for hearth Feature 1168 and sequential photographs (3-6) of sediment block collection in the field from Feature 1168.

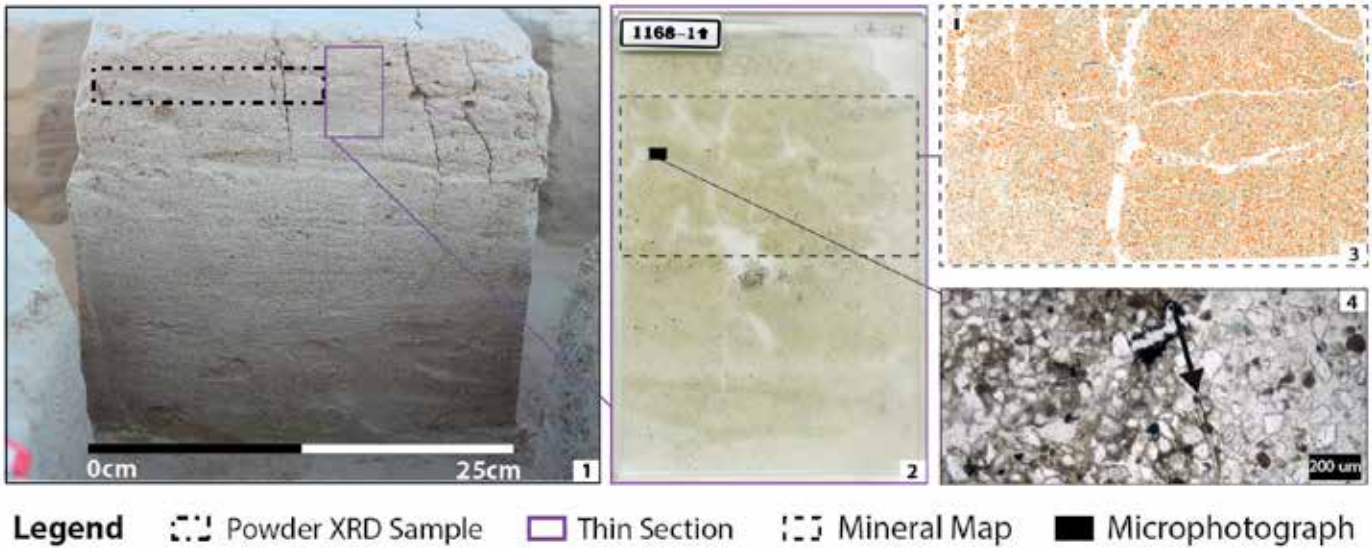

Figure 2: Multipanel showing locations of sub-sampling of the sediment block from hearth Feature 1168 including: powder X-ray diffraction (1), thin section slide (1-2 and 4) and QEM-EDS mineral map (3). Microscopic burnt bone within sands, identified as hearth rake out, is displayed

- *in the QEM-EDS mineral map (3) as blue linear components (distributed in the top two thirds of the mineral map) embedded within quartz sand (orange), together with clay (green) and*
- *under high magnification as a pale-yellow, linear component marked with a black arrow in the microphotograph (4).*

A STUDY OF STONE ARTEFACTS ASSOCIATED WITH HEARTHS ON THE LAKE MUNGO LUNETTE

Isabel Tickle

MUNGO ARCHAEOLOGY PROJECT

Degree: Bachelor of Archaeology (Honours)

Duration: 2015-2016

Institution: Department of Archaeology and History, La Trobe University

Discipline: Archaeology

RESEARCH GOALS

This project investigated stone artefacts recovered from eleven hearths on the Lake Mungo lunette to examine the stone working activities that took place around the hearths, as well as the stone technologies used. The artefacts studied were those which people discarded when they moved on from the hearths. This also generated interest for information about what was carried into these locations and what people carried with them when they moved on. This study provided insights into the way in which people ensured that they had tools or the raw material for making them, with them when they camped on the Mungo lunette where there was no naturally occurring stone.

Technological analysis of the artefact assemblages, including refitting, was undertaken as part of this investigation. Features of the hearths and the palaeoenvironmental contexts of the assemblages were compared to the characteristics of the artefact assemblages. This was to investigate whether there was a relationship between lake conditions and the way that stone tools were made and used there and carried away. This approach makes the working assumption that stone technology is one of the ways in which people adjust to the challenges of changing environments.

KEY OUTCOMES

The stone artefact assemblages revealed considerable variation in both the stone-working activities undertaken at the hearths and what people transported to, and from, these features. The study also showed that the toolkits people used contained multiple components at any one time, including cores for making fresh flakes (Figure 1, Figure 2), whole flakes and retouched tools (Figure 2).

A pattern was identified between lake conditions and stone technology, which fits with Tumney's 2011 findings that people went to greater lengths to conserve raw material when lake levels were low or oscillating. This suggests that people were not as mobile when there was less water in the surrounding landscape and thus encountered stone sources less often.

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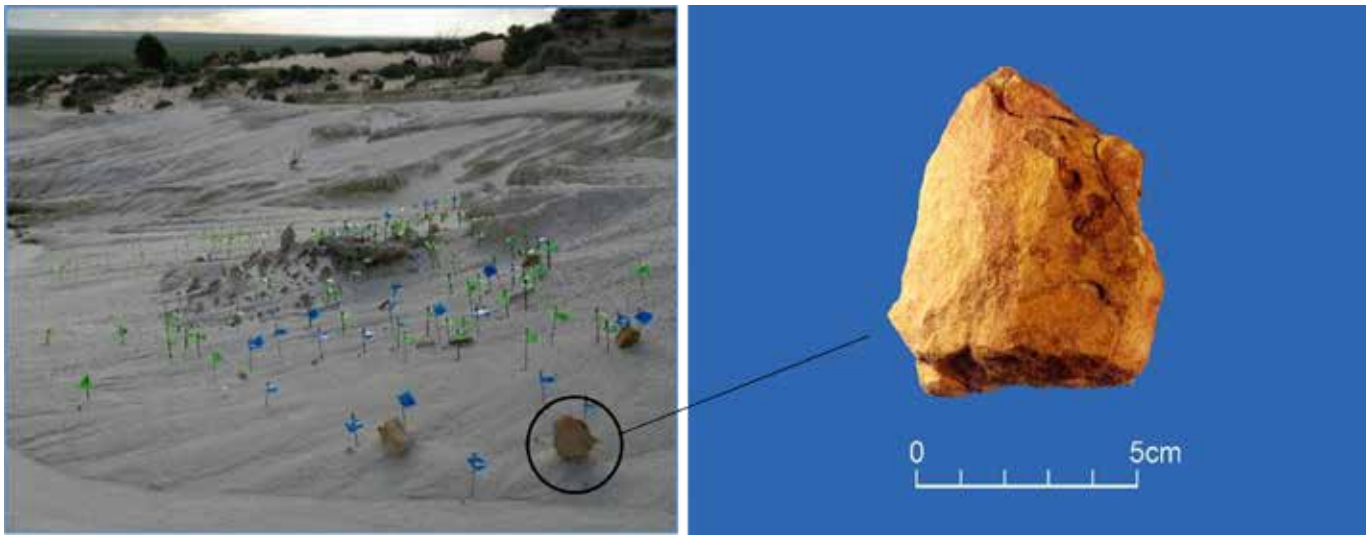

Figure 1: Hearth 368 (Photo: Mungo Archaeology Project); a baked sediment hearth where a bettong, a hare-wallaby, a bandicoot and a small rodent were cooked. The hearth assemblage included refit sets demonstrating stone working at the hearth, as well as the discard of a utilised flake and a retouched tool. The second image shows one of the refit sets comprising a core, two whole flakes and a conjoining proximal and distal flake which were likely removed from the core at the hearth. The core can be seen in the foreground of the hearth image. (Refit photo: Ming Wei).

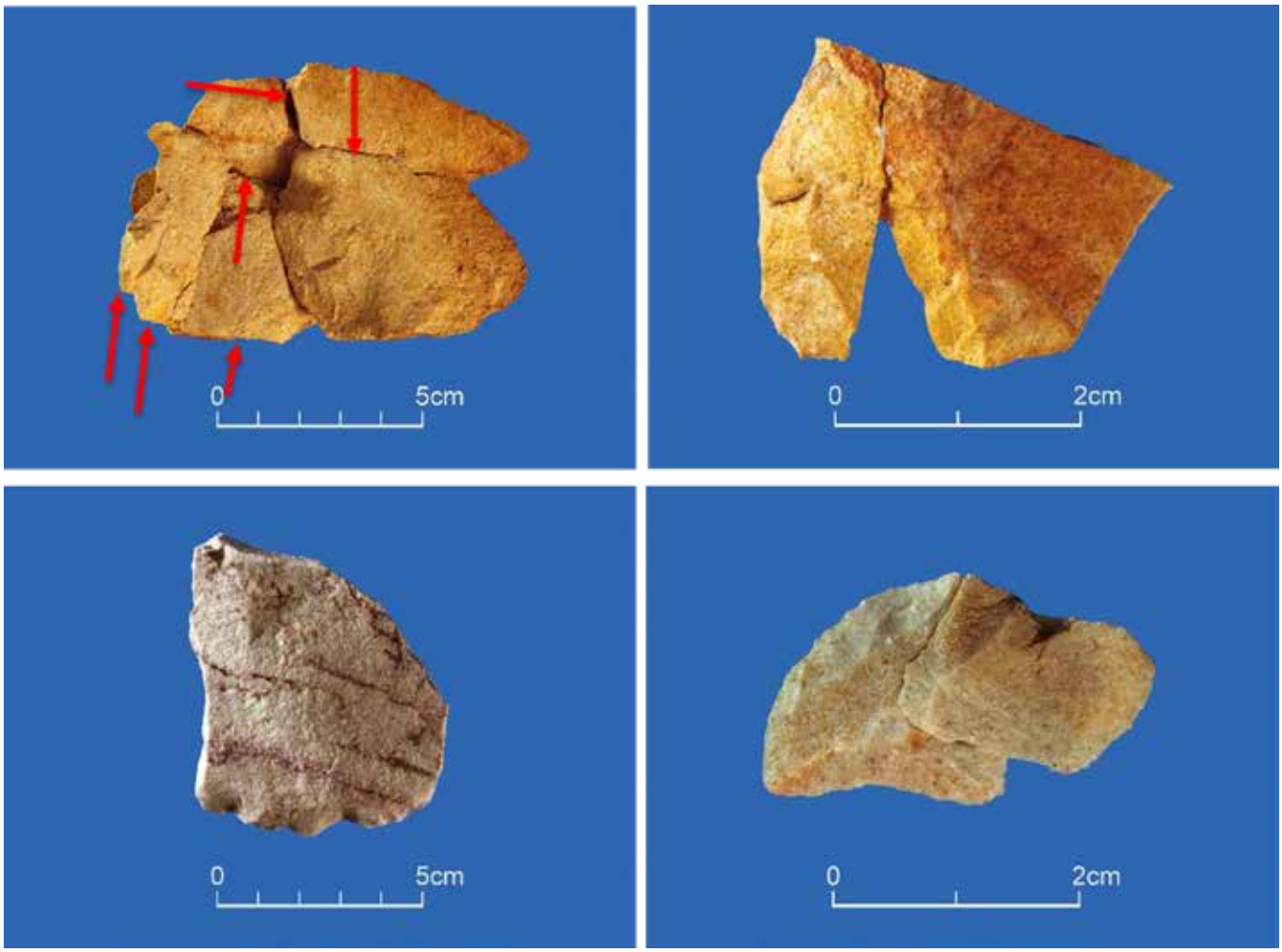

Figure 2: A selection of artefacts from the hearth assemblages, clockwise from top left: A refit set from hearth 368 comprising two left split flakes, a distal flake and five whole flakes. The arrows indicate the direction in which the flake was removed from the core. This demonstrates how the core was rotated when it was worked; A refit set comprising a whole flake and a right split flake manufactured from fine-grained silcrete. The refit was identified at hearth 1168, the location at which some Golden Perch were processed; A medium grained silcrete notched scraper identified at hearth 1441 where some emu eggs were cooked; A fine-grained silcrete utilised flake and whole flake that refit. These artefacts were identified at hearth 184, a hearth where some duck eggs were processed (Images: Ming Wei).

TRACES OF PAST HUMAN ACTIVITY AT AN INTER-LAKE CLAY PAN IN THE WILLANDRA LAKES REGION: THEIR CONTEXT AND SIGNIFICANCE

Lana Edwards

MUNGO ARCHAEOLOGY PROJECT

Degree: Bachelor of Archaeology with Honours

Duration: 2016-2017

Institution: La Trobe University, Department of Archaeology and History

Discipline: Archaeology

RESEARCH GOALS

The thesis examined a locale between Lakes Mungo and Leaghur featuring a shallow clay pan which holds water after significant rainfall. A low-density scatter of traces of human occupation are dispersed along the margins of this clay pan, including hearths and stone artefacts. The goal of the thesis was to develop an approach to documenting exposed features as well as possible sub-surface features in settings like this, which occur throughout the Willandra Lakes Region. The location and shallow deposits in which these archaeological traces lie suggest that it provides insights into post-lake activities, an under-studied but prominent feature of the archaeological record in the Willandra Lakes Region. In this semi-arid, post-lake landscape, access to fresh water would have been a constraint to movement. This made the location ideal for study as it was likely a node through which people travelled when it was seasonally recharged by rainfall. Study of the location allowed for the examination of archaeological traces built up over repeated visitation and provided an insight into which resources may have been exploited here.

Multiple techniques were utilised to examine the site with the aim of identifying the types of archaeological traces preserved in these settings and the best approach to investigating and documenting them. Stone artefact analysis and interpretation was complimented by magnetic gradiometry, drone photography and mapping, photogrammetry, and ground penetrating radar (GPR) which are becoming more commonplace in Australian archaeology.

The data gathered through these methods were analysed and interpreted using the framework of landscape archaeology and the ecology of foraging activities. Given the amount of research focussed on deep antiquity of the Willandra Lakes Region, one goal of the thesis was to address a lack of highly detailed site specific post-lake archaeology in the region, and to produce a framework for utilising a variety of techniques to study the post-lake cultural landscape.

KEY OUTCOMES

The outcome of the study was twofold. The site was recorded for posterity in a highly detailed manner using a range of methods. Furthermore, the research identified the benefits and constraints of various techniques for recording these traces of human activity. Each technique contributed useful data, however, the drone photography and artefact mapping using highly accurate total station recording was the most expedient and effective method of recording the locale in detail. Magnetic gradiometry and GPR had limited success in identifying or interpreting sub-surface archaeological traces, but was useful in exploring the pedogenic and hydrological processes at the clay pan. These data preserve a snapshot of this important site and can be compared to future survey of the site, and other similar locales in the region, to help build a picture of the post-lake cultural landscape.

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Figure 1: Hearth, facing north (photo: Lana Tranter-Edwards)

Figure 2: Clay pan after significant rainfall, facing west (photo: Katherine Thomas)

GEOARCHAEOLOGICAL AND CHRONOLOGICAL INVESTIGATIONS OF COMBUSTION FEATURES AT LAKE MUNGO, NSW

Megan R. Ensor

MUNGO ARCHAEOLOGY PROJECT

Degree: Bachelor of Science (Honours)

Duration: 2018-2019

Institution: School of Earth, Atmospheric, & Life Sciences, Faculty of Science, Health and Medicine, University of Wollongong

Discipline: Geoarchaeology

RESEARCH GOALS

This Honours project was undertaken alongside the palaeoenvironmental and geochronological work of Dr Nathan Jankowski. The hearths preserved along the Mungo lunette are an invaluable source of information about the food getting and processing activities that were undertaken on the lunette.

However, there is limited information about the microscopic composition of these hearths and their history of creation, usage, and subsequent abandonment. The goals of this study were to:

1. Study the microscopic composition of two hearths using thin sections to understand their depositional history, e.g., are they singular or multiple events, have they remained intact or undergone post-depositional modification.

2. Conduct laboratory experiments to test whether the maximum firing temperature range of these hearths could be recorded within the clay minerals found in these features.

3. Determine bracketing ages for these hearths using optical dating of sand grains collected from within the sediment blocks.

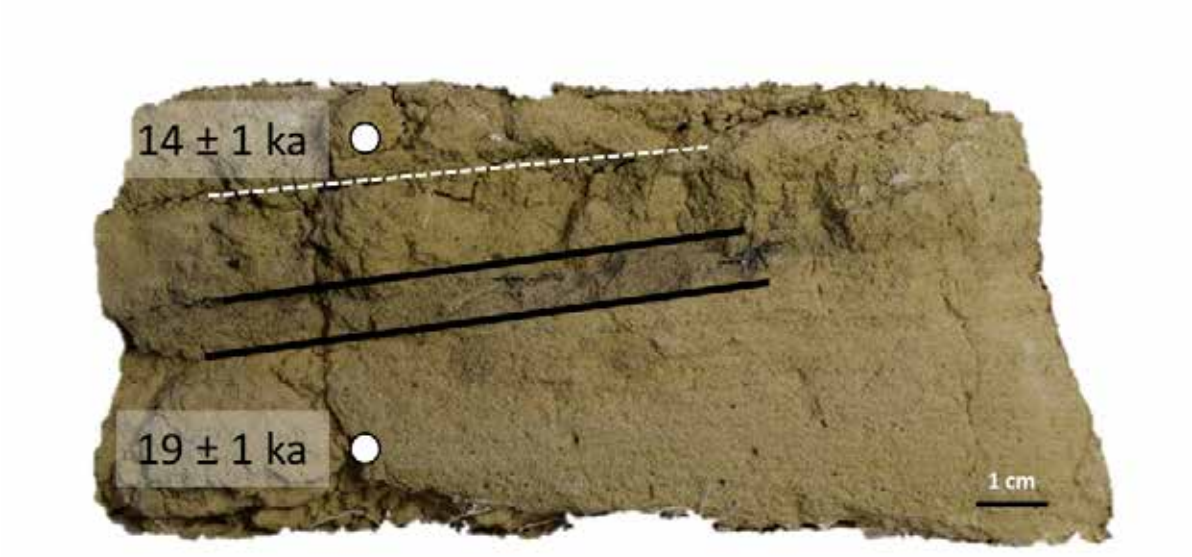

Figure 1. Sediment block from Hearth 1455. The two solid black lines represent the boundaries of the sediments containing burnt fire place material. The dashed line position where these sediments were truncated. The position of samples collected for optical dating are shown as white circles, with their respective ages alongside (± 1σ uncertainty).

KEY OUTCOMES

Two hearths in the central part of the Mungo lunette were studied as part of this honours project: Hearth 1455 and 1467; see Figure 1.

The first priority was to determine whether or not a potential firing temperature range could be estimated for each hearth using a technique known as Fourier Transform Infrared Spectroscopy (or FTIR). This method provides a chemical fingerprint for the materials being analysed. In this project, the FTIR fingerprint of clay minerals was used as previous studies had found these useful indicators for archaeological sites elsewhere in the world. A series of laboratory tests were conducted using unheated clay samples and showed that significant changes in the FTIR fingerprint occurred between 400 and 500 °C, indicating that they could be used as a kind of ancient thermometer (see Figure 2). However, when we examined the clay material of samples collected systematically through the Lake Mungo hearth blocks, no such changes in FTIR fingerprint were observed.

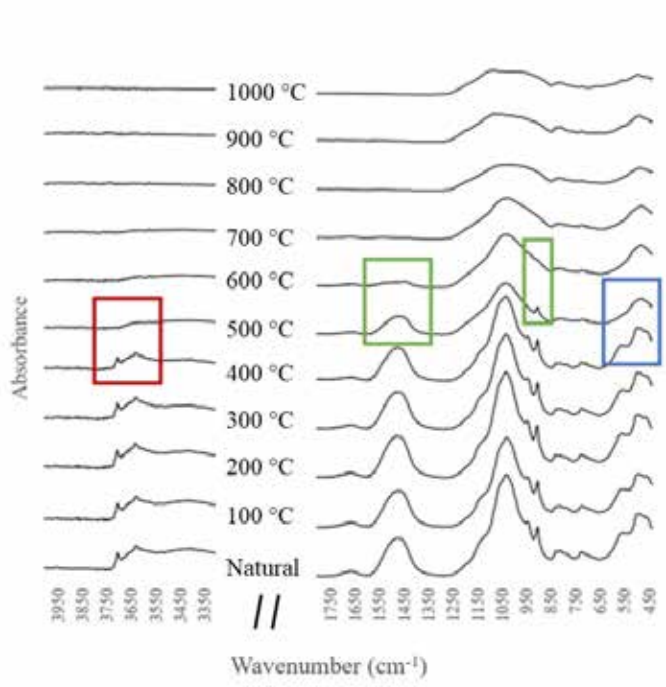

Figure 2. Experimental Fourier Transform Infrared spectroscopy (FTIR) fingerprints for samples of clay collected from the Lake Mungo lunette. Different subsamples of the same clay were heated to specific temperatures (shown in the centre of the figure). The first evidence for change in the FTIR fingerprints occurs between 400 and 500 °C, as shown by the red and blue boxes. This loss of peaks in the red box is associated with loss of water from within the clay mineral structure, whereas the changes observed in the blue box are associated with changes in the clay minerals themselves. Continued heating to temperatures of 600 °C and higher sees the clay minerals begin to breakdown further and transform as noted by the green boxes.

This lack of any changes in the FTIR results warranted a more detailed investigation of the sediments themselves. Analysis of thin sections from both hearths showed that the sediments themselves were not consistent with the interpretation of these hearth features as cooking hearths, as the microscopic constituents of the hearths are jumbled and disorganised. These sedimentological observations, along with the FTIR fingerprinting results, allowed us to hypothesise that the sediment blocks were collected from the rake-out from a nearby cooking hearth which hasn't been preserved. These features thus represent food processing, rather than cooking.

Further analysis of the thin sections showed that the upper part of both sediment block appeared to have been truncated sometime in the past before further sediments were deposited over the top of the remaining hearth material. This observation was supported by the optical dating of sediments collected from below and above the hearth debris levels from within the sediment blocks. Basal ages for the two blocks indicate that they were lit just before and just after the height of the last ice age respectively: the sediments immediately beneath Hearth 1467 have an estimated age of 24 ± 1 thousand years while those underlying hearth 1455 have an age 19 ± 1 thousand years. The sediments at the top of both hearth blocks are consistent with one another (15 ± 1 thousand years for 1467 and 14 ± 1 thousand years for 1455) and are much younger than the original firing ages of the hearths.

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BETTONGS FOR DINNER. AN INTERDISCIPLINARY STUDY OF THE FAUNAL ASSEMBLAGE AT SITE 1319, LAKE MUNGO

Haley Geiberras

MUNGO ARCHAEOLOGY PROJECT

Degree: Bachelor of Arts (Honours)

Duration: 2018-2021

Institution: Department of Archaeology and History, La Trobe University

Discipline: Archaeology

RESEARCH GOALS

This project studied the animal bones that were excavated from a hearth feature in the central area of the Lake Mungo lunette in 2014. The baked sediments and animal bones from this feature represent the rake-out from a cooking fire: the remains of a meal shared on the lunette. The site dates to the last glacial maximum and its study was designed to contribute to our understanding of diet and foraging activities during this period of extreme cold, windiness and aridity.

This research aimed to

- Identify the 1229 faunal fragments recovered from the 2014 excavations of Hearth 1319 to find out what animals had been cooked and what can be learned about hunting, cooking and food discard at this location
- Investigate the effects of cooking on the characteristics of the bone assemblage, for example, the impact of heating and burning, and fragmentation,
- Investigate whether ethnohistoric information about the hunting and butchering practises could enhance the interpretation of this cultural feature.

This hearth dates to the last glacial maximum and adds to a corpus of information being built up about life at Lake Mungo during this period (see Foley this volume).

Figure 1: Fragment of a macropod mandible. (Photo: Nicola Stern, Mungo Archaeology Project)

KEY OUTCOMES

A significant proportion of the faunal assemblage exhibits evidence for exposure to high temperatures, as would be expected for faunal remains discarded with the raked-out ashes of a hearth. This evidence includes physical changes associated with exposure to high temperature such as discolouration of the bones, pitting, shrinkage, and fragmentation.

Fragmentation presented a challenge to the identification of the animal bones, and most identifiable elements were classified to genus. Present in the assemblage are the remains of bandicoot, (Perameles), burrowing bettong (Bettongia leusur), hare wallaby (Largochestes), red kangaroo, (Osphranter rufus), muridae (Notomys), and potoroo (Potorous).

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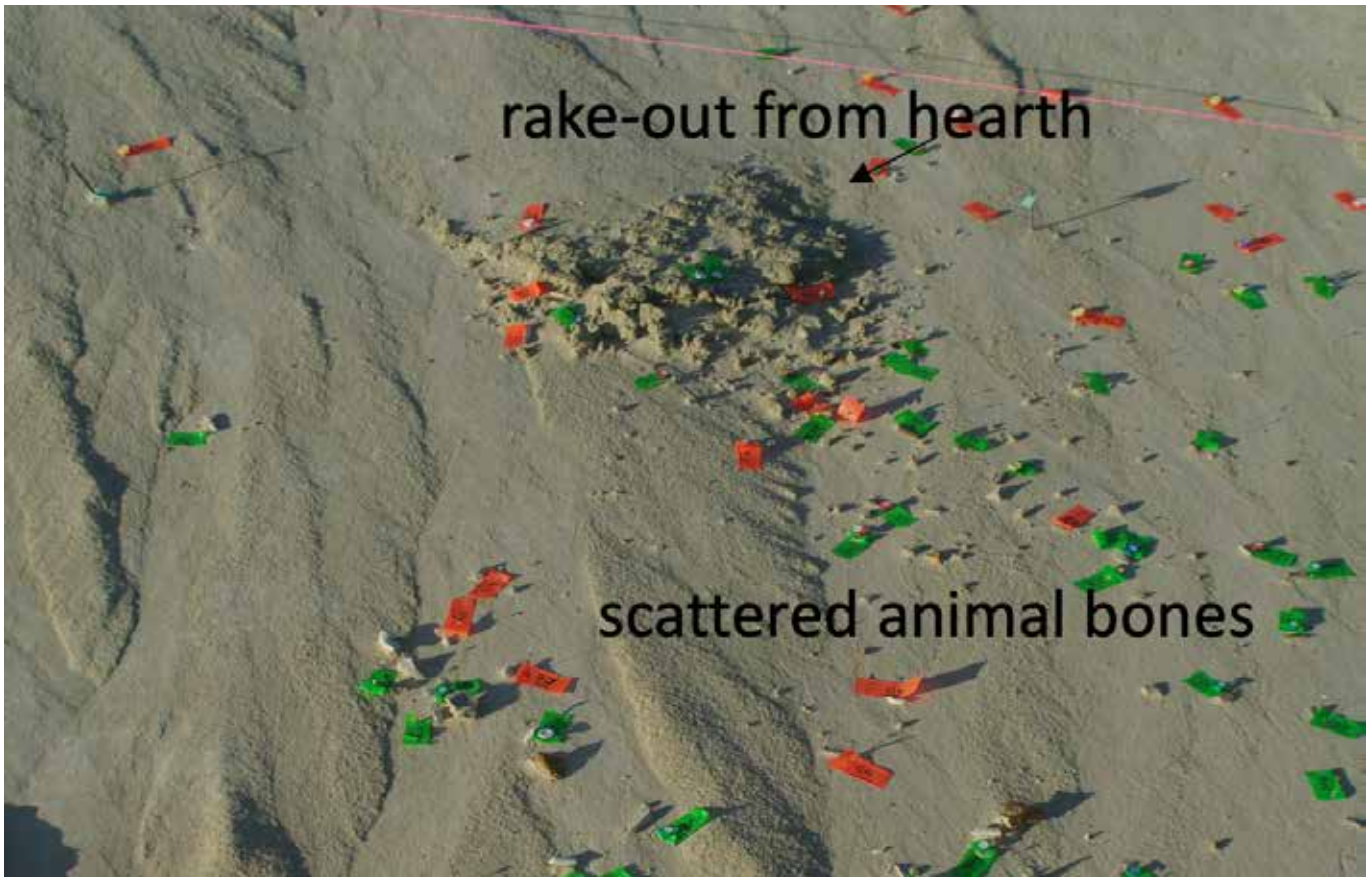


Figure 2: Hearth 1319 and adjacent Hearth 1317, showing topographic and stratigraphic setting. (Photo: Nicola Stern, Mungo Archaeology Project)

Figure 3: Close up of Hearth 1319 showing associated scatter of animal bones. (Photo: Rudy Frank, Mungo Archaeology Project)

JUST CRACKING THE SURFACE: AMINO ACID RACEMIZATION IN ARCHAEOLOGICAL EMU EGGSHELL

Maddison Crombie

MUNGO ARCHAEOLOGY PROJECT

Degree: Master of Science

Duration: 2020-2021

Institution: Department of Archaeology and History and Chemistry and the Department of Archaeology and History and Department of Biochemistry and Chemistry, La Trobe University

Discipline: Archaeology

RESEARCH GOALS

Emu eggshell is commonly found in archaeological sites across Australia and is an ideal substrate for amino acid racemization (AAR) analysis which can be used for geochronology and palaeothermometry. Although AAR is a well-established technique, it has not been used widely in Australia. This is in part due to predominance of shallow and surface archaeological sites in Australia and high summer temperatures which accelerate the rate of racemization. It has been a long-held belief that material used in AAR analysis should be excavated from depths of >1m due to the effect of fluctuating temperatures on the surface. However, little work has been undertaken to confirm this. This project aimed to explore the following:

- To develop a model for emu eggshell racemization in Australia.
- To determine if material recovered from the surface of open sites like those at Lake Mungo can be used for AAR analyses designed to reconstruct climate history.
- To generate new temperature estimates for Lake Mungo during the last glacial maximum.
- To investigate whether compound specific isotope analysis can be applied to emu eggshell as an indicator of an emu's diet.

KEY OUTCOMES

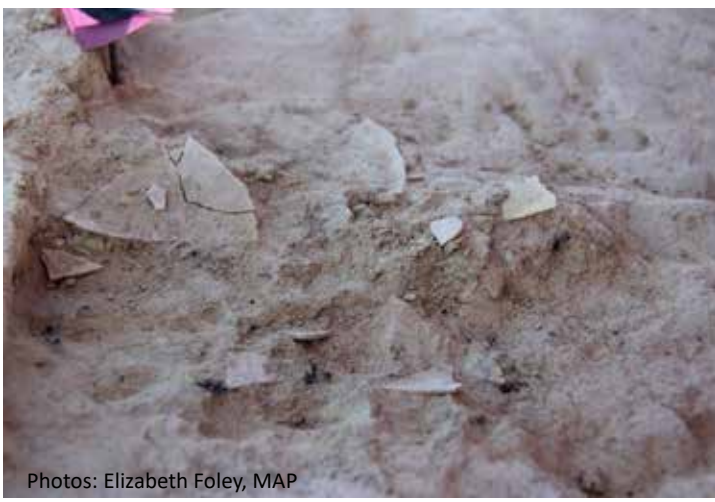
This research presents an alternative model for emu eggshell racemization in Australia and its application to archaeological eggshell from Lake Mungo. The experimental results from this research suggest that:

- Reliable temperature estimates can be generated through AAR analysis of eggshell recovered from open sites, provided it is from shallow excavations and the shell has not been bleached by the sun.
- Material associated with hearths is also appropriate for use with AAR, provided that it was not heavily burnt.
- The current temperature estimates generated by Miller et al. (1997) may be underestimating the temperature at Lake Mungo during the Last Glacial Maximum.
- Between 19,000 and 13,000, there was a 3°C increase in temperature.
- Compound specific isotope analysis can be used to investigate the diet of emus.
- This study produced promising results, but it is based upon a small dataset and further work would be needed to generate a more robust set of data points in order to develop a climate model. Most significantly, this research dispels the myth that AAR is not suitable for open sites like those found at Lake Mungo and suggests that AAR may be valuable for generating paleotemperature estimates for Lake Mungo at different times in the past.

LA TROBE UNIVERSITY

Figure 1: Biomolecular Archaeology lab, La Trobe University

Figure 2: Excavation of emu eggshell from hearth 1466 by Elizabeth Foley



Photos: Elizabeth Foley, MAP

Figure 3: In-situ emu eggshell

INDIVIDUAL PROJECTS

Australian National University

AUSTRALIAN RESEARCH COUNCIL
Centre of Excellence for Australian Biodiversity and Heritage

Griffith UNIVERSITY

THE UNIVERSITY OF SYDNEY

MAX PLANCK INSTITUTE

UNIVERSITY OF WOLLONGONG AUSTRALIA

BROKEN HILL REGIONAL ART GALLERY

CONCORDIA

AUSTRALIAN MUSEUM

SHARING STORIES FOUNDATION

USC

RMIT UNIVERSITY

UNSW THE UNIVERSITY OF NEW SOUTH WALES

MUNGO STORIES - WALKING TOGETHER APP - CASE STUDY WITH NSW NPWS

Sharing Stories Foundation

Project Contributors: The Willandra Lakes Region World Heritage Aboriginal Advisory Group (AAG), Taz Miller, Chris Little, Dale Patterson, Leanne Mitchell, Daryl Pappin, Lawrence Slade, Tressna Martin, Dan Rosendahl, Michelle Ballestrin

Institutions: The Sharing Stories Foundation, Griffith University, NSW National Parks and Wildlife Service

Duration: 2015-current

Disciplines: Heritage conservation, interpretation and visitor management

PROJECT GOALS

This project synthesises 20 years of research and through community direction enhances the preservation and promotion of Aboriginal Culture and Heritage in the Willandra Lakes Region. A unique visitor experience and opportunity for revenue for Traditional Owners will be created through development of this GPS visitor app and interactive multimedia interpretations of the stories surrounding the 20 thousand year old Willandra Fossil Trackway site. This interpretation will allow visitors to virtually walk together with Ancestors, increasing access to knowledge and respectful ways of traveling through Country.

Figure 1

Sharing Stories Foundation (SSF) has been working alongside The AAG and other members of the Three Traditional Tribal Groups (3TTG) of the Willandra Lakes Region World Heritage site over 6 years, implementing Digital Storytelling Programs that connect elders and young people whilst developing culturally significant media regarding knowledge of the Willandra Lakes Region.

Community members worked deeply across all aspects of the project, as creative directors, storytellers, artists, animators, sound designers, narrators, performers, and curators. Between 2015 and 2021, 42 community members contributed a combined total of 3146 hours towards the creative interpretations and app development, reclaiming the narrative of cultural stories shared in the Willandra region.

Community should also be celebrated for their roles as Archaeologists, conservators, excavators, physical anthropologists, data capturers, trackers, environmental and cultural interpreters, all vital roles in ensuring this important cultural heritage site and stories continue to be living stories.

The project engaged many project partners including Sharing Stories Foundation, Griffith University, Willandra Lakes Region World Heritage Area, Parks NSW and Mildura Primary School and independent contractors, from archaeologists to impact producers, who collectively have also provided the project with 5000 hours of pro-bono support.

Figure 2

Figure 3

Figure 4

Figure 5

LANDSCAPE CHANGE AND THE ARCHAEOLOGICAL RECORD IN THE WILLANDRA LAKES, NSW

Nathan Jankowski

INDIVIDUAL PROJECT

Duration: June 2021 – Ongoing (May 2024)

Institution: Centre for Archaeological Sciences, School of Earth, Atmospheric and Life Sciences, University of Wollongong

Discipline: Geomorphology, geochronology (DE210100157)

Researchers: The Investigators associated with this project are subdivided into two categories: Primary Investigators and Collaborators. Primary Investigators are directly involved in planning, directing, and undertaking research activities associated with this project. Collaborators are leading experts in their field of research and will help with the analyses and interpretation of results.

RESEARCH GOALS

Despite being inscribed onto the World Heritage List for both its archaeological and geological heritage values, the evidence for past environmental change preserved within the Willandra Lakes Region World Heritage Area has remained understudied. This DECRA project aims to build upon the enduring legacy of Professor Jim Bowler by bringing a new suite of modern dating methods and analytical techniques to locations beyond the shores of Lake Mungo within the Willandra. In doing so, our goal is to develop a palaeoenvironmental framework of landscape, lake-level and vegetation changes that occurred at key locations across the breadth of the Willandra. By generating this critical landscape information, we can then better understand the Willandra's extraordinary settlement history, stemming from the archaeological research that Associate Professor Nicola Stern and her colleagues have been doing as part of the Mungo Archaeology Project (see this volume).

The project's goal will be achieved by revisiting critical sites within two major lake basins, Mulurulu and Arumpo/Chibnalwood, at the top and the tail of the Willandra Lakes Region. Optical (sand grain) dating will be used to link together these landscapes in time to determine when critical environmental changes occurred. By understanding when changes occurred, it is possible to try and answer deeper questions such as how fast did the lakes fill and empty, how many times did this happen, and why these changes occurred. This project will also use a range of methods including: phytolith (plant crystal) analyses (see Molly Turnbull this volume), fish otolith (ear stone) studies (see Kelsie Long, this volume), ostracod (freshwater water flea) palaeoecology, sediment analyses and geological mapping. By the completion of this project we aim to be able to assess how the fluctuations in water availability throughout the Willandra Lakes Region influenced the way in which people lived on Country since time immemorial.

NAME	DISCIPLINE
Nathan Jankowski	Geology and geography, focusing on landscape change
Molly Turnbull	Archaeology, focusing on vegetation communities
Adrian Parker	Geography focusing on vegetation communities and landscape change.
Zenobia Jacobs	Archaeology, focusing on optical (sand grain) dating of sediments
Timothy Cohen	Geography, focusing on landscape change
Nicola Stern	Archaeology, focusing of landscape archaeology in open landscapes
Anna Florin	Archaeology, focusing on vegetation and plant food usage
Paul Goldberg	Geologist, focusing on microscopic studies of sediments
Jessica Reeves	Geography, focusing on fresh water crustacean ecology
Kelsie Long	Archaeology, focusing on freshwater fish records

Figure 1: Panorama image of study location at Top Hut Station, near the Mungo Youth Project camp site. This location is reported to chart the development of the Lake Arumpo lunette from more than 40,000 to about 20,000 years ago.

Figure 2: Panorama image of an eroded gully section through the northern end of the lunette at Mulurulu Station, Lake Mulurulu.

	INSTITUTION	ROLE
	University of Wollongong	Primary Investigator (Lead Researcher)
	University of Wollongong	Primary Investigator (PhD Student)
	Oxford Brookes University, UK	Primary Investigator (Co-supervisor of Molly Turnbull)
	University of Wollongong	Collaborator (Mentor for Nathan Jankowski)
	University of Wollongong	Collaborator (Co-supervisor of Molly Turnbull)
	La Trobe University	Collaborator (Co-supervisor of Molly Turnbull)
	Cambridge University, UK	Collaborator
	University of Wollongong	Collaborator
	Federation University	Collaborator
	Australian National University	Collaborator

KEY OBJECTIVES

1. Reconstruct past lake level, landscape and vegetation change within the Mulurulu and Arumpo/Chibnalwood basins.

2. Determine the physio-chemical conditions of the lake water within the Mulurulu and Arumpo/Chibnalwood basins using geochemical records locked within faunal remains (ostracod and otoliths).

3. Examine the ability of modern and ancient phytoliths to accurately record patterns of vegetation change

4. Examine modern erosion rates of critical landscape features in collaboration with the WLRWH Aboriginal Advisory Group.

5. Systematically date key palaeoenvironmental changes using optical (sand grain) and radiocarbon dating across the Willandra Lakes study sites.

6. Integrate the palaeoenvironmental records with the region's archaeological record to determine the extent to which past environmental change influenced the life-ways of people living in the Willandra.

KEY OUTCOMES

Although officially starting on the 1st June 2021, the COVID restrictions in place for much of 2021 in NSW meant that this project is yet to truly get underway. However, the Research Team has been able to achieve a number of positive outcomes in 2021 that will enable the research, particularly the field aspects, to quickly gain traction in 2022. These include:

- The co-development of guiding Research Design and Protocols with the WLRWH Aboriginal Advisory Group as per their Research Code of Practice;

- Approval of this project's Research Protocol by the University of Wollongong's Human Research Ethics Committee;

- The successful advertising and filling of the PhD position associated with this project by Ms Molly Turnbull who will investigate the past vegetation changes within the Willandra using phytoliths (plant crystals).

- Two field seasons were conducted in April and June 2022 with sediment and vegetation samples collected from key locations at Lake Arumpo and Lake Mulurulu.

Figure 3: Panorama image from within Long Waterhole Gully on located on the floor of Lake Arumpo on Top Hut Station. This site is important for being one of the only locations in the Willandra where lake bed sediments are exposed for us to record, as well as containing the remains of a shellfish midden considered to be older than about 36,000 years.

AN ASSESSMENT OF THE SUITABILITY OF PHYTOLITHS TO CHART PALAEOVEGETATION CHANGE WITHIN THE WILLANDRA LAKES REGION

Molly Turnbull

UNIVERSITY OF WOLLONGONG AUSTRALIA

INDIVIDUAL PROJECT

Research Project: Landscape change and the archaeological record in the Willandra Lakes, NSW (DE210100157)

Degree: PhD

Duration: August 2021 - Current

Institution: Centre for Archaeological Sciences, School of Earth, Atmospheric and Life Sciences, University of Wollongong

Discipline: Environmental Sciences

RESEARCH GOALS

The dynamics of past vegetation changes and their response to major climatic and environmental upheavals remains an aspect of scientific research yet to be fully realised within the Willandra Lakes Region World Heritage site (WLRWH). This PhD project, working alongside the overarching DECRA project conducted by Dr Nathan Jankowski (this volume), seeks to provide a highly detailed analysis of past vegetation and plant-use in the Willandra using phytoliths–the microscopic crystalline remains of plants found within the sediments. Phytoliths, meaning 'plant stones,' serve as a fingerprint of the long since vanished vegetation communities because their characteristic shape and size patterns (morphologies) are often unique to specific plant types. So, when preserved within the sediments, phytoliths allow us to identify these ancient plant communities and how they have changed through time.

This never before attempted research approach for the WLRWH site has two overarching goals:

1. To understand the vegetation histories of the Willandra using phytoliths sampled from lake floors, lunettes and aeolian dune features; and

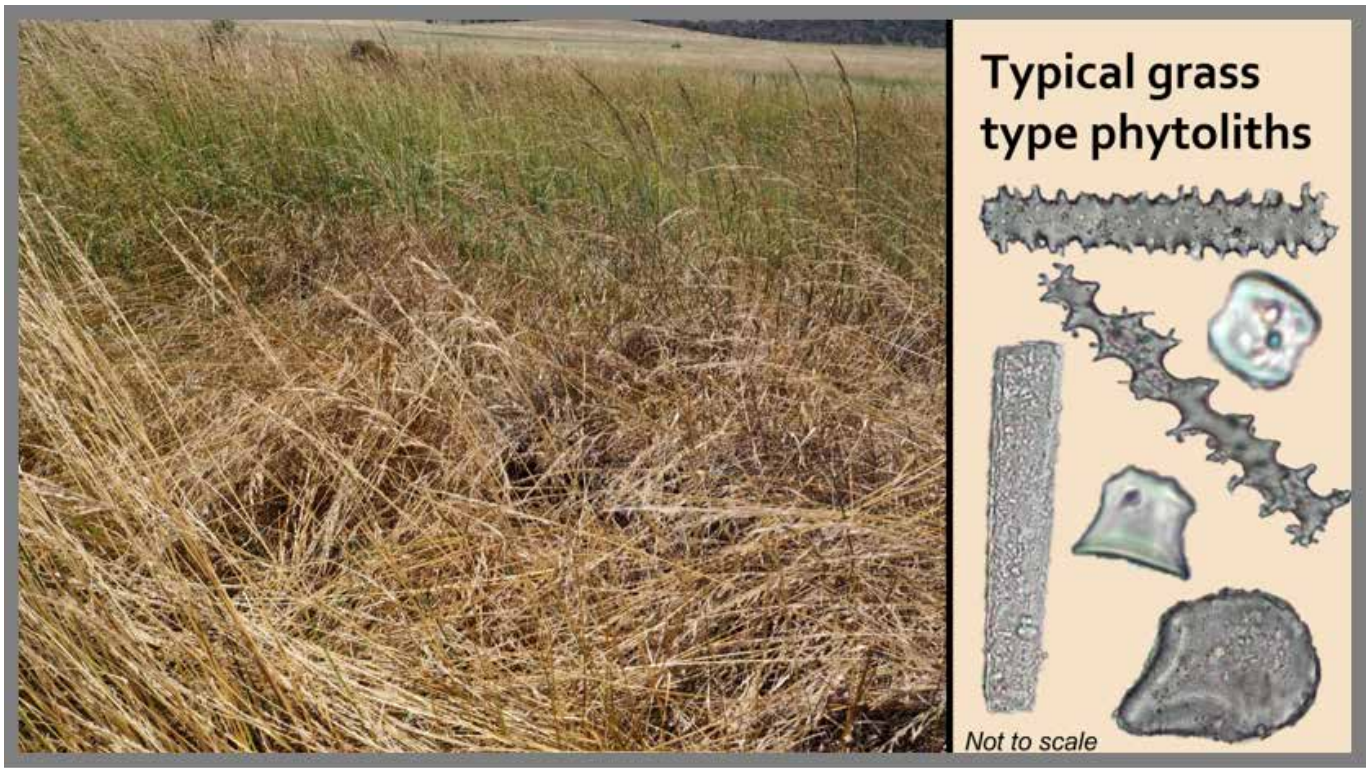
2. To investigate the wider landscape contexts of phytolith samples and the changing WLRWH landscape.

However, to make sense of the Willandra's ancient phytolith record requires that we first investigate and understand the phytolith morphologies produced by modern vegetation (see images of the phytoliths produced by grasses and trees). This outcome involves creating a modern reference collection using plants species that are significant to the people and environment of the Willandra and is equivalent to building up a library of fingerprints. The ability of this reference collection to accurately fingerprint past vegetation communities will first be tested on phytoliths obtained from modern surfaces samples from recorded vegetation communities within the Willandra, before being used to aid the identification of ancient phytolith remains. This research will then be integrated within the wider DECRA project's results, as well as the ongoing archaeological research by the Mungo Archaeology Project.

KEY OUTCOMES

Anticipated key outcomes from this PhD project include:

- Produce a modern phytolith reference collection based on the vegetation of WLRWH site, focusing on plants of ecological and cultural significance.
- This collection is to be stored On-Country and housed within the Willandra Lakes Research and Teaching Centre for future education and research purposes.
- Investigate the phytoliths of soils in modern vegetation communities in the WLRWH site.
- Collect, prepare and analyse ancient sediments collected from the WLRWH study areas.
- Interpret the phytoliths from ancient sediments to generate patterns of vegetation change through time.
- Examine landscape change and provide critical landscape details based on phytolith data.
- Combine these results into the wider WLRWH cultural and environmental records through time.
- The results produced will contribute to cultural and environmental knowledge and research, cultural tourism, public educational outreach, and Caring for Country policy.



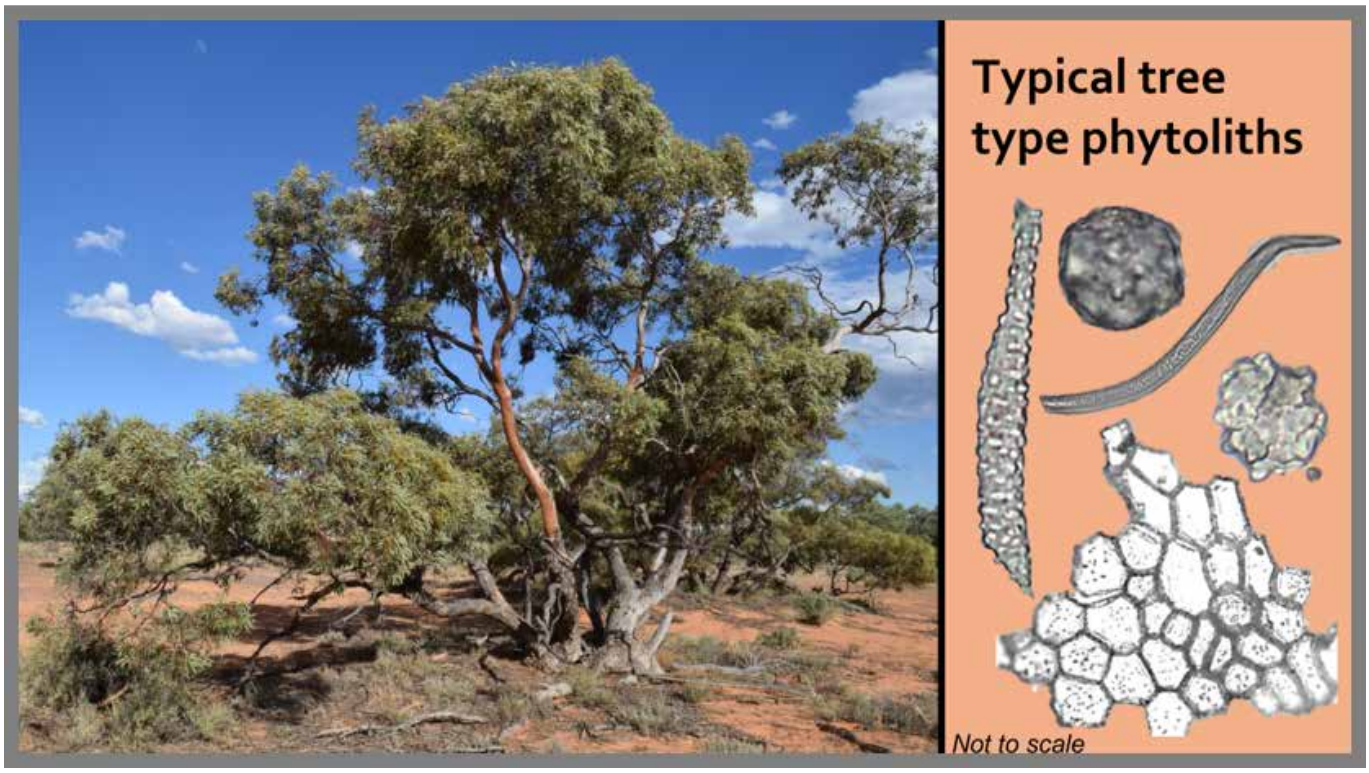


Figure 1: Plate of typical examples of phytoliths, the crystalline remains of plants found in the sediments, coming from grass (top plate) and tree (bottom plate) type species. The phytoliths are not shown at the same scale but are all less than or equal to the size of sand grains.

WOMEN ARTISTS RESIDENCY AT MUNGO

Liz O'Reily

INDIVIDUAL PROJECT

Project Title: Lakebed

Researchers and Artists: Sam Newstead, Barbara Nicholls, Natalie O'Connor, Sharron Ohlsen, Liz O'Reilly

Duration: 2015-ongoing

Institutions: Broken Hill Regional Art Gallery and Concordia Gallery Newington Sydney

Discipline: Visual Arts practices of Sculpture, Painting, Printmaking, Performance and Installation

RATIONALE

In February 2016, we asked The Willandra Lakes Region Aboriginal Advisory Group to give us permission for a one-month artists residency to take place in August 2016. This they gave to us willingly, but by necessity of life's unexpected storms and the actual weather, the residency took place in two parts, in August 2016 and March 2017.

Individually and as a group, the challenge artists Sam Newstead, Barbara Nicholls, Natalie O'Connor, Sharron Ohlsen and Liz O'Reilly took up, was to offer a narrative of the Willandra Lakes Region Heritage site beyond the obvious.

Unified in our respect for Aboriginal people as First Nations Peoples and custodians of the land, we consulted the Mungo community at each step of our project and continue to do so whenever we return or make artwork about our experiences at Mungo.

Two artists had been to Mungo before, some extensively researched its' archaeological significance before travelling, and yet others arrived in the landscape without prior investigation or preconception. With this project, the artists sought to excavate their own discoveries by immersing themselves in the landscape, their human interconnection occurring over multiple residencies.

As a group of exclusively women artists, to travel purposefully into the significant landscape of Mungo, was to activate an archive of equity in the traditions of plein air painting in Australia.

If major climactic changes can be seen not just as ice ages coming and going, but as shifts in philosophical temperatures and atmospheric changes to history, the implications are that we could see ourselves belonging in the Australian landscape differently. The south-westerly blowing winds that continue to shape the lunettes and dunes at Mungo might well uncover new discoveries, about ourselves, and reveal a change in mood as we contemplate connecting to the living world in a contemporary way.

BROKEN HILL REGIONAL ART GALLERY

CONCORDIA

Figure 1

Figure 2

Figure 3

Figure 4

KEY OUTCOMES

Warmly accommodated by the generous communities of Mungo and with the sharing of knowledge and stories, the artists were influenced and guided to an understanding that commits them to continual learning about this unique landscape.

Changes in working processes occurred as the environment dictated materiality with almost very artist altering aspects of their art practice dramatically; the use of gums leaves as canvas, layering and shifts in the framing of space; an almost forensic investigation into layers of colour, circular formats, multi-disciplinary creations, text-based and emotive responses to scale and memory inherent in the landscape.

lakebed is a body of work arising from this experience and understanding, and was shared in two major exhibitions, one at Broken Hill Regional Art Gallery and the other at Concordia Gallery Newington.

Artists Natalie O'Connor and Liz O'Reilly both have leadership roles in Education – directly within the Education system itself and through organisations such as the NSW Aboriginal Education Consultative Group and Hazelhurst Regional Gallery. At each exhibition Natalie and Liz have initiated, developed and delivered Public Programs that aim to actively engage the wider community in making their own connections to Lake Mungo and the Willandra Lakes Regional World Heritage area.

For some of the artists who participated in the residency, the changes experienced as a result have formed ongoing connections to Mungo and continue to fuel the search for new ways of expressing landscape, new ways of being and the deepening of respect for what has always been.

OUT AT MUNGO…THERE'S A MOMENT, AND IT DAWNS ON YOU, EXACTLY WHERE YOU ARE…DEEP INSIDE THE LAKEBED

PUBLICATION

Artists Profile Magazine Issue 41
Links
https://insites.newington.nsw.edu.au/concordiagallery/gallery/
https://newsletter.newington.nsw.edu.au/blackandwhite/newsletter/2018-10-30/print/
https://www.instagram.com/lakebed_exhibition/?hl=en

A DESICCATED GARDEN OF EDEN: IMAGING THE AUSTRALIAN LANDSCAPE THROUGH AN EXPANDED PHOTOGRAPHIC PRACTICE

Alice Duncan

INDIVIDUAL PROJECT

Degree: PhD

Duration: 2020 – July 2023

Institution: School of Art, RMIT University, Melbourne

Discipline: Fine Art and Visual Arts

RESEARCH GOALS

This practice-led research project utilises an expanded photographic practice to excavate the histories and possible narratives that surround contested sites and landscapes within Australia. As a white settler to Australia, acknowledging the historical use of the camera as a tool for documenting colonial narratives, my research seeks to disrupt photography's seemingly intrinsic ability to directly represent the Australian landscape. This research explores this through academic theories of haunting, erasure and colonial anxiety.

Specifically, my research focuses on the landscape of Lake Mungo - on the traditional lands of the Barkindji/Paakantyi, Mutthi Mutthi and Ngyiampaa people. Since the discovery and removal of ancient human remains in the 1960s, Lake Mungo has been the site of a tense and ongoing dialogue between Traditional Custodians and scientists. It is a conversation that connects Australia's recent past with a much deeper history. This work involves making site visits to Lake Mungo and creating photographs in situ as well as research into archival and historical visual material of Lake Mungo and the surrounding area.

More recently, my work utilises carbon - a material used by scientists to accurately measure time by determining the age of artefacts. Moving between digital, analogue and sculptural photographic practices, I draw parallels between both the use of carbon and photography as materials that address the past within the present Australian landscape. This research explores deep past as a living heritage and recognises the possibilities and responsibilities it generates.

KEY OUTCOMES

This research project will culminate in an exhibition of photographic works, as well as a published photobook and exegesis that contributes to dialogues around the role landscape images play in the construction of national identity within Australia. Specifically, the outcomes of this research include:

- Utilizing a combination of analogue and digital photographic techniques to produce a series of images that alter Colonial driven understandings of environment and place within an Australian context.
- To explore how an expanded photographic imaging techniques be utilised to create landscape photographs that are inclusive of collective identities.
- How can an exploration of carbon, within a photographic practice, articulate concepts of deep-time within the contemporary Australian landscape?

PUBLICATIONS

More images of my works can be found on my website: http://alicelduncan.com

The images created at Lake Mungo have also been published and exhibited both nationally and internationally, including:

The 2021 Aesthetica Art Prize at the York Gallery of Art in the UK:
https://aestheticamagazine.com/artprize/

The 2021 Blake Prize for Contemporary Art in Sydney:
https://www.casulapowerhouse.com/__data/assets/pdf_file/0008/204848/BlakePrize66th_web_02.pdf

The 2020 Sunshine Coast Art Prize in QLD:
https://gallery.sunshinecoast.qld.gov.au/Art-Prizes/Sunshine-Coast-Art-Prize/Previous-Winners/2020-Winners/Finalists-2020

RMIT UNIVERSITY

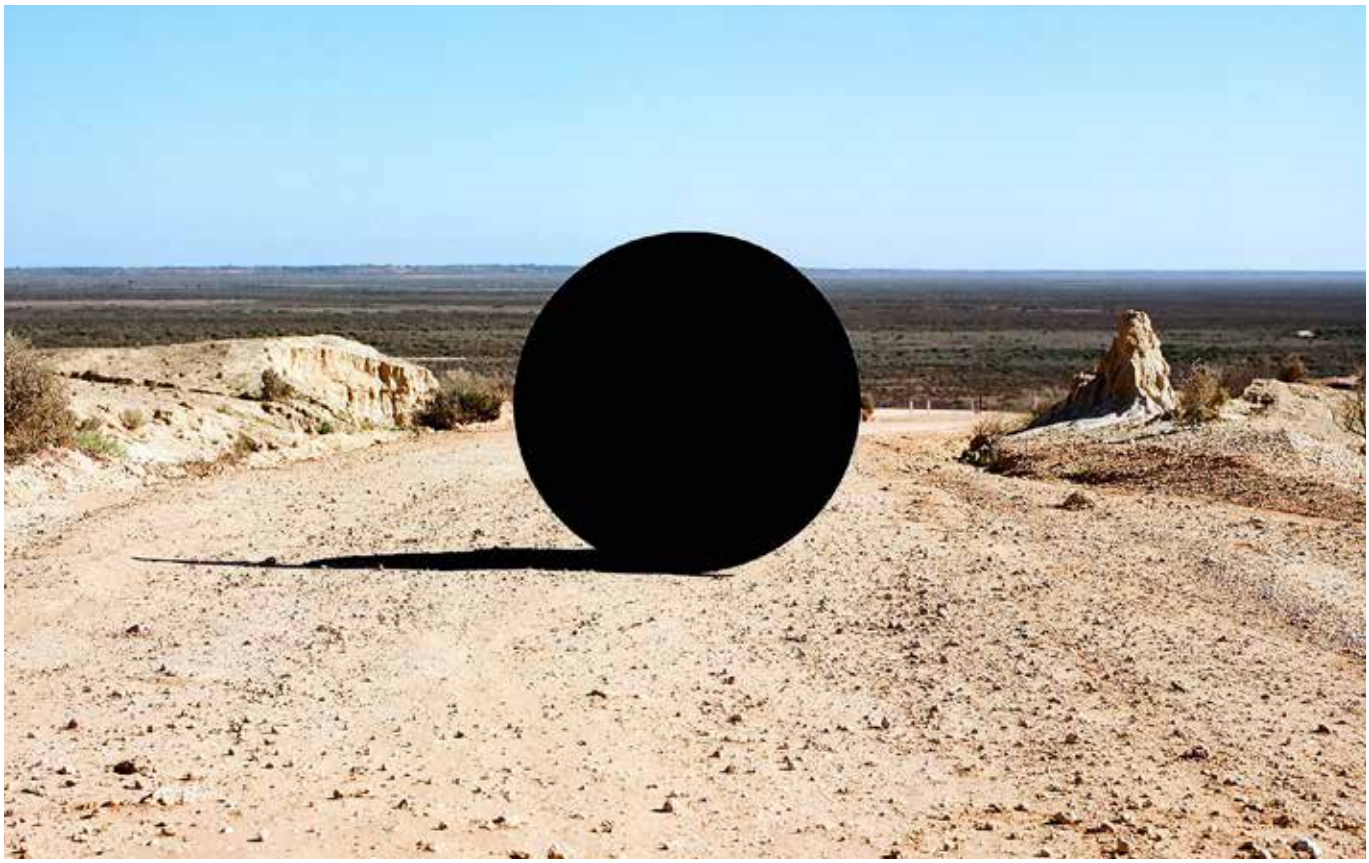


Figure 1

Figure 1

NATURE OF REDNESS

Natalie O'Connor

INDIVIDUAL PROJECT

Duration: 2014 - 2022

Institution: University of New South Wales

Discipline: Interdisciplinary/Visual Arts/Practice-based research

RESEARCH GOALS

My practice-based research and thesis examine material colour on the contemporary artists' palette and its transformation since the early nineteenth century. My work is centred on the English colourmaker George Field's standardisation of material colour and recontextualises his inherent qualities of pigments (Field, 1835). My interdisciplinary research asks: how can the study of red pigments offer a new understanding of material colour?

My original contribution to knowledge is a reframing of Field's inherent qualities of pigments to propose a new understanding of the contemporary artists' palette. I explore red pigments through a series of experimental installations and visual autoethnographic (Ellis & Adams, 2018) reflections documented through a website, #redresearch. These installations are observational studies that I began in response to my artist residency at Lake Mungo, NSW, where I experienced a 100,000-year-old red colour exposed in the deepest geological layer existing there. This red is the cornerstone of my comparative analysis of pigments as an exemplar of colour, examining the genealogy of red's nature, inherent qualities, behaviour and working properties as per the framework developed by Field.

My creative, reflective research (Candy, 2020) brings a fresh perspective to the characterisations of the artists' palette. It establishes a connection between Field's notebooks and our understanding of the palette today. Few accounts of Field's contribution to material colour exist in the literature. John Gage (1993) and Alexandra Loske (2019) provide primarily historical and biographical accounts. Instead, I discuss Field's ideas as relevant to art practitioners. Also, I discuss artists who have engaged with redness but through an approach that reduces colour to a tool (Bolt, 2007). My art practice takes a different approach as I re-engage with red pigments and argue that through a reframing of Field's inherent qualities of pigments, a deeper understanding of the locality, agency, materiality, and sensory nature of colour can be achieved.

To this end, my practice-based research directly engages and benefits art practitioners' approach to their palette as it exposes existing industry standards and considers new possibilities as artists engage with future colour innovations.

KEY OUTCOMES

This research directly benefits the painter as they are the users of artists colours. Still, there is an opportunity worthy of exploration to see if Field's characterisations relate to the experience of colour in the digital spectrum. Employing the subtleties of transparency/opacity, the beauty of colour (delicacy, pure, brilliant) or (deep, rich, and intense) may add nuances for a sensorial experience with the viewer. The characterisation of material colours can intersect and support a deeper understanding of the digital colour spectrum.

As my research engaged with a place, I explored ideas of the interconnectedness of colour and their nature. It led me to the unique environment of lake mungo, and this place asked questions of me. This place and its people challenged what I understand about the materiality of colour and made me consider other stories and beginnings. I had not heard these stories before because I was not listening. The Mungo community has shared many stories about red and different colours. These are not my stories to share; they are the stories of First Nations people. I hope my continuing commitment to making art with young people at Mungo will connect them with creative ways to tell their stories.

In closing, making art is often about looking back so that you can see how to move forward. I observed the red layer of the Gol Gol unit with my eyes but through the lens of a nineteenth-century colourmaker. I listened to the voices of the people at Mungo, but I could still hear the murmurs from the colourmaker.

I discovered that each red pigment is different, like the places I have travelled, and the people that I have met.

Finally, with the words of a dear friend and Mutthi Mutthi woman, 'we are all red inside.'

Figure 1: Experimenting with black and white paper and earth from the backyard at the Mungo Homestead.

Figure 2: Gol Gol Layer Colour Observation #3 was conducted at the Mungo Youth Project site. Looking at the colour comparison to the landscape of reds.

Figure 3: Gol Gol Layer Colour Observation #5.1 at Concordia Gallery, Newington College. 2018.

PUBLICATIONS

The following links highlight different times I have reflected on the connections of ideas and histories between my art practice and Mungo. There is a comprehensive account of the artworks GGLCO#5, 6 &7 on my website that has been hidden from public view until after consultation with the AAG and 3TTG. I will create live links during the consultation period but restrict them until all parties can view and recommend additions or deletions.

www.natalieoconnorartist.com

Go to #redresearch
Password is #RedResearch#21 (case sensitive)

The following links will take you to my journal that evidences my research journey and interactions with Mungo.

https://www.natalieoconnorartist.com/blog/colour-of-our-country

https://www.natalieoconnorartist.com/blog/sanguinemoon

https://www.natalieoconnorartist.com/blog/keeping-its-place

https://www.natalieoconnorartist.com/blog/gol-gol-layer-colour-observation-5-lakebed-concordia-gallery

https://youtu.be/HsNQQz5J-Ug
This video retells the process of my art practice called Gol Gol Layer Colour Observations (GGLCO). This video documents GGLCO#5 as part of the Lakebed exhibition that included five artists that travelled to Mungo for an art residency. The Lakebed project will be documented in a separate report.

UNSW
THE UNIVERSITY OF NEW SOUTH WALES

Figure 4: GGLCO #5 dry sate red pigments on paper after 2500 hours and GGLCO #6 wet state red pigments with paper in test tubes. Installation at the Hazelhurst Regional Gallery Art on Paper Award Finalist, 2019

Figure 5: Venetian Red Pigment on Paper after 2500 hours. GGLCO#5

ADVANCED 3D REALITY CAPTURE IN AREAS OF HUMAN EXPERIENCE AND INTERACTION

Chris Little

INDIVIDUAL PROJECT

Degree: PhD

Duration: 2015-current

Institution: Queensland College of Art, Griffith University

Discipline: Digital Design and Engineering

RESEARCH GOALS

Recent advances in technology present an opportunity to explore the effectiveness of the methods applied for capturing high-quality three-dimensional details of the Willandra Lakes Region Fossil Trackway site and expanding these conventional uses for 3D technologies to include new levels of visitor engagement. Defined as “turning a cold site into a warm site, this perspective is based in entertainment and distribution of knowledge (rather than scientific analysis) and as such, this research involves capitalising on the accuracy of the existing 3D data to develop visually interactive ways of enabling users to experience the history of the footprints and how they were created, thereby not only preserving the footprints, but also highlighting their cultural significance through the use of new technology to create immersive visitor experiences.

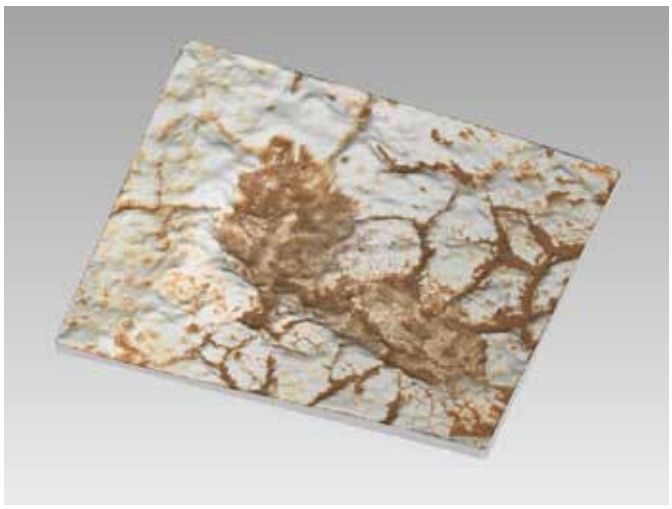


Figure 1

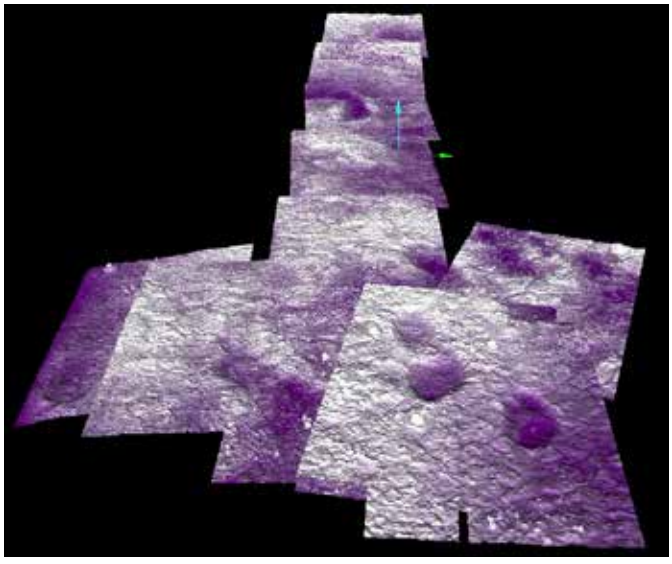


Figure 2

Figure 3

KEY OUTCOMES

1. 3D printed replica of footprints from the trackway site
2. Establish web-based viewer for analysis and teaching
3. Introduce and present post-processing workflows to Three Traditional Tribal Groups of the Willandra Lakes Region and Mungo Youth Project to provide professional development for Aboriginal students
4. Develop interactive augmented reality visitor experience using a mobile device to provide interesting information and accounts of the early Aboriginal stories surrounding the trackways

PUBLICATIONS

Little, C., Bec, A., Moyle, B. D., & Patterson, D. (2019). Innovative methods for heritage tourism experiences: creating windows into the past. Journal of Heritage Tourism, 1-13.

Bec, A., Moyle, B., Schaffer, V., Timms, K., Skavronskaya, L., Little, C. (2019). Management of immersive heritage tourism experiences: a conceptual model. Tourism Management, 72, 117-120.

Little, C., Patterson, D., Moyle, B., & Bec, A. (2018, January). Every footprint tells a story: 3D scanning of heritage artifacts as an interactive experience. In Proceedings of the Australasian Computer Science Week Multiconference (pp. 1-8).

Griffith UNIVERSITY

MICROSTRATIGRAPHIC INVESTIGATIONS ON MUNGO LUNETTE

Tim Denham

INDIVIDUAL PROJECT

Research Project: Landscape Archaeology at Lake Mungo with the Mungo Archaeological Project

Project Director: Tim Denham

Duration: 2012 – ongoing

Institution: Australian National University

Disciplines: Archaeology; Geoarchaeology

RESEARCH GOALS

I have been working on geoarchaeological projects on the Mungo Lunette since 2012, primarily supporting Nikki Stern's and co-workers investigations in the central portion of the lunette, as well as more recently working on previously collected materials from the Joulni portion of the lunette. Microstratigraphic investigations have entailed fieldwork and monolith sampling, with thin section microscopy and mineral mapping (using QEMSCAN©). The original intention of this research was to create three highly detailed 'local' stratigraphies for different parts of the lunette – essentially central-to-southern portions – which would enable more detailed histories of landscape formation, which in turn would provide more accurate environmental contexts for the interpretation of archaeological remains.

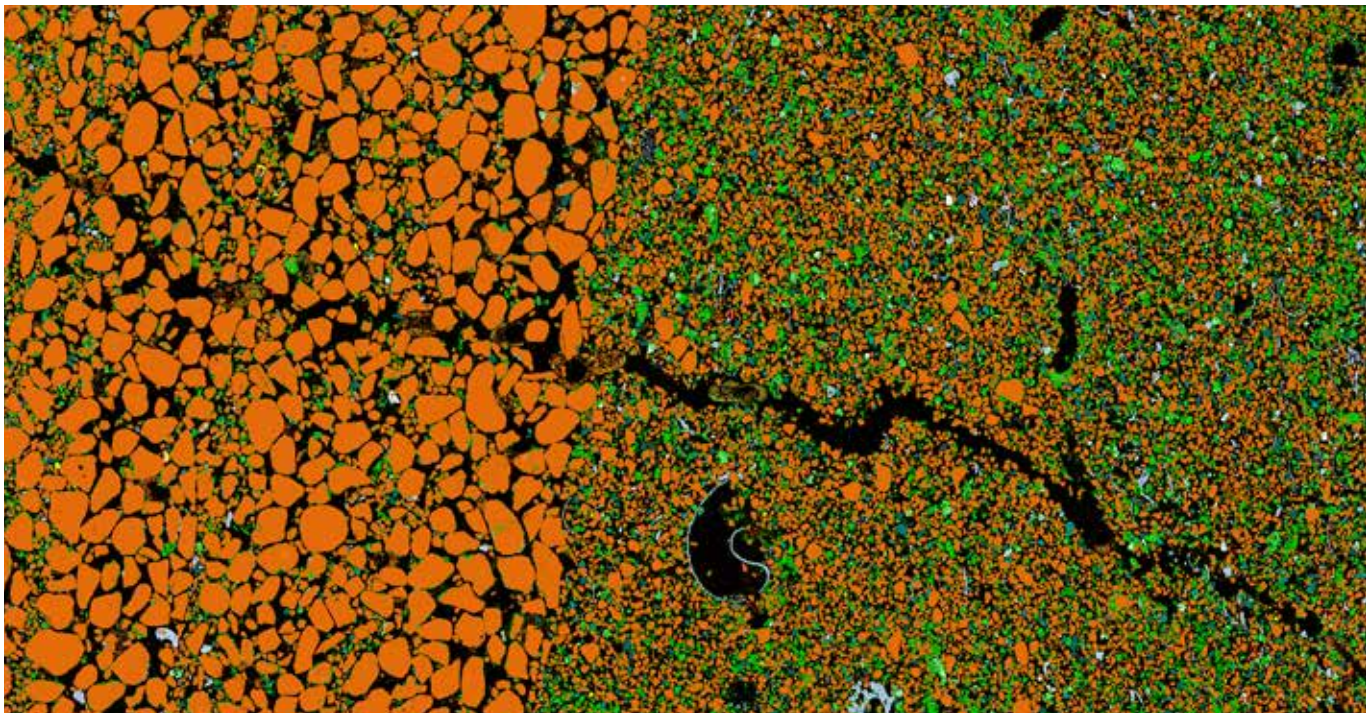


Figure 1

Figure 2: Photo credits - Tim Denham recording stratigraphy at Mungo Lunette (2013, photo: Louise Holt)

KEY OUTCOMES

Microstratigraphic investigations were undertaken in the Central portion of the lunette by research students – Emily Dillon and Lauren Prossor – for their respective Honours research theses:

Dillon, E. 2014. A geoarchaeological study of location 969660, Lake Mungo: a mixed method, multi-scalar approach to investigating human-environmental interactions. Unpublished Honours thesis (Archaeology), School of Archaeology and Anthropology, Australian National University.

Prossor, L.N. 2015. Lake Mungo Hearths: A multi-scale, mixed method geoarchaeological investigation of burning features at Lake Mungo, New South Wales (NSW), Australia. Unpublished Honours thesis (Archaeology), School of Archaeology and Anthropology, Australian National University.

Additional research is ongoing in terms of clarifying aspects of the geoarchaeological record of the central and southern portions of the lunette. Progress has been delayed by various factors, although hopefully additional results will be forthcoming shortly.

PUBLICATIONS

Publication Submitted: Prossor, L., T.P. Denham, F. Brink, U. Troitzsch and N. Stern. submitted. The microstratigraphic (thin section description and QEMSCAN®) investigation of hearth features at Lake Mungo, Australia. Journal of Archaeological Science : Reports.

Conference Talks

Denham, T.P., J. Bowler and E. Dillon. 2017. The geoarchaeology of Transects I and III, Joulni, Mungo Lunette, NSW. Australian Archaeological Association Conference, Melbourne (December)

Dillon, E., N. Stern and T.P. Denham. 2014. A question of scale: investigations of localised archaeostratigraphy on the Lake Mungo lunette. Australian Quaternary Association Conference, Mildura (June)

LEAGHUR, GARNPUNG, AND MULURULU SHELL MIDDENS AT THE AUSTRALIAN MUSEUM: A RE-ANALYSIS OF THE ALLEN (1972) ASSEMBLAGES

Patrick Faulkner, Annette Oertle

INDIVIDUAL PROJECT

Duration: 2018 – Current

Institutions: The University of Sydney; Max Planck Institute for the Science of Human History

Discipline: Archaeology

RESEARCH GOALS

Since the 1970s, shell deposits in the Willandra Lakes Region have featured prominently in discussions focused on the use of freshwater resources. Although faunal composition has been discussed in several prominent publications over the last 40 years or more, very little detail on the freshwater mussels recovered from these sites is currently available. This is particularly the case for abundance estimates of these molluscs, creating difficulties in the comparative analyses and robust assessment of the recovered terrestrial and freshwater fauna. As a result, there have been quite different interpretations of the role of freshwater resources in the diet, ranging from high economic importance, being part of a broad-spectrum diet, or being a supplement to terrestrial resources.

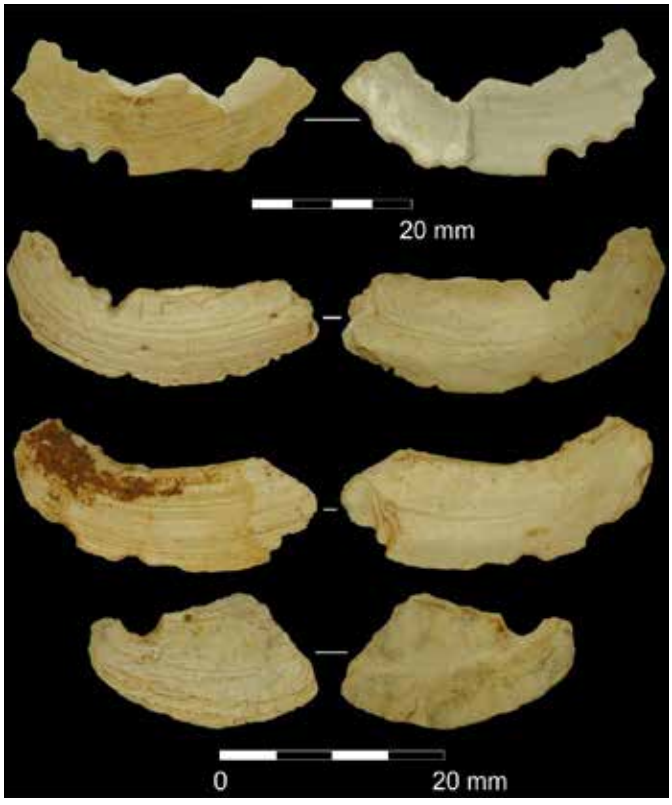


Figure 1

Seven sites located on Lakes Leaghur, Garnpung and Mulurulu, originally investigated by Harry Allen and discussed in his 1972 doctoral thesis, are currently housed by the Australian Museum in Sydney. As different aspects of the excavations and faunal compositions of these sites have been discussed over several decades, they were seen to provide an opportunity to evaluate the molluscan fauna in more detail. This is particularly the case when applying current archaeomalacological (the study of shell-fish in the archaeological record) methods in the recording and analyses of the freshwater molluscs. The goal of this project was to investigate whether further insights into comparative foraging strategies across the region could be gained when the freshwater molluscs are considered in greater detail relative to other dietary components.

KEY OUTCOMES

The key outcome of this research thus far is a preliminary scientific report submitted to the Aboriginal Advisory Group. A paper on the findings of this research is currently being prepared for publication based on these analyses, this will be co-authored by the Aboriginal Advisory Group, Patrick Faulkner, Annette Oertle and Harry Allen, and pending further consultation, submitted for review in late 2022.

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MAX PLANCK INSTITUTE

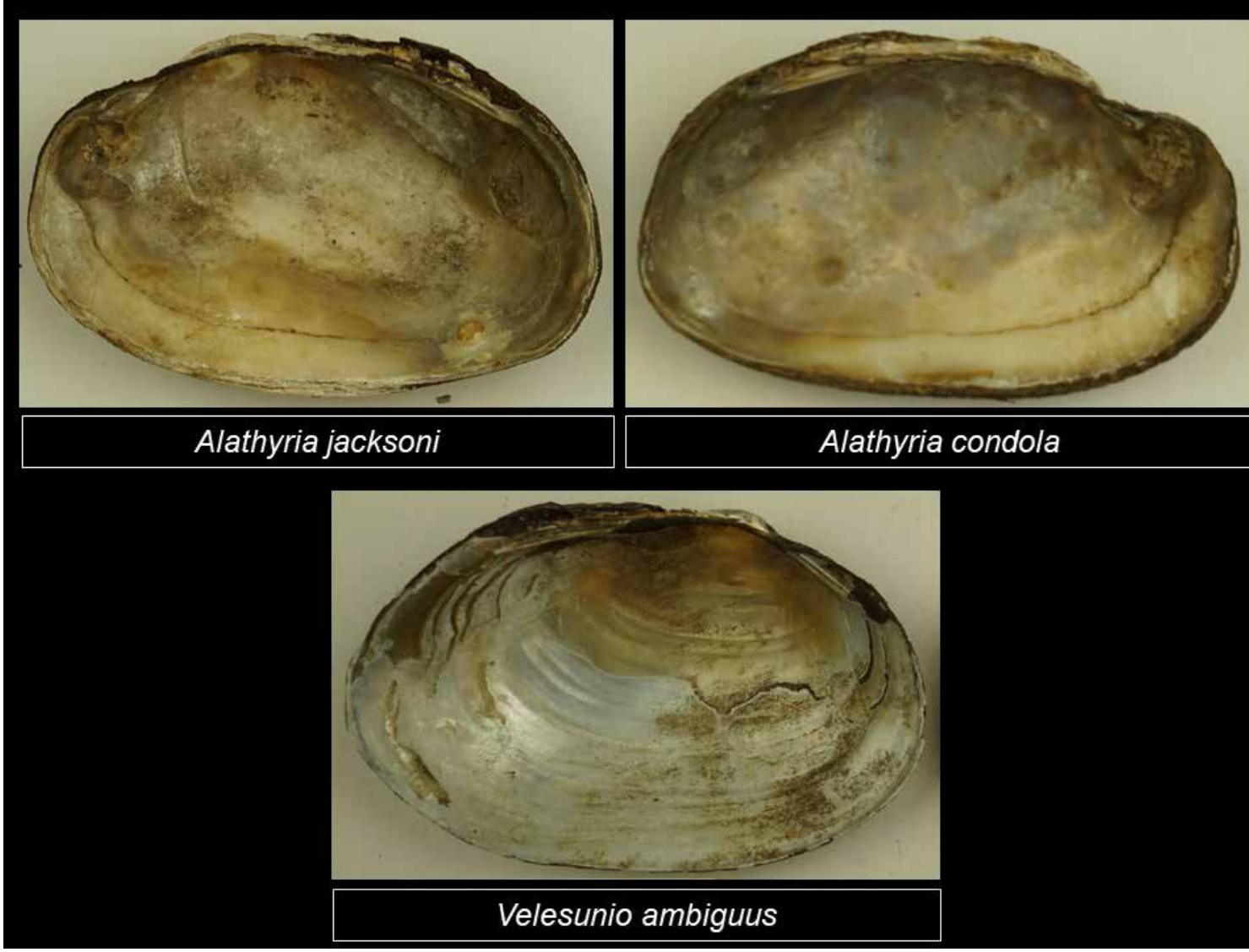

Figure 2

Figure 3

REFINING OUR UNDERSTANDING OF HUMAN-ENVIRONMENT INTERACTION VIA ARCHAEOLOGICAL GEOPHYSICAL INVESTIGATIONS

Aaron Fogel

INDIVIDUAL PROJECT

Degree: PhD

Duration: 2016 - ongoing

Institution: School of Environment, Griffith University

Department: Archaeology

RESEARCH GOALS

Despite a long history of research in the Willandra Lakes Region, the region has never been subject to a systematic assessment of the suitability and applicability of near surface geophysical methods (i.e. Ground Penetrating Radar, magnetic resistivity, magnetic susceptibility) for identifying buried cultural features or how these instruments may inform long-term management of tangible cultural resources.

My research has focused on the following questions:

1. Can geophysical methods identify buried cultural features?
2. Which geophysical methods are best suited for different types of buried cultural features?
3. How can geophysical methods be effectively included in long-term heritage management?
4. What are the ages of the sites investigated?
5. How does the artefact evidence relate to what is being recorded by current projects at Lake Mungo and existing knowledge for the Willandra Lakes region?

Several previously identified archaeological sites were selected due to perceived suitability for geophysical investigations. They cover a range of site types that are common to the Willandra Lakes Region and greater Australia to include shell middens, combustion features (hearths, earth ovens) and camps. These sites are located on varied landscape features, with differing soil types and are assumed to span several different climatological periods.

To meet the overall objectives of the investigation, a phased methodology was implemented to determine when geophysical investigations are appropriate and can assist with long-term heritage management in Australia. Following background research, geophysical survey was completed on numerous sites across the region. Select geophysical anomalies were then tested via traditional archaeological investigation methods.

Figure 1

Figure 2

KEY OUTCOMES

Investigations on Willandra Creek and at Lake Garnpang have successfully identified numerous Late Holocene (<5000 years old) buried archaeological features including the ability to discern hearths from earth ovens. Investigations in the Inter-lake area have successfully identified a 19,000 year old shell midden. The ca. 38,000 year old shell middens at Outer Arumpo have proved more elusive to successfully identify in geophysical survey. New techniques are being developed to identify how these small, discrete deposits can be located. Additionally, Ground Penetrating Radar (GPR) was tested at the Fossil Trackway site and successfully mapped the sediment that the footprints are in. Last, GPR capabilities and demonstrations have been presented to Mungo Youth Project attendees on two different occasions.

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Figure 3

THE NATURAL AND CULTURAL HISTORY OF THE DINGO: A 3D GEOMETRIC MORPHOMETRIC INVESTIGATION

Loukas Koungoulos

INDIVIDUAL PROJECT

Degree: PhD

Duration: 2018-2022

Institution: University of Sydney

Discipline: Archaeology

RESEARCH GOALS

The goal of my research was to utilise the unique collection of ancient dingo remains from the Willandra Lakes Region (and Lake Mungo in particular) to gain a greater understanding of the early history of Australia's native dog, including both in terms of natural and cultural history. I had a particular interest in the question of whether the dingo has changed in appearance during its time in Australia. This is partly because it is already known that there is variation in its skull shape and body size/weight throughout different areas of the country, suggesting adaptation had occurred over time. It is also possible that the tame dingoes living with First Nations peoples had different lifestyles and may have accordingly developed slightly different forms to their wild cousins.

The research aims were achieved through an osteological and morphometric study, with a focus on the application of 3D geometric morphometrics. This is a specialised modern methodological approach which uses coordinate-like landmarks to depict and mark out outlines of shapes on 3D computer models, which can then be compared and analysed directly. For this, I focused on the skull and mandible (lower jaw). In addition, I took 7 samples for radiocarbon dating. This was important as the sedimentary context of the dingoes implied they were of extreme antiquity (in excess of 20-24,000 years), but it was suspected they were considerably younger and actually intrusive to those layers.

The data collected from the Mungo dingoes was compared with a large data set gathered from hundreds of modern dingoes, as well as dogs from New Guinea and East Asia, wolves, and coyotes; in addition there were more detailed comparisons made with several dozen ancient "fossil" dingoes found in cave sites throughout southern Australia (WA, SA, NSW and VIC), and many others from archaeological sites.

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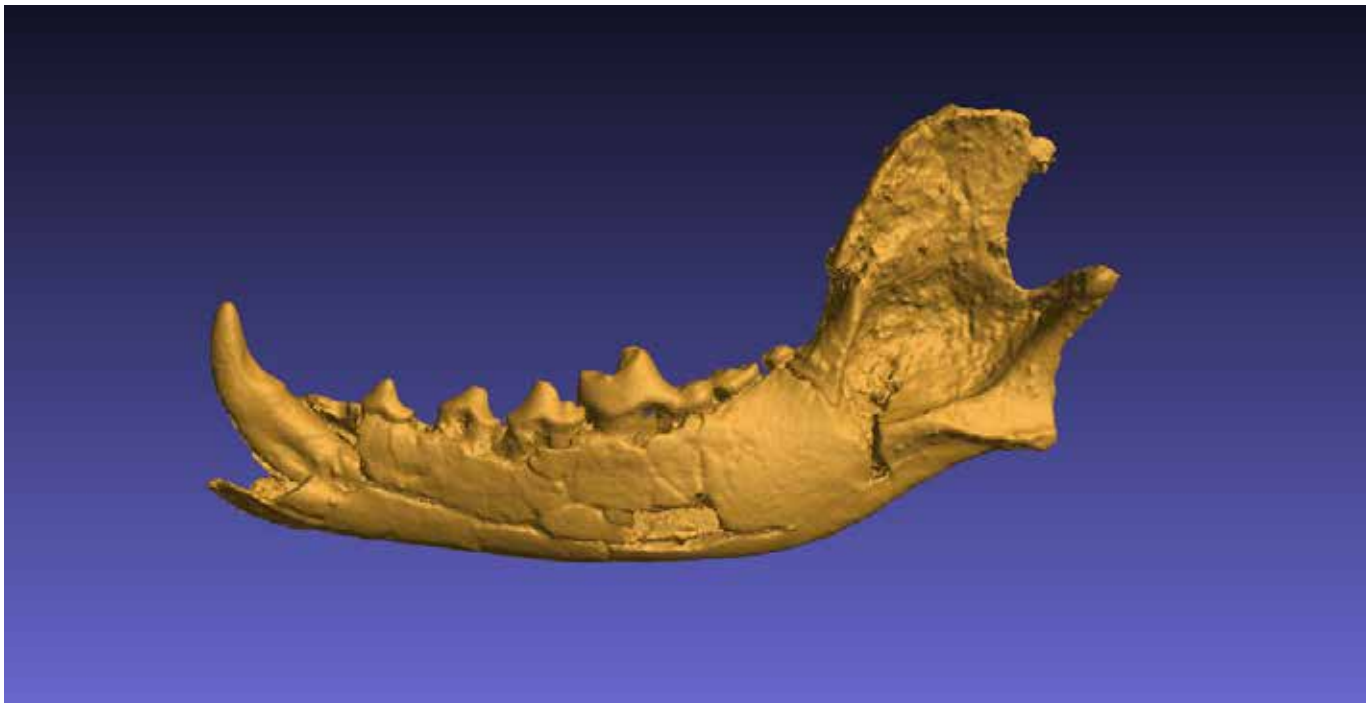

Figure 1: Ancient dingo skull from Lake Mungo during 3D scanning setup

KEY OUTCOMES

AMS radiocarbon dates on remains of two dingoes were obtained, these being the 2nd and 4th oldest in Australian respectively for the species. In addition, it was discovered that these dingoes were unusually small despite being adults, suggesting that early members of the species in Australia were closer in size to contemporary Southeast Asian dogs, and have since increased in size (during the last 3000 years at least). Another undated specimen from a burrow dug into Pleistocene layers on the South Mungo lunette exhibited a radically different cranial morphology to both modern and ancient dingoes with greater similarity to contemporary New Guinean and East Asian dogs. It was suggested that this individual belonged to an older, local variety of dingo which became extinct. As all dingoes studied derive from natural depositions rather than deliberate burials, they are assumed to be of wild origin and their unusual appearance could not be linked to direct human influence such as domestication.

PUBLICATION

One draft manuscript is currently in preparation for submission to an international journal, which focuses on the above described Key Outcomes.

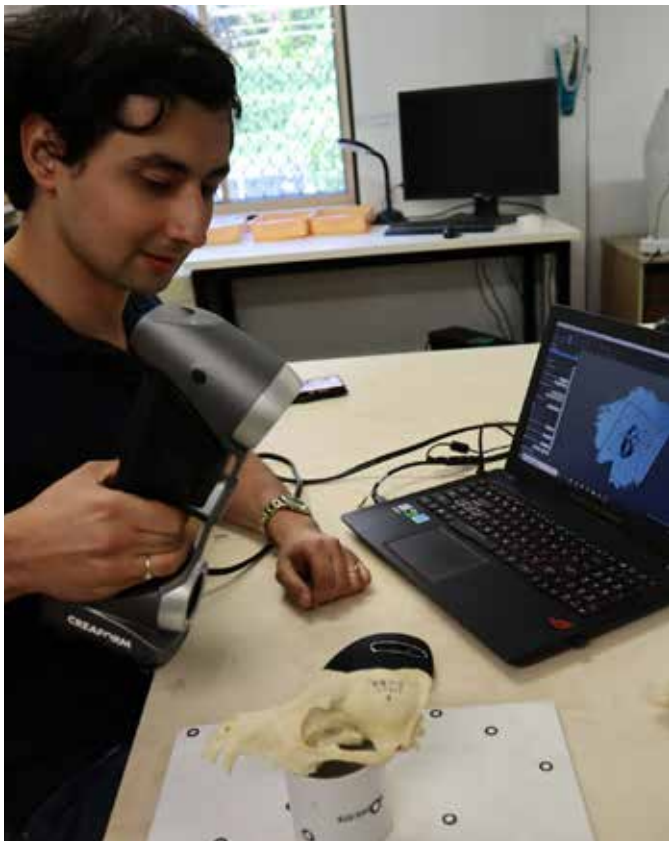

Figure 2: Scanning a New Guinea Singing Dog skull for comparison

A GENOMIC HISTORY OF ABORIGINAL AUSTRALIA

David Lambert

INDIVIDUAL PROJECT

Researchers: Prof David Lambert and Dr Sankar Subramanian

Duration: 2014 - current

Institutions: The Australian Research Centre for Human Evolution (ARCHE), Griffith University and University of the Sunshine Coast

Discipline: Ancient and modern genomics

RESEARCH GOALS

In 2001 a group of Australian researchers (Adcock et al. 2001) reported the recovery of short mitochondrial DNA sequences from a number of ancient Australians, including the 42,000 years old Mungo Man. This landmark study suggested that an early modern human mitochondrial lineage emerged in Asia and that the theory of modern human origins and their relationship to Aboriginal Australians needed to be re-evaluated. The goal was to check these results given our suspicion that contamination of the original samples was a strong possibility. We also considered it unlikely that Mungo Man was a member of an ancient people who predated Aboriginal Australians. Our manuscript was important, because the research was planned, conducted and published with the support of First Nations Australians.

A second goal of this work was to recover, for the first time, complete nuclear DNA sequences from a large number of tissue samples from modern Aboriginal Australians, as well as similar samples from Indigenous people from Papua New Guinea. We aimed to work with as many First Nations communities across Australia as possible to collect such samples and to publish the results of this research with First Nations communities. The resulting publication (Malaspinas et al, 2016) was the first study to report the complete nuclear genomes of a large number of First Nations Australians. This enabled a new level of understanding of the relationships among people from different language groups.

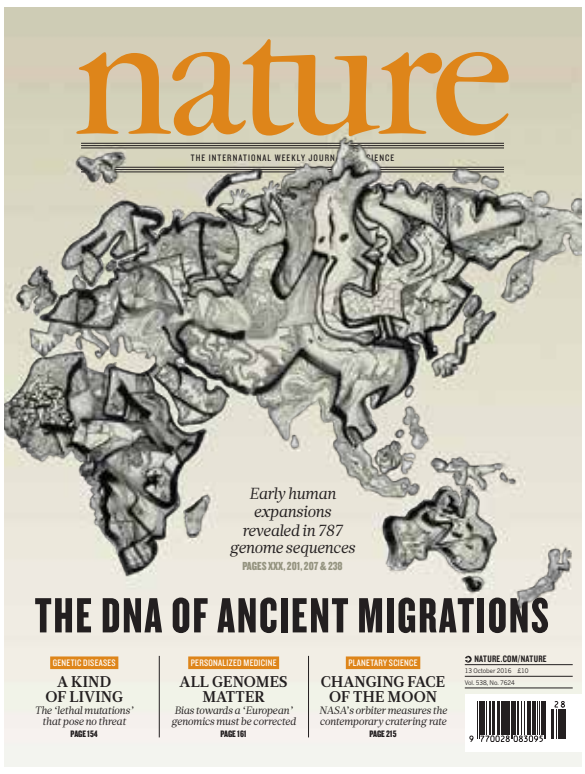

Figure 1

Figure 2

KEY OUTCOMES

In 2016 we published two high profile research papers on this topic. The first disproved the previous report by Adcock et al. (2001) suggesting that Mungo Man belonged to an earlier group who predated Aboriginal Australians. We showed that the DNA recovered from Mungo Man was due to contamination by the researchers. However, in the same publication, and using new DNA methods, we were the first researchers to recover a complete authentic mitochondrial genome from another ancient First Nations man known as Willandra Lakes Hominid 4 (WLH4). WLH4 is highly significant because he was buried a very long time after Mungo Man, but only a few hundred meters from him. The second publication, in the journal Nature, reported 83 complete nuclear genomes of contemporary First Nations peoples from throughout Australia and from Papua New Guinea. Our paper was ranked by the international journal Science as one of the top 10 scientific publications worldwide of 2016.

Recently, in 2022 we have been awarded a substantial Australian Research Council (ARC) Discovery research grant of $430,182 to extend this research. In preparation for this research we have also been awarded an Aboriginal Heritage Impact Permit (AHIP) from the New South Wales government. This is required for any destructive sampling of ancient remains. The AHIP will enable the removal of a tooth from the lower jaw and provide an opportunity to sequence genetic material from Mungo Man. In addition, the research funding will also enable us to determine the radiocarbon age of WLH4.

PUBLICATIONS

https://experts.griffith.edu.au/18641-david-lambert/publications

https://theconversation.com/new-dna-study-confirms-ancient-aborigines-were-the-first-australians-60616

https://theconversation.com/dna-from-ancient-aboriginal-australian-remains-enables-their-return-to-country-108168

https://theconversation.com/ancient-dna-sheds-light-on-the-origin-of-europeans-33907

https://theconversation.com/the-dreamtime-science-and-narratives-of-indigenous-australia-95919

https://www.science.org/doi/full/10.1126/sciadv.aau5064

https://www.nature.com/articles/nature18299? zeitraum=30 &suchbegriff=&ascdesc=DESC&sortierung=date&offset=125&i =113136&facelift=true&addUrlParams=true

https://www.frontiersin.org/articles/10.3389/fevo.2020.00217/full

https://www.science.org/doi/full/10.1126/science.1211177

https://link.springer.com/referenceworkentry/10.1007%2F978-1-4419-0465-2_667

https://academic.oup.com/gbe/article/4/11/1127/553973?login=true

https://onlinelibrary.wiley.com/doi/full/10.1002/arco.5207

https://academic.oup.com/mbe/article/35/3/623/4705837?login=true

https://www.science.org/doi/full/10.1126/science.aat3628

https://www.tandfonline.com/doi/full/10.1080/00438243.2019.1683466

https://www.nature.com/articles/463739a

REPATRIATION OF ANCIENT ABORIGINAL AUSTRALIANS

David Lambert

INDIVIDUAL PROJECT

Researchers/Investigators: Prof David Lambert[1], Dr Ehsan Sanaei Griffith[1], Dr Sankar Subramanian[2] and Dr Manoharan Kumar[2].
[1] Australian Research Centre for Human Evolution, Griffith University, [2] University of Sunshine Coast.

Year Commenced: 2016

Year Completed: Still current

Institution: The Australian Research Centre for Human Evolution (ARCHE), Griffith University

Disciplines: Ancient and modern genomics

RESEARCH GOALS

The term repatriation is used in diverse contexts. It can refer to the act of returning items, goods, 'cultural material' or human remains to their original communities. Historically a large number of human remains were taken from Indigenous communities worldwide. These were either curiosities or were intended for museum and private collections. Over the last 30 years, there has been a growing movement amongst First Nations people from colonised nations to demand the return of such remains to their original Place and Country. In addition, over the same period, there have been pressures on institutions – international, governmental bodies, museums - to agree to such returns. However, in many cases the geographic origins of such remains are simply unknown due to poor or absence of any documentation of the location it was taken from. This problem can potentially be resolved using a range of methods including strontium, craniometric methods, and stable isotope signatures. However, ancient and modern DNA diversity has proved to be the most accurate and reliable technique available. Our current research is focused on the development of these methods to achieve the identification of Aboriginal Australian ancient remains that are held in institutions, but without any significant provenance details.

Members of the Three Traditional Tribal Groups (3TTG) of the Willandra Lakes Region have supported this research by providing their DNA to assist in the determination of the provenance of stolen remains that are still held in institutions. The remains comprising the Willandra Ancestral Collection, are important because their provenance is known. Such positive controls are important to the success of this research program because they enable the construction of a 'genomic map' of contemporary Aboriginal Australia which in turn, enables us to identify the origin of these ancient remains.

Figure 1

KEY OUTCOMES

In 2018 this research team published details of an ancient DNA method that shows substantial promise with regard to the identification of the geographic origins of ancient Aboriginal Australian skeletal remains. The remains that were examined in that study were aged up to 1540 years before the present. With the assistance of Indigenous communities including the Willandra Tribal Groups who kindly provided saliva samples for DNA analysis, we compared the ancient genomic sequences to those from 100 high-coverage contemporary Aboriginal Australian genomes whose provenance was precisely known (Wright et al., 2018). We were able to show that each of the ancient remains were closely related to a set of modern DNA sequences whose locations had previously been accurately determined. This success was possible given that we were able to show that there were strong genetic affinities between ancient and contemporary Aboriginal Australian individuals from the same geographic location. The above work has provided a basis for a possible genetic comparison of WLH4 who was buried in the vicinity of Mungo Man (WLH3), potentially several thousands of years later.

Following the support from the Willandra Tribal groups, the Queensland Museum has now granted us access to remains held by the museum and whose provenance have been unable to be determined using available methods and approaches. Working with Mr Dany Williams Manager, Repatriation, Queensland Museum we are now recovering nuclear sequences from the remains of these ancient people. We will then compare those sequences to a large database of genomes we have sequenced from Aboriginal Australians living today. This database now comprises ~200 genomes of people from the Western Desert to Cape York, the Gulf of Carpentaria and Victoria. Our aspiration is that these studies will enable us to assist the museum to return many of these remains to their Place and Country. We are not unaware also that this such studies can be used to identify the origins of members of the Stolen Generation, and we are currently working to progress such research. Early studies of Aboriginal Australians who are not aware of the ancestry, have suggested that, in some cases at least, it is possible to identify their likely origins. A larger scale study of this kind has now begun.

Figure 4

An important outcome of all the above research has been the establishment of an Aboriginal Advisory Board which will oversee our research in relation to Indigenous people. Prof Cindy Shannon Pro Vice Chancellor Indigenous at Griffith University has kindly agreed to Chair the Board. Others have now agreed to be members of the Board including Elders from tribal groups across Australia.

PUBLICATIONS

https://www.science.org/doi/full/10.1126/sciadv.aau5064

https://www.nature.com/articles/nature18299?zeitraum=30&suchbegriff=&ascdesc=DESC&sortierung=date&offset=125&i=113136&facelift=true&addUrlParams=true

https://www.frontiersin.org/articles/10.3389/fevo.2020.00217/full

https://www.science.org/doi/full/10.1126/science.1211177

https://link.springer.com/referenceworkentry/10.1007%2F978-1-4419-0465-2_667

https://academic.oup.com/gbe/article/4/11/1127/553973?login=true

https://onlinelibrary.wiley.com/doi/full/10.1002/arco.5207

https://academic.oup.com/mbe/article/35/3/623/4705837?login=true

https://www.science.org/doi/full/10.1126/science.aat3628

https://www.tandfonline.com/doi/full/10.1080/00438243.2019.1683466

https://www.nature.com/articles/463739a

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AUSTRALIA'S LIVING TECHNOLOGIES: BONE TOOLS FROM FIRST PEOPLES TO CONTACT –

Dr Michelle Langley

INDIVIDUAL PROJECT

Duration: 2017-ongoing

Institution: Australian Research Centre for Human Evolution, Griffith University. Research carried out as part of ARC DECRA to Michelle Langley with the Mungo Archaeological Project.

Discipline: Archaeology

RESEARCH GOALS

Brief mentions have been made in the archaeological literature of discoveries of bone points at Willandra Lakes Region, though the only details available on these finds are included in Clark's (1987) unpublished report (details provided by the MAP team for this proposal):

- Around 10 sharpened bone points were collected from lake edge sites at Mulurulu, Garnpang and Mungo
- Only two previously reported — bi-point from Mungo 1 and broken tip from Lake Mulurulu
- GG-16 bi-point at Garnpung pre-dates 10,000 B.P. (published in Mulvaney 1975)
- Lake Mungo shorter bi-point pre-dates 22,000 B.P. (published in Mulvaney 1975)
- GG-19 much smaller point collected from shell midden horizon dating to 32,100 B.P.
    - found in blowout on W shoreline of Garnpang
    - one end ground to point, the other scraped to cutting edge
    - similar to hafted spear barb recorded at Wyrie Swamp, S.A. (published in Flood 1983)

All of these points are reported to be made on macropod long bone with the exception of two which appear to be human fibula — one from WOC-1 and another from the Lake Mungo visitor area. On these, the internal and external morphology match that of human fibula, and the point from visitor area displays abrasion marks and smoothing of surface features along sharpened end.

Taking a closer look at the points made on macropod bone — identifying any use wear present, traces of manufacture, and describing their morphology (cross-sections, length, width, depth) in detail will allow me to understand how they compare and contrast to similar artefacts found in the surrounding region and further afield. Given the importance of the Willandra Lakes Region for Australian prehistory, including the bone technology of this area is important for building a comprehensive understanding of Australia's diverse technologies and the people who made them.

Having been given permission by the AAG to study the bone points found across Willandra Lakes thus far, two bone points held at Lake Mungo were examined and recorded in 2018. Examination of other artefacts have not yet occurred as the collection was transferred from the Australian National University to The Australian Museum in Sydney. With travel interstate and access to museums becoming possible again, I hope to continue this work, delivering a full report to the AAG.

Figure 1

Figure 2

KEY OUTCOMES

With the analysis continuing at some point in the future (when the museum collections are available for study once again), at this time the only outcome known is that the long bone artefact found at Lake Garnpung GG-16 appears to be a 'nose bone' similar in morphology to those found in the wider Desert region of the Australian continent. If the date (10,000 BP) is correct, this is a significant item of personal adornment for understanding past ornamentation traditions in this part of the world.

PUBLICATION

Thus far we have not produced any publication on the bone technology found in Willandra Lakes Region, but hope to do so with the collaboration and permission of the Traditional Owners down the track.

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PRESERVATION OF THE WILLANDRA LAKES WHA ANCIENT TRACKWAYS SITE

Colin Macgregor

INDIVIDUAL PROJECT

Duration: 2021-2022

Institution: Australian Museum, Sydney (honorary)

Discipline: Archaeological Conservation

RESEARCH GOALS

Increase understanding within the international conservation community of the preservation of the Fossil Trackway site and the pivotal role of the Traditional Owners in the decision-making process around its conservation and presentation.

KEY OUTCOMES

Present the preservation of the Ancient Trackways to a global conservation audience, highlighting the fragile nature of the site and the involvement of all stakeholders in deciding to rebury the site.

Highlight to an international audience the consultation process with the Thee Traditional Tribal Groups of the area and the factors considered when compiling the Site Management Plan in 2006.

Describe the latex moulding and photogrammetry and scanning work used to record and replicate the site.

Discuss possible future plans for the interpretation of the site.

Increase international understanding of the collaboration between First Nations communities and scientists in archaeological projects in Australia.

PUBLICATIONS

MacGregor. 2022. Preserving the ancient human trackway site in the Willandra Lakes World Heritage Area. Studies in Conservation 67, sup 1: 150-155.

Presentation to be delivered at the International Institute of Conservation Congress in Wellington, NZ in September 2022. Online video of presentation to be accessible for wider global audience.

AUSTRALIAN MUSEUM

Figure 1

PLANT FOODS AT LAKE MUNGO

Anna Florin

INDIVIDUAL PROJECT

Duration: 2022 – ongoing

Institutions: St John's College, Cambridge; McDonald Institute for Archaeological Research, University of Cambridge; Australian Research Council Centre of Excellence for Australian Biodiversity and Heritage, University of Wollongong

Disciplines: Archaeology, archaeobotany, ethnobotany

RESEARCH GOALS

This research aims to intertwine the Traditional Ecological Knowledge of the Barkindji/Pakaantyi, Mutthi Mutthi and Ngiyampaa Nations and archaeological science to investigate how Aboriginal communities living at Lake Mungo used plant foods to adapt to shifting lake and climatic conditions through the Last Glacial Maximum cycle, ~42–16,000 years ago. It incorporates two research methods to achieve this:

1. Archaeobotanical research: the analysis of charred plant macrofossils preserved within ancient hearths; and,

2. Ethnobotanical research and plant reference collection: the discussion, collection and preparation of plant foods from similar environments today with the Three Traditional Tribal Groups.

The archaeobotanical research will focus on a series of 11 hearths from the Last Glacial Maximum cycle, already excavated as part of the Mungo Archaeological Project (see Stern this volume). These hearths offer a glimpse of life on the lake's edge during a period of increasing aridity, fluctuating lake levels and lake drying. Using microscopy to compare the shape and cell structure of charred plant macrofossils to modern plants, this research will identify plant food scraps preserved within these hearths. This will provide evidence for changes in past plant food use, cooking practices and landscape use practiced at Lake Mungo during the Last Glacial Maximum cycle.

The ethnobotanical research and plant reference collection will focus on the collection and preparation of a range of traditional plant foods in ecological communities likely to be present at Lake Mungo in the past. This research has been designed in collaboration with the Aboriginal Advisory Group to record Traditional Ecological Knowledge, and to allow for the inter-generational transfer of this knowledge. The plant reference collection produced by this research will allow for the identification of the archaeological plant macrofossils, and the Traditional Ecological Knowledge will allow for the interpretation of past Aboriginal lifestyles that left behind these remains.

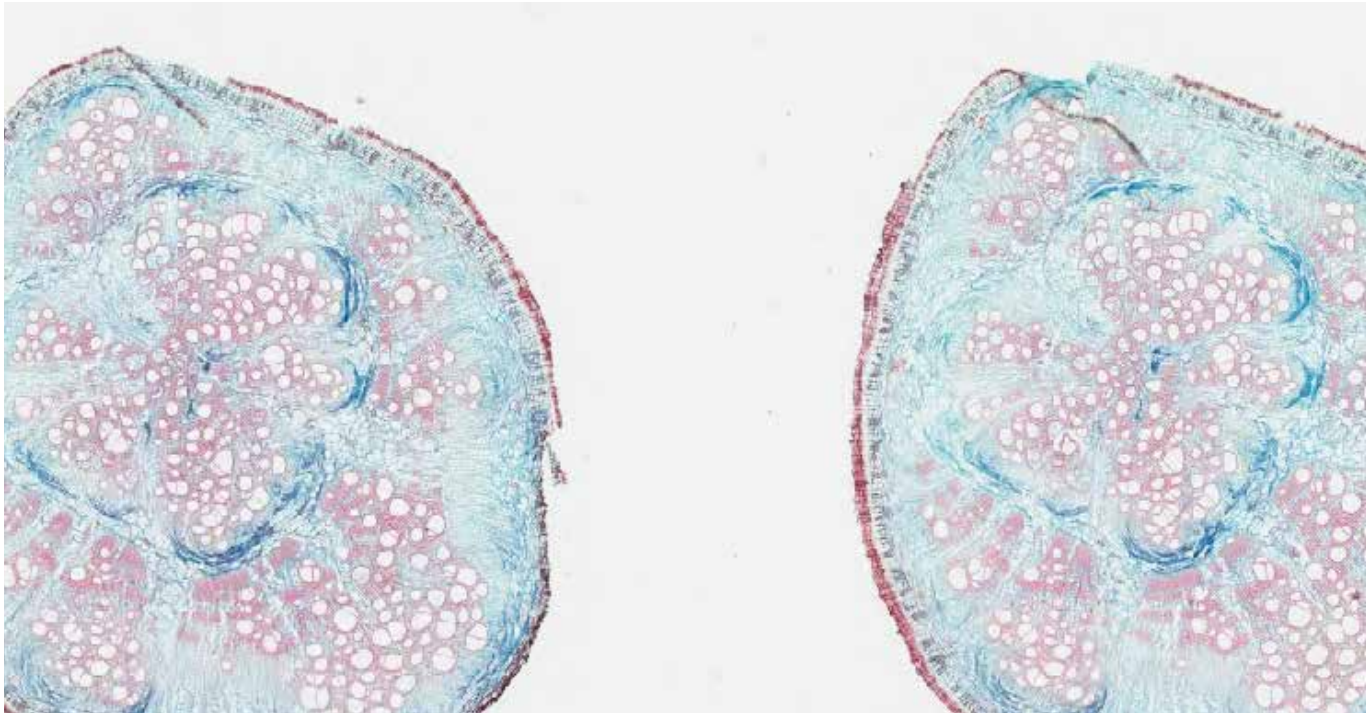

Figure 1: Thin section of a tuber

Figure 2: Photo of eroding hearth on Lake Mungo lunette (Hearth 386). Photo: Rudy Frank, Mungo Archaeology Project.

KEY OUTCOMES

This project will enable an Aboriginal and archaeological story of past plant and landscape use to be told for the Lake Mungo lunette, centring the Barkindji/Pakaantyi, Mutthi Mutthi and Ngiyampaa peoples' ongoing connection to Country and Traditional Ecological Knowledge. It will add to our knowledge of the archaeology of Lake Mungo lunette, and will produce a more detailed picture of past plant foods and human-environment interaction at the edge of the Australian arid zone. The research will also document Traditional Ecological Knowledge and provide on-Country employment for members of the Three Traditional Tribal Groups. By employing both knowledge holders and younger members of the Three Traditional Tribal Groups this project will facilitate inter-generational transfer of knowledge about plant foods. The data produced by the modern plant collection and ethnobotanical component of this project will also produce a plant reference collection key to future archaeological and palaeoenvironmental research in this region.

PUBLICATIONS

As the project has not yet commenced there are no publications or other outputs.

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AUSTRALIAN RESEARCH COUNCIL
Centre of Excellence for Australian Biodiversity and Heritage

MITOCHONDRIAL DNA DIVERSITY IN ABORIGINAL AUSTRALIANS

Sheila van Holst Pellekaan

INDIVIDUAL PROJECT

Duration: 1992-2014 however with ongoing evaluation of published genetic studies

Institutions: School of Biological Sciences & Faculty of Nursing, University of Sydney and BABS (Biotechnology & Biological Sciences), University of New South Wales.

Disciplines: Anthropology/Archaeology, Population Genetics

RESEARCH GOALS

The purpose of this contribution is to show how currently available maternally inherited mitochondrial DNA (mtDNA) genetic data can validly be used to shed light on the demographic connections of First Nations descendants within the local and broader Australian continent.

The aim of this report is to provide a summary of the currently available mitochondrial DNA (mtDNA) evidence for First Nations families, men and women, of Willandra and Darling River communities and in some other First Nations participants across Australia. Although this evidence is powerful for exploring local and regional maternal relationships, the studied numbers are not large enough to form highly informative population databases. Information and understandings

about an individual's ancestral geographic or group affiliation, therefore can not be made using this data set. Another limitation with mitochondrial research is with males. Males are not excluded from mtDNA studies but need to understand that they carry mtDNA from their direct maternal ancestors (mother-mothers-mother etc) but cannot pass it on to their offspring.

The report will include a summary of anonymised results from this author's previous maternally inherited mtDNA research (van Holst Pellekaan et al 1998; van Holst Pellekaan et al 2006) and more recently published mtDNA studies (Tobler et al 2016; Nagle et al 2017). It also includes one study of ancient DNA (Heupnik et al 2016). It does not include studies of Y-chromosome (direct paternal inheritance) or nuclear DNA (bi-parental) research. Thus it is a story of maternal connectedness.

Secondly, iIn interpreting DNA datasets it is important to explain why genetic connectedness does not equate with cultural connectedness and does not assume social identity. It tells a far deeper ancestral story about matrilines (connections through mothers and daughters) over thousands of years rather than the history of communities over the last 2-3 hundred years. Language and cultural variations change much more rapidly than DNA changes that give us clues to time depths. Thus, interpretations of genetic connectedness should avoid confusion with cultural connectedness where processes over time of language differentiation (eg Hercus 2013), song line links, kinship regulation, anthropological and historical (both oral and documented) variation have occurred.

Readers need to understand the following points with regard to genetic connectivity:

- mtDNA studies reveal deep ancestral connections of First Nations people today, showing that early maternal ancestors, (great, great+++ grannies) dispersed within Australia over long distances, thousands of years ago at a time estimated to agree with dating from archaeological studies. This leads to questions of how founding lineages of First Nations ancestors spread, how much movement was influenced by climate and resources, if movements were a result of traditional practices (like kinship rules between moieties, or trading routes) and, more recently, how much was a result of colonial enforced relocation from country.

- It also leads us to ask this question. How useful are results of living participants (modern) as well as ancient DNA studies from human remains, in confirming traditional connections? Genetic variations (called mutations) occur slowly, and to compare a group of modern mtDNA sequences to an ancient mtDNA sequence requires an estimation of how much time might have elapsed since they had a common ancestor. We can use best estimates for the mtDNA mutation rate, for example as used in Nagle et al (2017), as in being around one change in the mtDNA in 3,624 years. Thus, DNA from very old burials is unlikely to show an exact match to living people; or might show similarity to examples from people within a local community or might be similar to people whose affiliation is with distant communities a long way away. Claiming ownership of ancient human remains by specific groups cannot be made by DNA comparisons alone, there needs to be evidence from other sources including archaeological context, historical documentation and cultural anthropology.

- By showing anonymised examples from available mtDNA studies, we can demonstrate how widespread are some of these maternal lineages. Genetic research can demonstrate genetic connectedness and variation within and between communities but cannot answer other questions of cultural connectedness that may have developed more recently

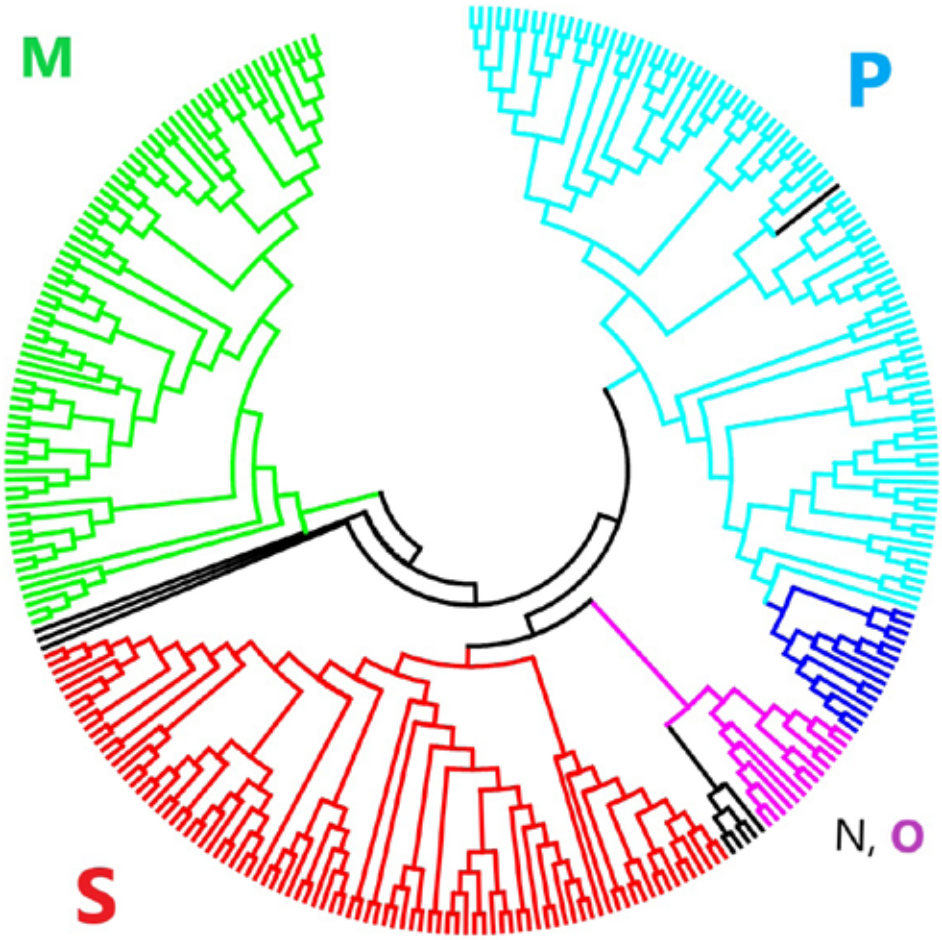

Figure 1: Shows how these groups connect. The figure is presented as a circle but is also shown in an available Community Report as a bush or tree shape.*

than genetic variation. Those questions offer opportunities for further research involving by First Nation people.

KEY OUTCOMES

The following summary serves to demonstrate how local mtDNA connections are also seen across the rest of Australia, reflecting a deep presence and dispersal across Australia.
The groups labelled below have been given names that have nothing to do with individuals or families. During the time since 1992 that I worked with community participants in the Willandra and Darling (Barka) region, many freely described their family connections including knowledge from recent history of dispossession/displacement. I maintained a process of consultation which was reported in van Holst Pellekaan (2000, 2004, 2012). Names of participants and families are not disclosed, labels are letters and numbers according to the way maternal lineages are expressed in the global literature.

1. Maternally inherited mtDNA sequences from living First Nations participants classify into 'superfamilies' called haplotypes. It is seen (Fig 1) that some cluster closer than others because they are more like each other than they are to another group. These can then be sorted into 4 big sub-groups, M, S, O&N and P, called haplogroups. They subdivide further: M14, 15, 42a, b, c; S1a, S2a1,2, S2b1,2; O; P1-11.

2. S1a is present in living people from Barkindji, Walbiri people from Yuendumu, Luruwita (Tasmania) and South Australia; S2 is in several Darling River families, NSW, WA, NT, Victoria. O is in Wangkumara, Malyangapa, Western and South Australia. Note that mtDNA from one Willandra burial, WLH4, estimated to be around 3500 years old classifies as S2a1 (Heupnik et al 2016). The mtDNA sequences are not exactly the same but very similar to other living Australians whose domiciles are regional.

3. M14, 15 WA, M42a is in Ngyemba, Kurnu, Murrawarri, NSW, Qld, M42c in SW Qld, southwestern Australia, NT, NSW.

4. P is a very large haplogroup or superfamily, with representations of many subgroups in New Guinea, Queensland, southern Barkindji, Mutthi-mutthi and south Australia. (P4b now P11).is strong in Darling River people from north to south, possibly including Murrawarri people.

Conclusions:
We can only make estimates of how long it would take to develop these haplogroup (family groups) subdivisions, as mutation rates are not completely understood and the numbers for some studied groups are very small. However, we believe that the best estimates support a continued presence in Australia of people well established by 40,000 years ago. This is not so different from the archaeological dates. It leads us to

Figure 2: 2013 Darling R near Wilcannia

conclude that Australia was settled by the First Australians long before my ancestors arrived in Scotland, Ireland and England. My maternal grandparents then settled in Cardross, on Nyer-Nyeri and later Latje-Latje land (Hercus 2010). First Nation descendants are survivors of colonization that began in 1788. DNA studies can enrich what we are now learning about very old, impressive, continuous cultural complexes in Australia along with other Indigenous complexes from Africa, Asia and near neighbours to the north. The Willandra region is one of the most important sites globally and recognised as significant in the story of humans.

PUBLICATIONS

2010 Hercus, Luise. Aboriginal people and Languages of the Murray. Pp169-173 in Allen, H (Ed) Australia William Blandowski's Illustrated Encyclopaedia of Aboriginal Australia. Aboriginal Studies Press.

2013 Hercus Luise. Language notes connected to the journey of the expedition as far as the Cooper. Ch 6, pp115-127 in Clark, Ian D. and Cahir, Fred. The Aboriginal Story of Burke and Wills. Forgptten narratives. CSIRO publishing Collingwood, Victoria.

2016 Heupnik, Ray Ancient mtDNA sequences from the First Australians revisited Tim H. Heupink , Sankar Subramanian , Joanne L. Wright , Phillip Endicott, Michael Carrington Westaway , Leon Huynen , Walther Parson, Craig D. Millar , Eske Willerslev, and David M. Lambert. https://doi.org/10.1073/pnas.1521066113

2017 Nano Nagle, Mannis van Oven, Stephen Wilcox, Sheila van Holst Pellekaan,

Chris Tyler-Smith, Yali Xue, Kaye N. Ballantyne, Leah Wilcox, Luka Papac, Karen Cooke, Roland A. H. van Oorschot, Peter McAllister, Lesley Williams, Manfred Kayser,

R. John Mitchell, The Genographic Consortium. Aboriginal Australian mitochondrial genome variation – an increased understanding of population antiquity and diversity.

Nature. Scientific Reports. 7:430-41. DOI: 10.1038/srep43041

2016 Tobler, Ray1 *, Adam Rohrlach2,3*, Julien Soubrier1,4, Pere Bover1 , Bastien Llamas1 , Jonathan Tuke2,3, Nigel Bean2,3, Ali Abdullah-Highfold5, Shane Agius5, Amy O'Donoghue5, Isabel O'Loughlin5, Peter Sutton5,6, Fran Zilio5, Keryn Walshe5, Alan N. Williams7 , Chris S.M. Turney7 , Matthew Williams1,8, Stephen M. Richards1 , Robert J. Mitchell9, Emma Kowal10, John R. Stephen11, Lesley Williams12, Wolfgang Haak1,13§ & Alan Cooper1,14§ Aboriginal mitogenomes reveal 50,000 years of regionalism in Australia

2017 Nature Vol 544 pp180. doi:10.1038/nature21416

1998. van Holst Pellekaan, S. M., Frommer, M., Sved, J. A. and Boettcher B. 1998 'Mitochondrial Control-Region Sequence Variation in Aboriginal Australians' American Journal of Human Genetics 62:435-449.

2000 van Holst Pellekaan, S. M. 2000 Genetic research: what does this mean for Indigenous Australian communities? Australian Aboriginal Studies 1&2:65-75, AIATSIS Canberra.

2004 van Holst Pellekaan S.M. 2004. Human Genome Diversity: Ethics and Practice in Australia. Human Evolution 19 (2):131-144, Springer Netherlands.

2006 van Holst Pellekaan, S.M., Ingman, M., Roberts-Thomson, J., & Harding, R. M. 2006. Mitochondrial genomics identifies major haplogroups in Aboriginal Australians. American J Physical Anthropology. 131:282-294.

2006 van Holst Pellekaan, S. M. and Harding, R. M. 2006. Excavating the mitochondrial genome identifies major haplogroups in Aboriginal Australians. Before Farming 2006-1- Article 3.2008 van Holst Pellekaan, Sheila M. March 2008. Origins of the Australian and New Guinea Aborigines. In Encyclopedia of Life Sciences (ELS). John Wiley and Sons, Chichester. DOI:10.1002/9780470015902.a0020815

2012 van Holst Pellekaan,S., Liu, PY & Wilton, A. 2010 Genetic heritage in the Darling River Aboriginal peoples captures ancient presence and post-contact survival. Before Farming 2010/4 article 1.

2011 van Holst Pellekaan, S., Genetic evidence for the colonization of Australia, Quaternary International.doi:10.1016/j.quaint.2011.04.014.

2012 van Holst Pellekaan, SM. Socially responsible genetic research with descendants of the First Australians. Investigative Genetics 3:22 doi:10.1186/2041-2223-3-22.

2013 van Holst Pellekaan, Sheila M (March 2013) Origins of the Australian and New Guinean Aborigines. In: eLS 2013, John Wiley & Sons Ltd: Chichester http://www.els.net/ [DOI: 10.1002/9780470015902.a0020815.pub2]

2017 Nano Nagle1, Mannis van Oven2, Stephen Wilcox3, Sheila van Holst Pellekaan4,5,

Chris Tyler-Smith6, Yali Xue6, Kaye N. Ballantyne2,7, Leah Wilcox1, Luka Papac1, Karen Cooke1, Roland A. H. van Oorschot7, Peter McAllister8, Lesley Williams9, Manfred Kayser2,

R. John Mitchell1 & The Genographic Consortium. Aboriginal Australian mitochondrial genome variation – an increased understanding of population antiquity and diversity.

Nature. Scientific Reports. 7:43041. DOI: 10.1038/srep43041. doi:10.1038/nature21416

WILLANDRA LAKES REGION BIBLIOGRAPHY

Adams, G. & Mortlock, A. J. 1974. Thermoluminescent dating of baked sand from fire hearths at Lake Mungo, New South Wales. *Archaeology and Physical Anthropology in Oceania* 9 (3):236–37.

Adcock, G. J., Dennis, E. S., Easteal, S., Huttley, G.A., Jermiin, L.S., Peacock, W. J. & Thorne, A. 2001. Lake Mungo 3: A response to recent critiques. *Archaeology in Oceania* 36 (3):170-74.

Adcock, G. J., Dennis, E. S., Easteal, S., Huttley, G.A., Jermiin, L.S., Peacock, W. J. & Thorne, A. 2001. Human Origins and Ancient Human DNA - Response. *Science* 292 (5522):1656.

Adcock, G. J., Dennis, E. S., Easteal, S., Huttley, G.A., Jermiin, L.S., Peacock, W. J. & Thorne, A. 2001. Mitochondrial DNA sequences in Ancient Australians: Implications for Modern Human Origins. *Proceedings of the National Academy of Sciences* 98 (2):537-42.

Allbrook, M. & McGrath, A. 2015. Collaborative histories of the Willandra Lakes. *Long History, Deep Time: Deepening Histories of Place.* ANU Press, Canberra. pp.241-52.

Allen, H. 1972. *Where The Crow Flies Backwards: Man and Land in the Darling Basin.* PhD Thesis, Research School of Pacific Studies, Australian National University.

Allen, H. 1974. The Bagundji of the Darling Basin: cereal gatherers in an uncertain environment. *World Archaeology* 5 (3):309-22.

Allen, H. 1990. Environmental history in southwestern New South Wales during the Late Pleistocene. *The World at 18 000 BP.* Unwin Hyman, London. pp.296–321.

Allen, H. 1998. Reinterpreting the 1969-1972 Willandra Lakes archaeological surveys. *Archaeology in Oceania* 33 (3):207–20.

Allen, H. & Holdaway, S. 2009. The archaeology of Mungo and the Willandra Lakes: looking back, looking forward. *Archaeology in Oceania* 44 (2):96–106.

Allen, H., Holdaway, S., Fanning, P. & Littleton, J. 2008. Footprints in the sand: appraising the archaeology of the Willandra Lakes, western New South Wales, Australia. *Antiquity* 82 (315):11 - 24.

Ambrose, W. R. 1984. Soil temperature monitoring at Lake Mungo: Implications for racemisation dating. *Australian Archaeology* 19:64-74.

Anderson, M., Capel, J., Galloway, D., Holmes, D., Houghton, G., Male, L., Moss, S., Potter, J., Pyemont, B., Thorley, P., Yeomans, A. & Russell, G. 1984. Aboriginal occupation of the Lake Mungo region during mid-late Holocene times. *Quaternary Australasia* 2:16-23.

Archer, D. & Griffin, T. 2002. A Study of Visitor Use and Satisfaction in Mungo National Park.

Aubert, M., Williams, I. S., Boljkovac, K., Moffat, I., Moncel, M.-H., Dufour, E., & R., G. 2012. In situ oxygen isotope micro-analysis of faunal material and human teeth using a SHRIMP II: a new tool for palaeo-ecology and archaeology. *Journal of Archaeological Science* 39 (10):3184–94.

Griffiths, B. 2018. A dessicated garden of Eden: Jim Bowler at Lake Mungo. *Deep Time Dreaming: Uncovering Ancient Australia.* Black Inc., Carlton.

Bandurski, C. M. 2018. *A Technological Study of Stone Artefacts from the Lower Mungo Unit Lake Mungo, Southwest New South Wales, Australia.* Honours Thesis, Department of Archaeology and History, La Trobe University.

Barbetti, M. 1973. *Archaeomagnetic and radiocarbon studies of aboriginal fireplaces.* PhD Thesis, Department of Geophysics and Geochemistry, Australian National University.

Barbetti, M. & Allen, H. 1972. Prehistoric man at Lake Mungo, Australia, by 32,000 years BP. *Nature* 240 (5375):46-48.

Barbetti, M. & McElhinny, M. W. 1972. Evidence of a geomagnetic excursion 30,000 yr BP. *Nature* 239 (5371):327-30.

Barbetti, M. & McElhinny, M. W. 1976. The Lake Mungo geomagnetic excursion. *Philosophical transactions of the Royal Society of London, A Mathematical and Physical Sciences* 281 (1305):515-42.

Barbetti, M. & Polach, H. 1973. ANU radiocarbon date list V. *Radiocarbon* 15 (2):241-51.

Barker, D. 2015. *A Study of the Mineralogical Variation in Ochre from the Lake Mungo Lunette.* Honours Thesis, Department of Archaeology and History, La Trobe University.

Barrows, T. T., Fitzsimmons, K. E., Mills, K.E., Tumney, J., Pappin, D. & Stern., N. 2020. Late Pleistocene lake level history of Lake Mungo, Australia. *Quaternary Science Reviews* 238:106338.

Bell, W. T. 1991. Thermoluminescence dates for the Lake Mungo Aboriginal fireplaces and the implications for radiocarbon dating. *Archaeometry* 33 (1):343-50.

Boljkovac, K. 2009. *In situ SHRIMP _18O and laser ablation ICP-MS Sr/Ca and 87Sr/86Sr measurements in fossil otoliths for palaeoclimate reconstructions at the Willandra Lakes World Heritage Area.* Honours Thesis, School of Earth Science, Australian National University.

Bowler, J. M. 1970. *Late Quaternary Environments: A Study of Lakes and Associated Sediments in Southeastern Australia.* PhD Thesis, Australian National University.

Bowler, J. M. 1971. Pleistocene salinities and climatic change: evidence from lakes and lunettes in southeastern Australia. *Aboriginal Man and Environment in Australia.* Australian National University Press. pp.47–65.

Bowler, J. M. 1973. Clay dunes: their occurrence, formation and environmental significance. *Earth-Science Reviews* 9 (4):315–38.

Bowler, J. M. 1976. Aridity in Australia: Age, origins and expression in aeolian landforms and sediments. *Earth-Science Reviews* 12 (2):279–310.

Bowler, J. M. 1983. 25 - 20ka: hydrologic evidence in southern Australia. *Proceedings of the First CLIMANZ Conference*:29-31.

Bowler, J. M. 1986. Spatial variability and hydrologic evolution of Australian lake basins: analogue for Pleistocene hydrologic change and evaporite formation. *Palaeogeography, Palaeoclimatology, Palaeoecology* 54 (1-4):21–41.

Bowler, J. M. 1990. Human occupation and environmental change: the ancient record from the Willandra Lakes. *The Mallee Lands: a Conservation Perspective. Proceedings of the National Mallee Conference 1989 (Adelaide).* CSIRO Australia, Melbourne. pp.152-61.

Bowler, J. M. 1998. Willandra Lakes revisited: Environmental framework for human occupation. *Archaeology in Oceania* 33 (3):120–55.

Bowler, J. M. 2009. Legacy of an Ice Age: foreword. *Archaeology in Oceania* 44:75–76.

Bowler, J. M. 2017. Lake Mungo and Willandra. *Encyclopedia of Geoarchaeology.* Springer. pp.460-64.

Bowler, J. M. 2018. Time to honour a historical legend: 50 years since the discovery of Mungo Lady. *The Conversation*.

Bowler, J. M., Gillespie, R., Johnston, H. & Boljkovac, K. 2012. Wind v water: Glacial maximum records from the Willandra Lakes. *Peopled Landscapes: Archaeological and Biogeographic Approaches to Landscapes.* ANU E Press, Canberra. pp.271-96.

Bowler, J. M., Johnston, H., Olley, J.M., Prescott, J.R., Roberts, R.G., Shawcross, W. & Spooner, N. A. 2003. New ages for human occupation and climatic change at Lake Mungo, Australia. *Nature* 421 (6925):837-40.

Bowler, J. M. & Magee, J. W. 2000. Redating Australia's oldest human remains: a sceptic's view. *Journal of Human Evolution* 38 (5):719-26.

Bowler, J. M. & Price., D. M. 1998. Luminescence dates and stratigraphic analyses at Lake Mungo: review and new perspectives. *Archaeology in Oceania* 33 (3):156-68.

Bowler, J. M., R. Jones, A., H. & A.G., T. 1970. Pleistocene human remains from Australia: a living site and human cremation from Lake Mungo, western New South Wales. *World Archaeology* 2 (1):39-60.

Bowler, J. M. & Reeves., J. 2017. Mungo Man's return: Next step in a long journey. *Quaternary Australasia.*

Bowler, J. M., Thorne, A. G. & Polach, H. A. 1972. Pleistocene man in Australia: age and significance of the Mungo skeleton. *Nature* 240 (5375):48-50.

Bowler, J. M. & Thorne., A. G. 1976. Human remains from Lake Mungo: Discovery and excavation of Lake Mungo III. *The Origin of the Australians.* Humanities Press, New Jersey. pp.127-38.

Bowler, J. M. & Wasson, R. J. 1984. Glacial age environments of inland Australia. *Late Cainozoic Palaeoclimates of the Southern Hemisphere.* CRC Press. pp.183-208.

Brown, P. 1987. Pleistocene homogeneity and Holocene size reduction: the Australian human skeletal evidence. *Archaeology in Oceania* 22 (2):41-67.

Brown, P. 2000. Australian Pleistocene variation and the sex of Lake Mungo 3. *Journal of Human Evolution* 38 (5):743-49.

Brown, P. & Gillespie, R. 2000. Mungo claims unsubstantiated. *Australasian Science* 21 (5):26-27.

Bulbeck, F. D. 2001. Robust and gracile Australian crania: the tale of the Willandra Lakes. *Sangiran: Man, Culture and Environment in Pleistocene Times.* Yayasan Obor, Jakarta. pp.60-106.

Bulgana. 1937. The story of the Darling River, its discovery and settlement. *The Australasian*.

Burgess, K. 2015. Mungo Man to be moved to National Museum of Australia's repatriation unit. *Canberra Times*.

Butzer, K. 1972. Aboriginal man and environment in Australia. D.J. Mulvaney and J. Golson eds. Australian National University Press, Canberra. *American Anthropologist* 74:1526-27.

Clark, P. M. & Barbetti, M. 1982. Fires, hearths and palaeomagnetism. *Archaeometry: an Australian perspective.* Department of Prehistory, Research School of Pacific Studies, Australian National University. pp.144–50.

Colgan, D. J. 2001. Commentary on G.J. Adock, et al., 2001 Mitochondrial DNA sequences in ancient Australians: implications for modern human origins. *Archaeology in Oceania* 36 (3):168-69.

Constantinidis, D. 2009. GIS for managing the analysis and protection of archaeological remains in the Willandra Lakes World Heritage Area. *Archaeology in Oceania* 44 (2):112-18.

Crombie, M. 2021. *Just Cracking the Surface: Amino-Acid Racemizaiton in Archaeolgoical Emu Eggshell.* Masters Thesis, Department of Chemistry, La Trobe University.

Curnoe, D. 2009. Possible causes and significance of cranial robusticity among Pleistocene-Early Holocene Australians. *Journal of Archaeological Sciences* 36:980-90.

Curnoe, D. & Green, H. 2013. Vault thickness in two Pleistocene Australian crania. *Journal of Archaeological Science* 40:1310-18.

Curnoe, D. & Thorne, A. 2000. The Mungo Man: new dates, old ideas? *Australasian Science* 21 (5):24-27.

Curnoe, D. & Thorne, A. 2006. Human origins in Australia: the skeletal evidence. Before Farming. *Before Farming* 5:1-28.

Dare-Edwards, A. J. 1979. *Late Quaternary Soils on Clay Dunes of the Willandra Lakes, New South Wales.* PhD Thesis, Australian National University.

Dare-Edwards, A. J. 1984. Aeolian clay deposits of south-eastern Australia: parna or loessic clay? *Transactions of the Institute of British Geographers* 9:337-44.

Dillon, E. 2014. *A Geoarchaeological Study of Location 969660, Lake Mungo. A mixed-method, multi-scalar approach to*

investigating human-environmental interactions. Honours Thesis, School of Archaeology and Anthropology, Australian National University.

Doerschner, N., Hern, ez, M. & Fitzsimmons, K. E. 2016. Sources of variability in single grain dose recovery experiments: insights from Moroccan and Australian samples. *Ancient TL* 34 (1):14-25.

Douglas, K. 1996. *Land Systems and Stratigraphy of Lake Mulurulu: Examination of Quaternary Palaeoenvironments.* Honours Thesis, School of Earth Sciences, University of Melbourne.

Douglas, K. 2004. *Pictures of time beneath'. Science, Landscape, heritage and the uses of the deep past in Australia 1830-2003.* PhD Thesis, Australian National University.

Durband, A. C., Rayner, D. R. T. & Westaway, M. 2009. A new test of the sex of the Lake Mungo 3 skeleton. *Archaeology in Oceania* 44 (2):77-83.

Durband, A. C. & Westaway, M. C. 2013. Perspectives on the origins of modern Australians. *The Origins of Modern Humans: Biology Reconsidered.* John Wiley & Sons. pp.123-50.

Eldridge, D. J. 1987. *Soil survey and assessment of erosion. Willandra Lakes World Heritage Area.*

Ellery, D. 2016. The time has come to lay Mungo Man to rest. *The Age*.

Ensor, M. R. 2019. *Geoarchaeological and Chronological Investigations of Combustion Features at Lake Mungo, NSW: Providing Fine Grained Detail to Burning Questions.* Honours Thesis, School of Earth and Atmospheric Life Sciences, University of Wollongong.

Faulkner, P. 2011. Stone artefact technology in Willandra National Park: reduction, risk and mobility. *Keeping your Edge: recent approaches to the organisation of stone artefact technology.* Archeopress, England, 5-20.

Feary, S. 1981. *The Potential of Freshwater Mussels as Seasonal Indicators in Archaeology.* Honours Thesis, Australian National University.

Finlay, K. 1979. Appeal to preserve ancient site the sandhills where mungo woman lived. *The Australian Women's Weekly.*

Fitzsimmons, K. E. 2011. An assessment of the luminescence sensitivity of Australian quartz with respect to sediment history. *Geochronometria* 38 (3):199-208.

Fitzsimmons, K. E. 2017. Reconstructing palaeoenvironments on desert margins: New perspectives from Eurasian loess and Australian dry lake shorelines. *Quaternary Science Reviews* 171:1-19.

Fitzsimmons, K. E. & Gromov, S. S. 2022. Northward expansion of the westerlies over glacial southeastern Australia: evidence from semi-arid lunette dunes, temperate basalt plains, and wind modelling. *Frontiers in Earth Science*10: 921264.

Fitzsimmons, K. E., Rhodes, E. J. & Barrows, T. T. 2010. OSL dating of southeast Australian quartz: A preliminary assesment of luminescence characteristics and behaviour. *Quaternary Geochronology* 5:91-95.

Fitzsimmons, K. E., Spry, C. & Stern, N. 2019. Holocene and recent aeolian reactivation of the Willandra Lakes lunettes, semi-arid southeastern Australia. *The Holocene* 29 (4):606-21.

Fitzsimmons, K. E., Stern, N. & Murray-Wallace, C. V. 2014. Depositional history and archaeology of the central Lake Mungo lunette, Willandra Lakes, southeast Australia. *Journal of Archaeological Science* 41:349-64.

Fitzsimmons, K. E., Stern, N., Murray-Wallace, C.V., Truscott, W. & Pop, C. 2015. The Mungo mega-lake event, semi-arid Australia: non-linear descent into the Last Ice Age, implications for human behaviour. *PloS One* 10 (6):e0127008.

Foley, E. 2011. *Refitting at Lake Mungo: A study of the integrity of surface stone artefact scatters on the Lake Mungo lunette.* Honours Thesis, Department of Archaeology and History, La Trobe University.

Foley, E. 2021. *The Cultural Landscape at Lake Mungo during the Last Glacial Maximum.* PhD Thesis, Department of Archaeology and History, La Trobe University.

Foley, E., Spry, C. & Stern, N. 2017. Establishing the integrity and stratigraphic origin of stone artefact scatters on the surface of the Lake Mungo lunette in south-eastern Australia. *Journal of Archaeological Science: Reports* 13:547-57.

Franklin, N. R. & Habgood, P. J. 2009. Finger markings and the Willandra Lakes footprint site, south-eastern Australia. *Rock Art Research* 26 (2):199-203.

Fullagar, R., Hayes, E., Stephenson, B., Field, J., Matheson, C., Stern, N. & Fitzsimmons, K. E. 2015. Evidence for Pleistocene seed grinding at Lake Mungo, south-eastern Australia. *Archaeology in Oceania* 50:3-19.

Fullagar, R., Hayes, E., Stephenson, B., Field, J., Matheson, C., Stern, N. & Fitzsimmons, K. E. 2015. The scale of seed grinding at Lake Mungo. *Archaeology in Oceania* 50 (3):177-79.

Fuller, N. M. 1986. *Archaeological sites in the Garnpung - Gogolo and Garnpung - Leaghur interlake zone.* Honours Thesis, Archaeology and Anthropology, Australian National University.

Garvey, P. 2021. Secret burial 'would destroy Mungo Man'. *The Australian*.

Garvey, P. 2021. Keeping place' plan to save Mungo Man for posterity. *The Australian*.

Garvey, P. 2021. Heritage NSW report on Mungo Man 'full of lies'. *The Australian*.

Gillespie, R. 1997. Burnt and unburnt carbon: Dating charcoal and burnt bone from the Willandra Lakes Australia. *Radiocarbon* 39 (3):239-50.

Gillespie, R. 1998. Alternative Timescales: A Critical Review of Willandra Lakes Dating. *Archaeology in Oceania* 33 (3):169-82.

Gillespie, R., Fink, D., Petchey, F. & Jacobsen, G. 2009. Murray-Darling basin freshwater shells: riverine reservoir effect. *Archaeology in Oceania* 44 (2):107-11.

Gillespie, R. & R.G., R. 2000. On the reliability of age estimates for human remains at Lake Mungo. *Journal of Human Evolution* 38 (5):727-32.

Goggin, C. L., Please, P. M., Ridges, M.J., Booth, C.A., Simpson, G.R., Green, R & Leys, J. F. 2017. Connecting with country in Mungo National Park, Australia: a case study to measure the emotional dimension of experience and place attachment. *Local Environment* 22 (10):1217-36.

Gostin, O. 1991. *Accessing the Dreaming. Heritage, Conservation and Tourism at Mungo National Park.* Masters Thesis, University of Adelaide.

Green, H. & Curnoe, D. 2005. Mandibular fossa of fossil Australians. *Journal of Comparative Human Biology.* 56:233-47.

Grounds, S. & Ross, A. 2010. Constant resurrection: The trihybrid model and the politicisation of Australian Archaeology. *Australian Archaeology* 70:55-67.

Groves, C. P. 2001. Lake Mungo 3 and his DNA. *Archaeology in Oceania* 36:166-67.

Grün, R., Spooner, N. A., Thorne, A., Mortimer, G., Simpson, J.J., Mcculloch, M.T., Taylor, L. & Curnoe, D. 2000. Age of the Lake Mungo 3 skeleton, reply to Bowler & Magee and to Gillespie & Roberts. *Journal of Human Evolution* 38 (5):733- 41.

Grün, R., Spooner, N. A., Magee, J., Thorne, A., Simpson, J., Yan, G. & Mortimer, G. 2011. Stratigraphy and chronology of the WLH 50 human remains, Willandra Lakes World Heritage Area, Australia. *Journal of Human Evolution* 60 (5):597-604.

Habgood, P. J. 1986. The origin of the Australians: A multivariate approach. *Archaeology in Oceania* 21 (2):130-37.

Hawks, J., Oh, S., Hunley, K., Dobson, S., Cabana, G., Dayula, P. & Wolpoff, M. H. 2000. An Australasian test of the recent African origin theory using the WLH-50 calvarium. *Journal of Human Evolution* 39 (1):1-22.

Hayes, E. H. 2015. *What Was Ground? A Functional Assessment of Grinding Stones from Madjedbebe and Lake Mungo, Australia.* PhD Thesis, Centre for Archaeological Science, University of Wollongong.

Henderson, A. & Donald, P. 2015. Australian National University offers apology to elders as Mungo Man remains handed back to traditional owners. *ABC News*.

Department of Environment and Heritage. 1999. Willandra Lakes Region. *Australia's World Heritage.* Department of Environment and Heritage, Canberra. pp.9-12.

Heupink, T. H., Subramanian, S., Wright, J.L., Endicott, P., Westaway, M.C., Huynen, L., Parson, W., Millar, C.D., Willerslev, E. & Lambert, D. M. 2016. Ancient mtDNA sequences from the First Australians revisited. *Proceedings of the National Academy of Sciences* 113 (25):6892-97.

Hill, E. C., Durb & , A. C. 2014. Mobility and subsistence at the Willandra Lakes: A comparative analysis of femoral cross-sectional properties in the Lake Mungo 3 skeleton. *Journal of Human Evolution* 73:103-106.

Hiscock, P. & Allen, H. 2000. Assemblage variability in the Willandra Lakes. *Archaeology in Oceania* 35 (3):97-103.

Hope, J. 1978. Pleistocene mammal extinctions: the problem of Mungo and Menindee, New South Wales. *Alcheringa: An Australasian Journal of Palaeontology* 2 (1):65-82.

Hope, J. 1985. A regional environmental plan for the Willandra Lakes World Heritage region. *Australian Archaeology* 20:32-37.

Hope, J. 1993. Pleistocene archaeological sites in the central Murray-Darling Basin. *Sahul in Review: Pleistocene Archaeology in Australia, New Guinea and island Melanesia.* Australian National University, Canberra. pp.183–96.

Hope, J. & Thom, B. G. 1974. Lake Mungo. *Australian Quaternary Newsletter* 3:6-7.

Huxtable, J. & Aitken, M. J. 1977. Thermoluminescent dating of Lake Mungo geomagnetic polarity excursion. *Nature* 265 (5589):40-41.

Hyde, R. & Wasson, R. J. 1983. Radiative and meteorological control on the movement of sand at Lake Mungo, NSW, Australia. *Developments in Sedimentology* 38:311-23.

Jankowski, N., Stern, N., Lachlan, T. & Jacobs, Z. 2020. A high-resolution late Quaternary depositional history and chronology for the southern portion of the Lake Mungo lunette, semi-arid Australia. *Quaternary Science Reviews* 233:106224.

Johnson, R. 2017. *Fire and Fragmentation: A Taphonomic Analysis of Bone Fragmentation.* Honours Thesis, Department of Archaeology and History, La Trobe University.

Johnston, H. 1993. Pleistocene shell middens of the Willandra Lakes. *Sahul in Review: Pleistocene Archaeology in Australia, New Guinea and island Melanesia.* Australian National University, Canberra. pp.197–203.

Johnston, H. 2014. The Willandra Lakes Region World Heritage Area, New South Wales, Australia: land use planning and management of Aboriginal and archaeological Heritage. *Archaeological Dimension of World Heritage.* Springer, New York. pp.39-55.

Johnston, H. & P., C. 1998. Willandra Lakes Archaeological Investigations 1968-98. *Archaeology in Oceania* 33 (3):105–19.

Johnston, R. & Mintern, R. 2013. Managing Australia's World Heritage in the Willandra Lakes Region. *Keeping the Outstanding Exceptional: The Future of World Heritage in Australia.* Australian Committee for IUCN Inc. pp.102-07.

Kefous, K. 1977. *We Have a Fish With Ears... and Wonder if it's Useful.* Honours Thesis, Australian National University.

Kemp, J. 2010. Downstream channel changes on a contracting, anabranching river: The Lachlan, southeastern Australia. *Geomorphology* 121:231-44.

Kemp, J., Pietsch, T., Gontz, A. & Olley, J. 2017. Lacustrine-fluvial interactions in Australia's Riverine Plains. *Quaternary Science Reviews* 166:352-62.

Kemp, J. & Pietsch, T. J., Olley, J. 2014. Digging your own

grave: OSL signatures in experimental graves. *Journal of Human Evolution* 76:77-82.

Keneally, T. 2018. Mungo Man imagined: writing the ultimate historical novel. *Journal & Proceedings of the Royal Society of New South Wales.* 151 (1):5-13.

Kibble, M. 2008. *The Study of Faunal Assemblages from Open Sites in the Willandra Lakes: A case study from locality 969660.* Honours Thesis, Department of Archaeology and History, La Trobe University.

Kurpiel, R. 2010. *Notched Artefacts from the Willandra Lakes World Heritage Area.* Honours Thesis, Department of Archaeology and History, La Trobe University.

Kurpiel, R. 2017. *Stone sources in the Willandra Lakes region, in south-eastern Australia: a study of source characterisation and raw material procurement.* PhD Thesis, Department of Archaeology and History, La Trobe University.

Kurpiel, R., Pickering, R., Maas, R. & Stern, N. 2019. Lead (Pb) isotope signatures for silcrete sources from the Willandra Lakes region, Australia: a pilot study of a new method for provenancing silcrete artefacts. *Journal of Archaeological Science: Reports* 23:62-71.

Lambert, D., Wright, J., Westaway, M. & Subramanian, S. 2016. New DNA study confirms ancient Aboriginies were the First Australians. *The Conversation*.

Long, K. 2012. *'An Ear to the Ground': Fish Otolith Geochemistry, Environmental Conditions and Human Occupation at Lake Mungo.* Honours Thesis, Australian National University.

Long, K. 2019. *Golden perch (Macquaria ambigua) otolith microchemistry: modern validations and ancient applications.* PhD Thesis, School of Archaeology and Anthropology, Australian National University.

Long, K., Heslop, D. & Rohling, E. J. 2021. Quantitative assessment of the oxygen isotope composition of fish otoliths from Lake Mungo, Australia. *Quaternary Research* 102:234-46.

Long, K., Stern, N., Williams, I.S., Kinsley, L., Wood, R., Sporcic, K., Smith, T., Fallon, S., Kokkonen, H., Moffat, I. & Grün, R. 2014. Fish otolith geochemistry, environmental conditions and human occupation at Lake Mungo, Australia. *Quaternary Science Reviews* 88:82-95.

Long, K., Wood, R., Williams, I.S., Kalish, J., Shawcross, W., Stern, N. & Grün, R. 2018. Fish otolith microchemistry: Snapshots of lake conditions during early human occupation of Lake Mungo, Australia. *Quaternary International* 463:29-43.

Lovell, C. 2015. *Fish and Fishing at Site 1168.* Honours Thesis, Department of Archaeology and History, La Trobe University.

Loy, T. H. 1990. Getting blood from a stone. *Australian Natural History* 23 (6):471-79.

MacGregor. 2022. Preserving the ancient human trackway site in the Willandra Lakes World Heritage Area. *Studies in Conservation* 67, sup 1: 150-155.

MacManus, T. 2008. *Rocks in a Box: An Assessment of Unprovenanced Artefact Collections from the Willandra Lakes World Heritage Area.* Honours Thesis, Department of Archaeology and History, La Trobe University.

Magee, J. W. 1976. Willandra Lakes Symposium - Stratigraphy and Archaeology. *Australian Quaternary Newsletter* 8:11.

Magee, J. W. 1988. *Chemical and clastic sediments and late Quaternary history, Prungle Lakes, New South Wales.* Masters Thesis, Australian National University.

Magee, J. W. 1991. Late Quaternary lacustrine, groundwater, aeolian and pedogenic gypsum in the Prungle Lakes, southeastern Australia. *Palaeogeography, Palaeoclimatology, Palaeoecology* 84 (1-4):3-42.

Magee, J. W. 2007. Lake level studies/Australia. *Encylopedia of Quaternary Science, 1st Edition.* Elsevier. pp.1359-66.

Magee, J. W. & Deckker, P. D. 2001. J.M. Bolwer's contribution to Australian Quaternary studies: a tribute to Jim Bowler. *Quaternary International* 83-85:1-4.

McGrath, A. 2021. People of the footprints: rediscovery, Indigenous historicities and the science of deep time. *Interventions*:1-27.

McGrath, A. 2022. People of the Footprints, Interventions, *International Journal of Postcolonial Studies*, 24: 181- 207.

McGrath, A., Rademaker, L. & Silverstein, B. 2021. Deep history and deep listening: Indigenous knowledges and the narration of deep pasts. *Rethinking History* 25 (3):307-26.

McIntyre, M. L. 1979. Procoptodon fossils from the Willandra Lakes, western New South Wales. *The Artefact* 3 (3):117-32.

Merrill, R. T. & McFadden, P. L. 2005. The use of magnetic field excursions in stratigraphy. *Quaternary Research* 63:232-37.

Midgley, E., Spennemann, D. H. R. & Johnston, H. 1998. The Impact of Visitors on Aboriginal Sites in Mungo National Park. *Archaeology in Oceania* 33 (3):221-31.

Miller, G. H., Magee, J. W., Johnson, B.J., Fogel, M.L., Spooner, N.A., McCulloch, M.T & Ayeliffe, L. K. 1999. Pleistocene Extinction of Genyornis newtoni: human impact on Australian megafauna. *Science* 283:205-08.

Miller, G. H., Magee, J. W. & Jull, A. J. T. 1997. Low-latitude glacial cooling in the Southern Hemisphere from amino-acid racemization in emu eggshells. *Nature* 385 (6613):241.

Miller, G. H. H., C.P., Roark, E.B.; Johnson, B.J. 2000. Isoleucine epimerization in eggshells of the flightless Australian birds Genyomis and Dromaius. *Perspectives in amino acid and protein geochemistry.* Oxford University Press, New York. pp.161-81.

Mills, C. H., Waudby, H., Finlayson, G., Parker, D., Cameron, M. & Letnic, M. 2020. Grazing by over-abundant native herbivores jeopardizes conservation goals in semi-arid reserves. *Global Ecology and Conservation.* 24:e01384.

Milne, A. K. & O'Neill, A. L. 1990. Mapping and monitoring land cover in the Willandra Lakes World Heritage region New South Wales, Australia. *International Journal of Remote Sensing* 11 (11):2035-50.

Mortlock, A. J. 1974. The archaeometry of Lake Mungo.

Australian Physicist 11 (11):213-15.

Moser, S. 1992. Visions of the Australian Pleistocene: Prehistoric Life at Lake Mungo and Kutikina. *Australian Archaeology* 35:1-10.

Muhlen-Schulte, R. 1985. *Mungo Rocks: A Technological Analysis of Stone Assemblages from Lake Mungo.* Honours Thesis, Department of Prehistory and Anthropology, Australian National University.

Mulvaney, D. J. 1979. Prehistoric Mungo. *Woroni*.

Mulvaney, D. J. & Bowler, J. M. 1981. Lake Mungo and the Willandra Lakes. *The Heritage of Australia: The Illustrated Register of the National Estate.* MacMillan, Melbourne. pp.180-83.

Murawski, T. 2007. *Lithics in the Willandra Lakes: the last 5,000 years.* Masters Thesis, School of Archaeology and Anthropology, Australian National University.

O'Neill, G. 1992. Dead men are heard from the grave. *The Canberra Times*.

Olley, J. M., Roberts, R. G., Yoshida, H. & Bowler, J. M. 2006. Single-grain optical dating of grave-infill associated with human burials at Lake Mungo, Australia. *Quaternary Science Reviews* 25 (19–20):2469–74.

Oyston, B. 1996. Thermoluminescence age determinations for the Mungo III human burial, Lake Mungo, Southeastern Australia. *Quaternary Science Reviews* 15 (7):739–49.

Pappin, G. 2007. Pursuing autonomy and Traditional Owners' aspiration: Management of the Willandra Lakes World Heritage Area and Mungo National Park. *Indigenous Governance and Management of Protected Areas.* pp.47-49.

Pardoe, C. 1988. The cemetery as symbol. The distribution of prehistoric aboriginal burial grounds in Southeastern Australia. *Archaeology in Oceania* 23 (1):1-16.

Pearlman, J. 2015. University returns 40,000-year-old Mungo Man to Australia's Aborigines. *Telegraph*.

Pickreil, J. 2014. Messages from Mungo. *Australian Geographic.*

Polach, H. A., Head, M. J. & Gower, J. D. 1978. ANU Radiocarbon Date List VI. *Radiocarbon* 20 (3):360-85.

Polach, H. A., J.F., L. & Bowler, J. M. 1970. ANU Radiocarbon date list IV. *Radiocarbon* 12:1-18.

Porteners, M. F. & Ashby, E. M. 1996. *Plants of Pooncarie and the Willandra Lakes.* Royal Botanic Gardens Sydney, Sydney.

Price, G.J., Fitzsimmons, K.E., Nguyen, A.D., Zhao, J.-X., Feng, Y.-X., Sobbe, I.H., Godthelp, H., Archer, M., Hand, S.J. 2021. New ages of the world's largest-ever marsupial: *Diprotodon optatum from Pleistocene Australia. Quaternary International* 603: 64-73.

Pritchard, J. C. 2004. *Linking fish growth and climate across modern space and through evolutionary time: otolith chronologies of the Australian freshwater fish, golden perch (Macquaria ambigua, Percichthyidae).* PhD Thesis, School of Botany and Zoology, Faculty of Science, Australian National University.

Prosser, L. 2015. *A Geo-archaeological Study of Baked Sediment Hearths from the Lake Mungo Lunette.* Masters Thesis, Department of Archaeology and History, Australian National University.

Prossor, L., Denham, T., Brink, F., Troitzsch, U., & Stern, N. 2022. The microstratigraphic investigation of hearth features at Lake Mungo, Australia. *Journal of Archaeological Science: Reports* 46: 103711

Redhead, M. 1984. *Thermoluminescence Dating of Some Australian Sedimentary Deposits.* PhD Thesis, Department of Physics and Theoretical Physics, Australian National University.

Robinson, J. G. 1980. *Lake Mungo: An Analysis of the Surface Collection.* Masters Thesis, Australian National University.

Ross, N. and Letnic, M. 2023. *Rabbit Impacts On Ground Layer Plant Communities in Arid Rangelands.* Final report to Foundation for Rabbit-Free Australia Inc.

Roy, L. 2013. *Reduced to Tools: A technological study of two stone artefact assemblages from Lake Mungo, Australia.* Honours Thesis, Department of Archaeology and History, La Trobe University.

Schmidt, P. & Hiscock, P. 2020. The antiquity of Australian silcrete heat treatment: Lake Mungo and the Willandra Lakes. *Journal of Human Evolution* 142:102744.

Shawcross, W. 1975. Thirty thousand years and more. *Hemisphere* 19:26-31.

Shawcross, W. 1998. Archaeological excavations at Mungo. *Archaeology in Oceania* 33 (3):183-200.

Shawcross, W. & Kaye, M. 1980. Australian archaeology implications of current interdisciplinary research. *Interdisciplinary Science Reviews* 5 (2):112-28.

Smith, M. A. 2015. What sort of seed grinding at Pleistocene Lake Mungo? *Archaeology in Oceania* 50 (3):175 - 76.

Smith, T. E. 2019. *Depositional History and Palaeoenvironments of the Lake Mulurulu Lunette, Willandra Lakes World Heritage Area, New South Wales.* PhD Thesis, Australian National University.

Spennemann, D. H. R. 1994. *The Willandra Lakes Conundrum: World Heritage in Policy Conflict.* Charles Sturt University, School of Environmental and Information Science.

Spry, C. 2014. *Refitting a past: A comparison of late Pleistocene and Terminal Pleistocene/early Holocene stone tool technology at Lake Mungo, southwestern New South Wales, Australia.* PhD Thesis, Department of Archaeology and History, La Trobe University.

Stephenson-Gordon, G. 2018. *The Inconspicuous Tool: An Experimental Study of Use-Wear on Fine-Grained Silcrete Flakes and Case Study of Hearth Sites at Lake Mungo.* Honours Thesis, Department of Archaeology and History, La Trobe University.

Stern, N. 2015. The Archaeology of the Willandra: its empirical structure and narrative potential. *Long History, Deep Time: Deepening Histories of Place.* Australian National University Press, Acton. pp.221–41.

Stern, N. 2020. Lake Mungo, Archaeology of. *Encyclopedia of Global Archaeology.* Springer International Publishing, New York. pp.1-14.

Stern, N., Tumney, J., Fitzsimmons, K.E. & Kajewski, P. 2013. Strategies for investigating human responses to changes in landscape and climate at Lake Mungo in the Willandra Lakes, Southeast Australia. *Archaeology in Environment and Technology: Intersections and Transformations.* Routledge, London. pp.31–50.

Stringer, C. 1998. A metrical study of the WLH 50 calvaria. *Journal of Human Evolution* 34:327-32.

Thomas, K. 2022. Exploratory GIS: modelling past land use and occupancy with functional connectivity, Willandra Lakes Region World Heritage Area, NSW, Australia. *Journal of Computer Applications in Archaeology* 5: 188–214.

Thomas, K. 2020. *Participatory and Experimental GIS in the Willandra Lakes Region World Heritage Area, NSW.* PhD Thesis, Department of Archaeology and History, La Trobe University.

Thomas, K. 2023. Biocultural mapping: unpacking the myth of an unsuitable Country in the arid zone, Willandra Lakes Region World Heritage Area, Australia. *Environmental Systems Research* 2023: 12-23.

Thorne, A., Grün, R., Mortimer, G., Spooner, N.A., Simpson, J.J., McCulloch, M., Taylor, L. & Curnoe, D. 1999. Australia's oldest human remains: age of the Lake Mungo 3 skeleton. *Journal of Human Evolution* 36 (6):591-612.

Thorne, A. a. C., D. 2000. Sex and significance of Lake Mungo 3: Reply to Brown Australian Pleistocene variation and the sex of Lake Mungo 3. *Journal of Human Evolution* 39:587-600.

Thorne, A. G. 1971. Mungo and Kow Swamp: morphological variation in Pleistocene Australians. *The Australian Journal of Anthropology* 8 (2):85-89.

Thorne, A. G. 1975. *Kow Swamp and Lake Mungo: Toward a Craniology of Early Man in Australia.* PhD Thesis, University of Sydney.

Thorne, A. G. 1977. Morphological contrasts in Pleistocene Australians. *Sunda and Sahul: Prehistoric studies in South East Asia, Melanesia and Australia.* Academic Press, London. pp.187-204.

Thorne, A. G. & Wilson, S. R. 1977. Pleistocene and recent Australians: A multivariate comparison. *Journal of Human Evolution* 6 (4):393-402.

Tickle, I. 2016. *A study of stone artefacts found in association with hearths at Lake Mungo.* Honours Thesis, Department of Archaeology and History, La Trobe University.

Tidemann, C. R. 1988. A survey of the mammal fauna of the Willandra Lakes World Heritage region, New South Wales. *Australian Zoologist* 24 (4):197-204.

Tranter-Edwards, L. 2017. *Traces of past human activity at an inter-lake clay pan in the Willandra Lakes Region their context and significance.* Honours Thesis, Department of Archaeology and Anthropology, La Trobe University.

Trueman, J. W. H. 2001. Does the Lake Mungo 3 mtDNA evidence stand up to analysis? *Archaeology in Oceania* 36:163-65.

Truscott, W. 2012. *Erosion on the Mungo Lunette: The effects of small and large scale weather events on archaeological materials.* Honours Thesis, Department of Archaeology and History, La Trobe University.

Tumney, J. 2012. *Environment, landscape and stone technology at Lake Mungo, southwest New South Wales, Australia.* PhD Thesis, Department of Archaeology and History, La Trobe University.

Tumney, J. 2018. Identifying and characterising different types of stone artefact accumulations on the surface of the Lake Mungo lunette, southwest New South Wales, Australia. *Journal of Archaeological Science: Reports* 21:380-88.

Vick, S. 2012. *Chibnalwood Beach Quarry: A technological study of a silcrete source from the Willandra Lakes Region World Heritage Area.* Honours Thesis, Department of Archaeology and History, La Trobe University.

Turnbull, M, Parker A and Jankowski, N. 2023. The history of phytolith research in Australasian archaeology and palaeoecology. *Vegetation History and Archaeobotany* 32: 655-677.

Walshe, K. 1987. *Faunal bone material from the Mungo B excavation.* Honours Thesis, Australian National University.

Walshe, K. 1998. Taphonomy of Mungo B Assemblage: indicators for subsistence and occupation of Lake Mungo. *Archaeology in Oceania* 33 (3):201-06.

Way, A. 2016. Between Discovery and Deep Time: *A Study of the Cultural Representations of Mungo Man.* Masters of Research Thesis, Macquarie University.

Webb, J. & Domanski, M. 2008. The relationship between lithology, flaking properties, and artefact manufacture for Australian silcretes. *Archaeometry* 50:555-75.

Webb, S. 2004. *Research work carried out on the GL7 (Footprint site), May 8-13th 2004.* Unpublished research report.

Webb, S. G. 1989. *The Willandra Lakes Hominids.* Department of Prehistory, Research School of Pacific Studies, Australian National University, Canberra.

Webb, S. G. 1990. Cranial thickening in an Australian hominid as a possible palaeoepidemiological indicator. *American Journal of Physical Anthropology* 82:403-12.

Webb, S. G. 1995. *Palaeopathology of Aboriginal Australians: Health and Disease Across a Hunter-Gatherer Continent.* Cambridge University Press, Cambridge.

Webb, S. G. 2006. *The First Boat People.* Cambridge University Press, Cambridge.

Webb, S. G. 2007. Further research of the Willandra Lakes fossil footprint site, southeastern Australia. *Journal of Human Evolution* 52 (6):711-15.

Webb, S. G. 2018. Part III: The Willandra Lake Collection: A Record. *Made in Africa: Hominin Explorations and the Australian Skeletal Evidence.* Academic Press. pp.275-400.

Webb, S. G. 2021. An echo from a footprint: a step too far. *Reading Prehistoric Human Tracks. Methods and Material.* Springer, Switzerland. pp.397-412.

Webb, S. G., Cupper, M. L. & Robins, R. 2006. Pleistocene human footprints from the Willandra Lakes, southeastern Australia. *Journal of Human Evolution* 50 (4):405-13.

Westaway, M. C. 2009. *The Peopling of Ancient Australia.* PhD Thesis, Department of Archaeology and Anthropology, Australian National University.

Westaway, M. C., Cupper, M. L., Johnston, H. & Graham, I. 2013. The Willandra fossil trackway: assessment of ground penetrating radar survey results and additional OSL dating at a unique Australian site. *Australian Archaeology* 76:84-89.

Westaway, M. C., Olley, J. & Grün, R. 2017. At least 17,000 years of coexistence: Modern humans and megafauna at the Willandra Lakes, South-Eastern Australia. *Quaternary Science Reviews* 157:206–11.

Westaway, M. C. & Price, G. 2019. A palaeontological perspective on the proposal to reintroduce Tasmanian devils to mainland Australia to suppress invasive predators. *Biological Conservation* 232:187-93.

Westbrooke, M. E. & Miller, J. D. 1995. The vegetation of Mungo National Park, Western NSW. *Cunninghamia: a journal of plant ecology for Eastern Australia* 4 (1):63-80.

Weston, E. 2013. *A Study of Shell Tools from the Lake Mungo Lunette.* Honours Thesis, Department of Archaeology and History, La Trobe University.

Weston, E., Szabó, K. & Stern, N. 2017. Pleistocene shell tools from Lake Mungo lunette, Australia: Identification and interpretation drawing on experimental archaeology. *Quaternary International* 427:229-42.

Williams, D. 1991. *The Case of the Shattered Stones: An Analysis of Three Aboriginal Quarry/Reduction Sites from the Willandra Lakes World Heritage Area, South Western New South Wales.* Honours Thesis, Australian National University.

Worthy, T. 2016. A case of mistaken identity for Australia's extinct big bird. *The Conversation*.

Zimmer, C. 1999. New date for the dawn of dream time. *Science* 284 (5418):1245-46.

Reports:

Assessment of Effectiveness of the Rabbit Warren Ripping Program. Willandra Lakes Region World Heritage area. 2014. Report prepared by Sunraysia Environmental for the Office of Environment and Heritage.

Ashley, G. & Dunn, M. 2017. *Leaghur Pastoral Station. Mungo National Park.* Report prepared for the NSW Office of Environment and Heritage.

Ashley, G., McIntyre-Tamwoy, S., Betteridge, M., Betteridge, C., Armstrong, J. & Dunn, M. 2003. *Mungo National Park Historic Heritage. Volume 1 of 3:* Report prepared for the NSW National Parks and Wildlife Service.

Ashley, G., McIntyre-Tamwoy, S., Johnston, C., Travers, I., Urwin, N., Bowler, J.M. & Stern, N. 2013. *Willandra Lakes region World Heritage Area Plan of Management. Issues and Options report.* Report prepared for the NSW Office of Environment and Heritage.

Fatchen and Associates. 1985. *Summary and discussion. Archaeological and geomorphological heritage assessments of part Prungle and part benenong.* Report prepared for the NSW Department of Environment and Planning, Sydney.

Fatchen and Associates 1987. *Rabbit, Kangaroo and Goat populations on the Willandra World Heritage Region, Western New South Wales. Distribution, Abundance and Management needs.* Report prepared for the NSW Department of Environment & Planning.

Donavan and Associates 1985. *Willandra Lakes World Heritage Region Study of the European Cultural History: European Cultural History Study.* Report prepared for the Willandra Lakes World Heritage Region Consultative Committee.

Barrett, T., Bye, D., Booth, S. & Leys, J. 2016. *Sustaining Willandra. Phase II of the Willandra Spatial Prioritisation Program.* Report prepared for the NSW Western Local Land Services.

Boles, W. E. & McAllan, A. W. 1987. *An Inventory of the Birds of the Willandra Lakes World Heritage Region.* Report prepared for the Willandra Lakes World Heritage Region Consultative Committee.

Bowler, J. M. 1980. *Geomorphic Survey of Mungo National Park.* Report prepared for the New South Wales National Parks and Wildlife Service

Bowler, J. M. & Magee, J. W. 1985. *Geomorphology of the Willandra Lakes Region World Heritage area.* Report prepared for The Willandra Lakes World Heritage Plan of Management Committee.

Stepping back into the deep past at Lake Mungo. 2019. CABAH Annual Report prepared for the Australian Research Council.

Clark, P. M. 1985. *Heritage Assessment of part Prungle and part Benenong Archaeological sites: The Impact of Land Clearing and Cultivation.* Report prepared for The N.S.W. Department of Environmental Planning

Clark, P. M. 1987. *Willandra Lakes Region World Heritage area Archaeological Resource Study.* Report prepared for the New South Wales Department of Planning and the Western Lands Commission of NSW.

The Mungo Report: Statement of Significance of the Willandra Lakes World Heritage Area to the Aboriginal People of Western New South Wales 2017. Compiled by Western Heritage Group Inc.

Dowling, P., Hamm, G., Klaver, J., Littleton, J, S,. Erson, N. & Webb, S. 1985. *Middle Willandra Creek Site Survey.* Report

prepared for the Department of Prehistory and Anthropology, Australian National University.

Eldridge, D. J. & Tozer, M. E. 1996. *Erosion status of the Willandra World Heritage Area.* Report prepared for The Willandra Lakes World Heritage Property Community Management Council.

Gates, G. 1986. *Groundwater investigation at Prungle Lake in the Willandra Lakes World Heritage region.* Report prepared for the Prepared for NSW Water Resources Commission Hydrogeological Report.

Green, D. R. 1987. *Management guides for key archaeological sites, Willandra Lakes Region World Heritage area.* Report prepared for the National Parks and Wildlife Service.

Green, D. R. 1988. *List of Species, Willandra Lakes Region World Heritage area.* Report prepared for the National Parks and Wildlife Service.

Green, D. R. 1988. *Stocking Rates and Land Management Willandra Lakes Region World Heritage area.* Report prepared for the National Parks and Wildlife Service.

Healy H. 2011. *Mungo Youth Project Report.* Report prepared for the Mungo Youth Project Organising Committee.

Healy, H. 2020. *Mungo Youth Project Review Report: Issues and Recommendations.* Report prepared for the Mungo Youth Project Organising Committee.

Office of Environment and Heritage. 2015. *Sustaining Willandra. Integrated Land Management Framework.* Project Report to Western Local Land Services Contract Number MU9057.

Hope, J., Donaldson, T. & Hercus, L. 1986. *A history of the Aboriginal people of the Willandra Lakes Region: Part of a Study on the Significance of the Willandra Lakes World Heritage Region to Aboriginal Communities.* Report prepared for the National Estate.

Implications of Climate Change for Australia's World Heritage Properties: A Preliminary Assessment. 2009 Report prepared by the Australian National University for the Department of Climate Change and the Department of the Environment, Water, Heritage and the Arts.

Johnston, H. 2013. *Joulni Cultural Landscape Management Plan.* Report prepared for the NSW National Parks and Wildlife Service & The Willandra Lakes Region World Heritage Area Community Management Council.

Keogh, L. 2018. *Listen to the Land. Pastoralists in the Willandra Lakes Region World Heritage Area, 1981-2003.* Report prepared for the NSW National Parks and Wildlife Service.

Magee, J. 1976. *The Willandra Lakes Region Southwestern New South Wales. Resource Survey.* Report prepared for the NSW National Parks and Wildlife Service.

Magee, J. 1985. *The Willandra Lakes Region southwestern New South Wales Resource Survey.* Report prepared for the Department of Environment, Housing and Community Development.

McBryde, I. 1975. *A Report on work undertaken on the Lake Mungo Lunette, Aug 74. Prepared for the*

McBryde, I., McGee, J. & Clark, P. 1995. *Willandra Lakes Region World Heritage Property: Review of Boundaries. Consideration of the boundaries from the perspective of the area's cultural and natural values. Report* prepared for the Technical and Scientific Advisory Committee (Willandra Lakes Region World Heritage Area).

Milne, A. K. & O'Neill, A. L. 1989. *Feasibility study for using landsat imagery to monitor land cover change in the Willandra Lakes World Heritage Region.* Report prepared for The Willandra Lakes World Heritage Plan of Management Committee.

Nomination of the Willandra Lakes Region for inclusion in the World Heritage List 1980. Report prepared for the Australian Heritage Commission

Rice, B. 1986. *Aspects of the vegetation of the Willandra Lakes World Heritage Region.* Report prepared for the NSW Department of Environment and Planning.

Ridges, M. & Simpson, G. 2018. *Mungo Youth Project 2017. Cultural Survey Report.* Report prepared for the NSW Office of Environment and Heritage.

Thomas, K. 2020. *Willandra Lakes Region World Heritage Area - GL7 Fossil Trackway.* Report prepared for the Office of Environment and Heritage

Tidemann, C. R. 1985. *The Mammal Fauna of the Willandra Lakes Region World Heritage area New South Wales.* Report prepared for the Department of Environment and Planning, New South Wales

Tuck, D. 2019. *Leaghur Pastoral Station. Homestead Precinct.* Report prepared for the NSW National Parks and Wildlife Service.

Wakefield, B. & Biggs, R. 2014. *Stories of Deep Time: Kids teaching Kids. Willandra Lakes World Heritage Area. Lake Mungo.* Mungo Youth Project Report 2014.

Williams, D. 2016. *Repatriation of Cultural Materials and Human Remains to the Willandra: A Brief Review.* Report prepared for the Office of Environment and Heritage.

Williams, M. 2016. *Key outcomes report of a Willandra Repatriation forum held in Mildura 17-18 February 2015.* Report prepared for the Office of Environment and Heritage.

Williams, M. 2016. *Key outcomes report of a 2nd Willandra Repatriation forum held in Buronga 9 November 2016.* Report prepared for the Office of Environment and Heritage.

Williams, M. 2017. *Key outcomes report of a 3rd Willandra Repatriation forum held at Inland Botanic Gardens, Buronga on 5th April 2017.* Report prepared for the Office of Environment and Heritage.

World Heritage in NSW Discussion Paper. 2010. Prepared for the NSW Department of Planning.