UNIVERSITY *of York*

This is a repository copy of *A database of radiocarbon dates for palaeoenvironmental research in eastern Africa*.

White Rose Research Online URL for this paper:
https://eprints.whiterose.ac.uk/100183/

Version: Published Version

Article:
Courtney-Mustaphi, Colin John and Marchant, Robert orcid.org/0000-0001-5013-4056 (2016) A database of radiocarbon dates for palaeoenvironmental research in eastern Africa. Open Quaternary.

https://doi.org/10.5334/oq.22

Reuse
This article is distributed under the terms of the Creative Commons Attribution (CC BY) licence. This licence allows you to distribute, remix, tweak, and build upon the work, even commercially, as long as you credit the authors for the original work. More information and the full terms of the licence here:
https://creativecommons.org/licenses/

Takedown
If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.

White Rose university consortium
Universities of Leeds, Sheffield & York

eprints@whiterose.ac.uk
https://eprints.whiterose.ac.uk/

OPENQUATERNARY

Courtney Mustaphi, C and Marchant, R 2016 A Database of Radiocarbon Dates for Palaeoenvironmental Research in Eastern Africa. *Open Quaternary*, 2: 3, pp. 1–7, DOI: http://dx.doi.org/10.5334/oq.22

DATA PAPER

A Database of Radiocarbon Dates for Palaeoenvironmental Research in Eastern Africa

Colin Courtney Mustaphi and Rob Marchant

York Institute for Tropical Ecosystems, Environment Department, University of York, Heslington, York, YO10 5NG, UK

Corresponding author: Colin Courtney Mustaphi (ccour087@gmail.com)

Radiocarbon dating is one of the most widely available and applied techniques to develop Late Quaternary chronologies of many ecosystems and is, thus, utilized in Quaternary studies, archaeology, hydrology, geomorphology, palaeoanthropology, palaeoclimatology, palaeoecology, palaeontology, and isotope analyses. A manual literature review search of published radiocarbon dates from eastern Africa was undertaken to store these data in the open-access format and included in the Canadian Archaeological Radiocarbon Database. Dates ranged from 57,804 to 0 ^{14}C years Before Present. The format of the database permits expansion of the dataset in the future and permits local, regional and global scale analyses of radiocarbon dates. This paper expands on some of these potential research areas and promote archiving of African data.

Keywords: Accelerator mass spectrometry; Africa; archaeology; carbon isotopes; chronostratigraphy; depositional systems; geochronology; palaeoanthropology; palaeoecology; palaeoclimate; sedimentary systems

Funding statement: This research was funded by a European Commission grant to RM (FP7-PEOPLE-2013-ITN 606879) and a PAGES grant to RM to host a workshop on land cover and land use in East Africa.

(1) Overview

Introduction

Increasingly, the ecological palaeoecology approach (Birks 2012; Rull 2014) is being applied to provide long-term contexts to modern ecological, human-environment interaction, conservation studies and land management policies (Willis & Birks 2006; Gillson & Marchant 2014). Geochronological information is critical to understanding past changes in ecosystem compositions and distributions, landscape ontogeny, and to characterize historical baselines of variability to inform management, conservation, and remediation efforts. Geochronological information permits analyses of the variability and rates of change to Earth system processes, including climate, ecosystem changes, evolution, phylogenies, and constraining the interactions between ecosystems and human modifications, across multiple spatiotemporal scales. Radiocarbon dating is one of the most widely available and applied techniques to develop Late Quaternary chronologies of many ecosystems (Libby 1946; Arnold & Libby 1949; Libby et al. 1949; Anderson & Libby 1951; Trumbore 2000) and is, thus, utilized in Quaternary studies, archaeology, hydrology, geomorphology, palaeoanthropology, palaeoclimatology, palaeoecology, palaeontology, and isotope analyses.

Within these scientific disciplines, radiocarbon dates are often reported alongside publication literature but have only recently begun to be collated into regional (Fyfe et al. 2008; Gajewski et al. 2011) and global databases (Gajewski et al. 2002, Marchant et al. 2002; Gajewski 2008; Grimm 2008; Power et al. 2008). Data repositories improve accessibility for research across multiple disciplines and to other interested groups outside of academia (Brewer et al. 2012; Grimm et al. 2013). Additionally, databases are useful as educational and professional training tools (Courtney Mustaphi et al. 2014; Goring et al. 2015). An accessible archive of published radiocarbon dates from eastern Africa is necessary for robust syntheses of multi-site and large spatial scale analyses of palaeoenvironmental sites (Daniau et al. 2010), data-model intercomparison (Braconnot et al. 2012; Marlon et al. 2015), and to provide a tool for investigating past human demographics (Gayo et al. 2015; Chaput et al. 2015). Empirical data of past environmental conditions are a critical resource for constraining model outputs of projected future change within the Earth system.

Context

Spatial coverage

Depositional environments in eastern Africa.

Description: Burundi, Egypt, Ethiopia, Kenya, Tanzania, and Uganda, Malawi, Mauritius, Mozambique, and the Gulf of Aden.

Northern boundary: 22.692141
Southern boundary: –22.231519
Eastern boundary: 57.518249
Western boundary: 29.083309

Temporal coverage

The spread of radiocarbon dates ranged from 57,804 ^{14}C yr BP to modern radiocarbon ages (1950 common era; 0 calibrated years BP). BP, before present.

(2) Methods

A manual literature search was conducted and published radiocarbon dates were entered from palaeoenvironmental studies, including palaeoclimatological, palaeoecological, environmental archaeology and palaeontological sources. Dates were collected from geologic (carbonaceous sediments, plant macroremains); anthropogenic (hearths, fire pits, and pottery); and faunal remains (eggshell, bone, dung). Other sources of dated material are noted in the data files. Dates from study sites required published coordinates and details pertaining to common radiocarbon dating reporting, such as laboratory code identifiers, radiocarbon ages and errors (Stuiver & Polach 1977; Van der Plicht & Hogg 2006; Millard 2014).

Steps

The vast majority of dates were entered in the database manually from tables in published literature or data sources. The data upload template has minimum requirements, including the identifier code supplied by the laboratory, the material dated, geographic coordinates, and the radiocarbon age with associated 1σ dating error.

Conforming to CARD criteria, publications that did not present radiocarbon laboratory identification codes were assigned as 'LUNK-000' or 'LLUNK-000' that can be updated in the future (n = 6). In cases where the δ^{13}C values were not recorded alongside radiocarbon dates (n = 392), the values were estimated as: –27‰ for peat, bulk sediment, picked organic samples, and dung; –25‰ for wood and charcoal; –10‰ for bone apatite; and 0‰ for marine shells and foraminifera. These values can also be updated if needed and are noted as assayed, estimated, or measured. Modern radiocarbon dates were inputted as 0±0 ^{14}C yr BP and users are referred to the data source reference.

Sampling strategy

Quality Control

Used the data input template (version 1.3; 29 September, 2015) of the CARD 2.0 database.

Constraints

(3) Dataset description

Radiocarbon dates (n = 793) were tabulated primarily from geologic settings (n = 763), archaeological (n = 23) and palaeontological (n = 7). Sixty eight study sites were examined encompassing 70 published papers. Modern radiocarbon dates were assigned as 0 ± 0 ^{14}C yr BP (n = 21). The majority of geological dates were from Kenya and Tanzania (**Fig. 1**). Most of the dates obtained were from the late Holocene (**Fig. 2**). Dates were dominantly from studies of lacustrine and palustrine sediments and fewer dates from soil, cave, fluvial or marine depositional settings. Dated samples of biogenic material such as charcoal and bone that were manipulated by human agency were assigned as archaeological. Faunal remains that were naturally deposited were classified as palaeontological.

Object name

CARD2.0 database:
CARD_Upload_Template_-_KITE_East_Africa_v1.0.xlsx

Harvard Dataverse:
Courtney Mustaphi, Colin, 2016, "Radiocarbon dates from eastern Africa in the CARD2.0 format", http://dx.doi.org/10.7910/DVN/NJLNRJ, Harvard Dataverse, V5

Data type

Collated secondary data with references to publication sources.

Format names and versions

MS Office 2010 Excel file (.xlsx) and identical version as a .csv file (Courtney Mustaphi, 2016).

Creation dates

The data was collated in this format beginning 30 August 2015 and ended 6 February 2016.

Dataset Creators

Colin J. Courtney Mustaphi, researcher, University of York.

Language

English.

License

The dataset is available from Harvard Dataverse under a CC0, Public Domain Dedication. The CARD database version requires registration and webpage login for access as part of the global database.

Repository location

Canadian Archaeological Radiocarbon Database (CARD version 2.0) (Morlan, 1999) http://www.canadianarchaeology.ca/

Duplicate deposited to the Harvard Dataverse (Courtney Mustaphi 2016) http://dx.doi.org/10.7910/DVN/NJLNRJ

Publication date

16-03-2016

(4) Reuse potential

The Canadian Archaeological Radiocarbon Database (CARD) was developed as a repository and database for querying archaeological, geologic and paleontological sites and is now a global database (Morlan 1999). An East African Radiocarbon Database developed at York

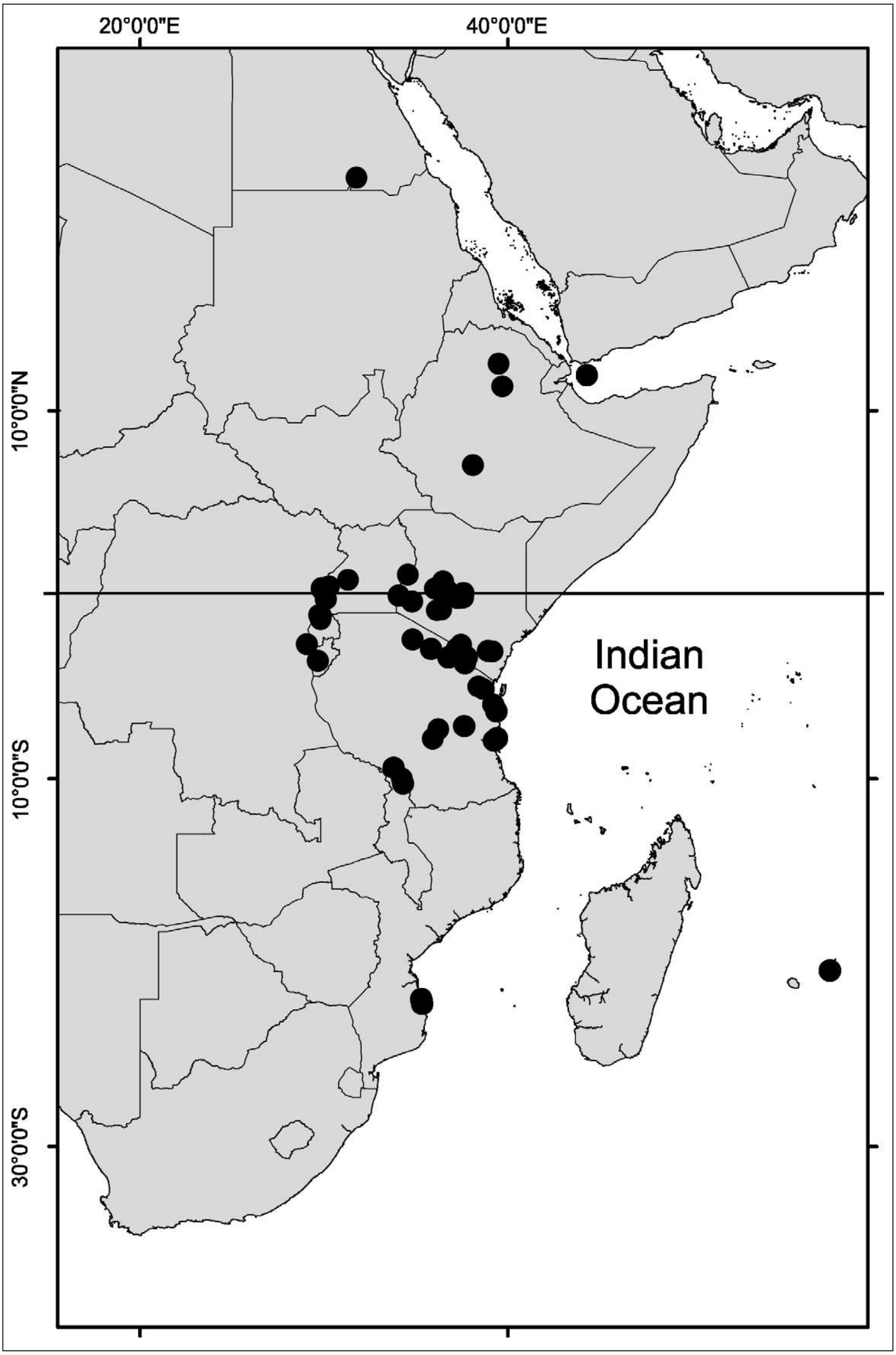

Figure 1: Map of eastern Africa and the locations of published radiocarbon dates presented in the dataset.

Institute for Tropical Ecosystems has been formatted to port into CARD2.0. It is freely available at http://www.canadianarchaeology.ca. Extremely few radiocarbon dates from Africa are stored within available databases (Chaput & Gajewski in press) and most dates pertain to cultural artefacts and not environmental sources that are useful for palaeoenvironmental and palaeoecological querying. Here we present nearly 800 reported radiocarbon dates

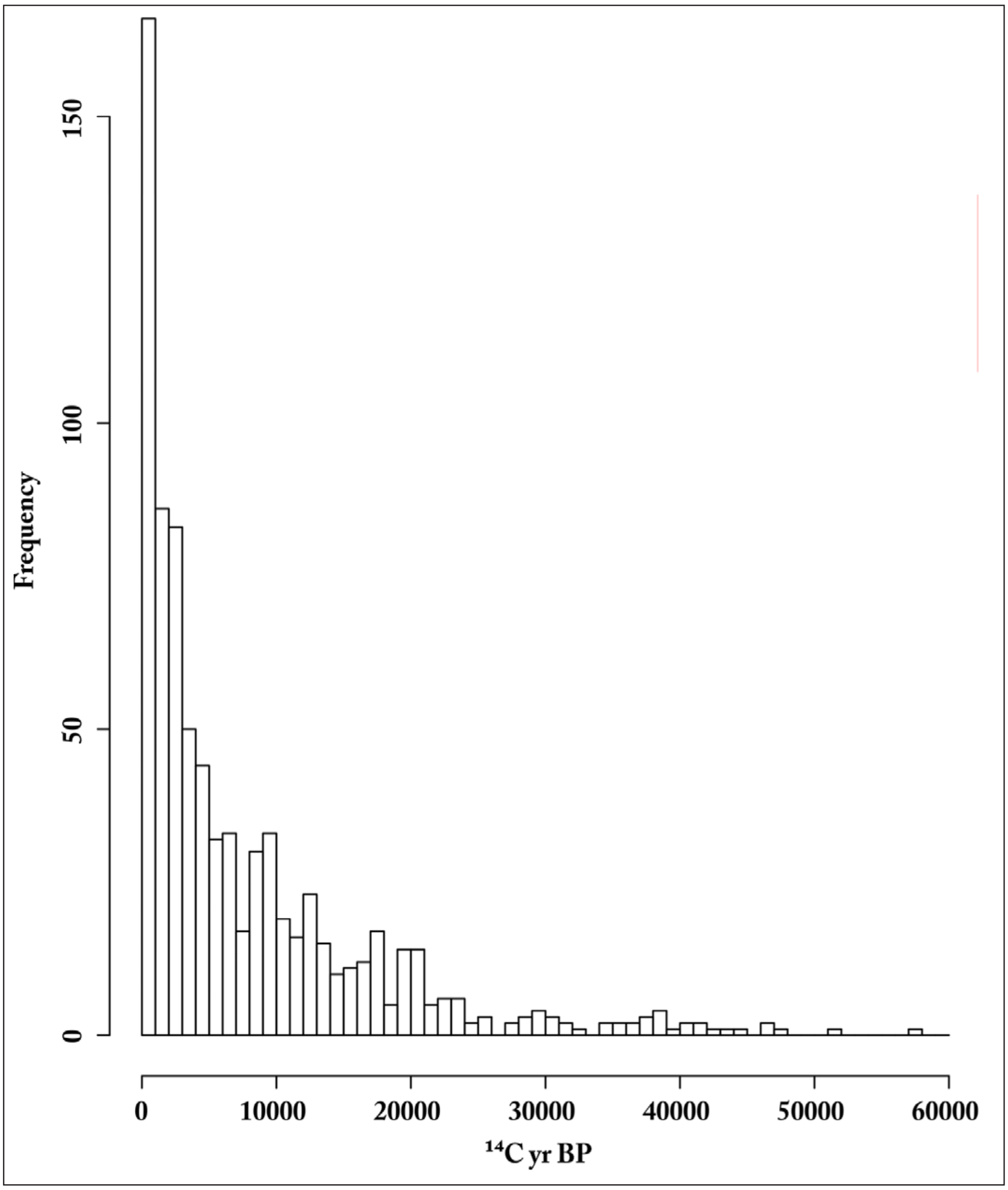

Figure 2: Histogram of uncalibrated radiocarbon dates in the dataset in 1000-year bins.

from eastern Africa, primarily derived from palaeoecological studies and encourage expansion by the palaeoecological, palaeontological and archaeological research communities with an interest in African climate, ecology, people and landscapes.

These data were compiled as part of ongoing work to collect palaeoenvironmental proxy data from study sites across eastern Africa and formatted to be shared via the global CARD database and website interface. This is especially important as few radiocarbon dates from Africa are readily available and here we present an initial fraction of the published dates from Africa. The database can be expanded as additional researchers contribute. These data can be used to examine environmental patterns of change across the region in the past (McClure 1976), including erosion and sediment accumulation rates (Goring et al. 2012; Crann et al. 2015), and past demographics using dated cultural material (Chaput et al. 2015). Sediment accumulation rates in fragmentary and non-sequential depositional systems, such as fluvial, colluvial, and turbidite environments may need further scrutiny due to the complexity of reworking, depositional hiatus, and instantaneous events (Chiverrell et al. 2009). Furthermore, caveats have been identified for the use of radiocarbon dates as potential proxies of ancient population numbers and this remains an active topic in archaeology (Shennan et al. 2013; Timpson et al. 2014; Attenbrow & Hiscock 2015; Brown 2015). Individual studies will require scrutiny of the radiocarbon data applied to investigate past demographies and substantiate the use of such proxy data (Torfing 2015). Palaeoenvironmental data continues to be accrued into various repositories and databases but all rely on baseline geochronological data. To improve reproducibility and data sharing, we suggest explicit presentation of stratigraphic and geochronological controls in papers so that age-depth models can be reconstructed.

We present the CARD2.0 database as a useful and readily accessible repository for radiocarbon age determinations from studies in Africa and hope to expand upon these initial samples with further effort in the research community for open-access use. It is foreseeable that there will be increasing global requirements for databased and referenced palaeoenvironmental data from multiple user groups across multiple disciplines in ecology, conservation, land management, policy, palaeoecology, environmental modeling, anthropology, archaeology, sedimentology, geochronology and education (Kriegel et al. 2010; Brewer et al. 2012; Marchant and Lane 2015).

Acknowledgements

We thank Richard Morlan and Andrew Martindale for developing and maintaining the CARD 2.0 database. We thank all participants of the PAGES LandCover6k working group on land cover and land use in East Africa hosted by the British Institute in Eastern Africa, Nairobi, Kenya (22–23 October, 2015).

Competing Interests

The authors declare that they have no competing interests.

References

Anderson, E C and **Libby, W F** 1951 World-wide distribution of natural radiocarbon. *Physical Review*, 81: 64. DOI: http://dx.doi.org/10.1103/PhysRev.81.64

Arnold, J R and **Libby, W F** 1949 Age determinations by radiocarbon content: checks with samples of known age. *Science*, 110: 678–680. DOI: http://dx.doi.org/10.1126/science.110.2869.678

Attenbrow, V and **Hiscock, P** 2015 Dates and demography: are radiometric dates a robust proxy for long-term prehistoric demographic change? *Archaeology in Oceania*, 50: 30–36. DOI: http://dx.doi.org/10.1002/arco.5052

Birks, H J B 2012 Ecological palaeoecology and conservation biology: controversies, challenges, and compromises. *International Journal of Biodiversity Science, Ecosystem Services and Management*, 8: 292–304.

Braconnot, P, Harrison, S P, Kageyama, M, Bartlein, P J, Masson-Delmotte, V, Abe-Ouchi, A, Otto-Bliesner, B and **Zhao, Y** 2012 Evaluation of climate models using palaeoclimatic data. *Nature Climate Change*, 2: 417–424. DOI: http://dx.doi.org/10.1038/nclimate1456

Brewer, S, Jackson, S T and **Williams, J W** 2012 Paleoecoinformatics: applying geohistorical data to ecological questions. *Trends in Ecology and Evolution*, 27: 104–112. DOI: http://dx.doi.org/10.1016/j.tree.2011.09.009

Brown, W A 2015 Through a filter, darkly: Population size estimation, systematic error, and random error in radiocarbon-supported demographic temporal frequency analysis. *Journal of Archaeological Science*, 53: 133–147. DOI: http://dx.doi.org/10.1016/j.jas.2014.10.013

Chaput, M A and **Gajewski, K** (in press) Radiocarbon dates as estimates of ancient human population size. *Anthropocene*. DOI: http://dx.doi.org/10.1016/j.ancene.2015.10.002

Chaput, M A, Kriesche, B, Betts, M, Martindale, A, Kulik, R, Schmidt, V and **Gajewski, K** 2015 Spatiotemporal distribution of Holocene populations in North America. *Proceedings of the National Academy of Sciences of the United States of America*, 112: 12127–12132. DOI: http://dx.doi.org/10.1073/pnas.1505657112

Chiverrell, R D C, Foster, G C, Thomas, G S P, Marshall, P and **Hamilton, D** 2009 Robust chronologies for landform development. *Earth Surface Processes and Landforms*, 34: 319–328. DOI: http://dx.doi.org/10.1002/esp.1720

Courtney Mustaphi, C J 2016 Radiocarbon dates from eastern Africa in the CARD2.0 format. DOI: http://dx.doi.org/10.7910/DVN/NJLNRJ, Harvard Dataverse, V5

Courtney Mustaphi, C J, Rucina, S M and **Marchant, R** 2014 Training in emerging palaeoenvironmental approaches to researchers on the dynamics of East African ecosystems. *Frontiers of Biogeography*, 6: 169–172.

Crann, C A, Patterson, R T, Macumber, A L, Galloway, J M, Roe, H M, Blaauw, M, Swindles, G T and **Falck, H** 2015 Sediment accumulation rates in subarctic lakes: Insights into age-depth modeling from 22 dated lake records from the Northwest Territories, Canada. *Quaternary Geochronology*, 27: 131–144. DOI: http://dx.doi.org/10.1016/j.quageo.2015.02.001

Daniau, A L, Harrison, S P and **Bartlein, P J** 2010 Fire regimes during the Last Glacial. *Quaternary Science Reviews* 29: 2918–2930. DOI: http://dx.doi.org/10.1016/j.quascirev.2009.11.008

Gajewski, K 2008 The Global Pollen Database in biogeographical and palaeoclimatic studies. *Progress in Physical Geography*, 32: 379–402. DOI: http://dx.doi.org/10.1177/0309133308096029

Gajewski, K, Lezine, A M, Vincens, A, Delestan, A and **Sawada, M** 2002 Modern climate–vegetation–pollen relations in Africa and adjacent areas. *Quaternary Science Reviews*, 21: 1611–1631. DOI: http://dx.doi.org/10.1016/S0277-3791(01)00152-4

Gajewski, K, Muñoz, S, Peros, M, Viau, A, Morlan, R and **Betts, M** 2011 The Canadian archaeological radiocarbon database (CARD): archaeological ^{14}C dates in North America and their paleoenvironmental context. *Radiocarbon*, 53: 371–394.

Gayo, E M, Latorre, C and **Santoro, C M** 2015 Timing of occupation and regional settlement patterns revealed by time-series analyses of an archaeological radiocarbon database for the South-Central Andes (16–25 S). *Quaternary International*, 356: 4–14. DOI: http://dx.doi.org/10.1016/j.quaint.2014.09.076

Gillson, L and **Marchant, R** 2014 From myopia to clarity: sharpening the focus of ecosystem management through the lens of palaeoecology. *Trends in Ecology and Evolution,* 29: 317–325. DOI: http://dx.doi.org/10.1016/j.tree.2014.03.010

Goring, S, Dawson, A, Simpson, G L, Ram, K, Graham, R W, Grimm, E C and **Williams, J W** 2015 neotoma: A Programmatic Interface to the Neotoma

Paleoecological Database. *Open Quaternary*, 1: 1–17. DOI: http://dx.doi.org/10.5334/oq.ab

Goring, S, Williams, J W, Blois, J L, Jackson, S T, Paciorek, C J, Booth, R K, Marlon, J R, Blaauw, M and **Christen, J A** 2012 Deposition times in the northeastern United States during the Holocene: establishing valid priors for Bayesian age models. *Quaternary Science Reviews*, 48: 54–60. DOI: http://dx.doi.org/10.1016/j.quascirev.2012.05.019

Grimm, E C 2008 Neotoma: an ecosystem database for the Pliocene, Pleistocene, and Holocene. *Illinois State Museum Science Papers*, E: 1.

Grimm, E C, Bradshaw, R H W, Brewer, S, Flantua, S, Giesecke, T, Lézine, A M, Takahara, H and **Williams, J W** 2013 Databases and their application. In: Encyclopedia of Quaternary Science (Eds. S.A. ELIAS & C.J. MOCK). Elsevier, Amsterdam. 831–838. DOI: http://dx.doi.org/10.1016/B978-0-444-53643-3.00174-6

Kriegel, H P, Kröger, P, Van Der Meijden, C H, Obermaier, H, Peters, J and **Renz, M** 2010 Towards archaeo-informatics: scientific data management for archaeobiology. In: *Scientific and Statistical Database Management*, Volume 6187. Springer, Berlin, pp. 169–177. DOI: http://dx.doi.org/10.1007/978-3-642-13818-8_14

Libby, W F 1946 Atmospheric helium three and radiocarbon from cosmic radiation. *Physical Review,* 69: 671. DOI: http://dx.doi.org/10.1103/PhysRev.69.671.2

Libby, W F, Anderson, E C and **Arnold, J R** 1949 Age determination by radiocarbon content: world-wide assay of natural radiocarbon. *Science*, 109: 227–228. DOI: http://dx.doi.org/10.1126/science.109.2827.227

Marchant, R, Almeida, L, Behling, H, Berrio, J C, Bush, M, Cleef, A, Duivenvoorden, J, Kappelle, M, De Oliveira, P, DE Oliveira-Filho, A T and **Lozano-Garćia, S** 2002 Distribution and ecology of parent taxa of pollen lodged within the Latin American Pollen Database. *Review of Palaeobotany and Palynology*, 121: 1–75. DOI: http://dx.doi.org/10.1016/S0034-6667(02)00082-9

Marchant, R and **Lane, P** 2015 Past perspectives for the future: foundations for sustainable development in East Africa. *Journal of Archaeological Science* 51: 12–21. DOI: http://dx.doi.org/10.1016/j.jas.2013.07.005

Marlon, J R, Kelly, R, Daniau, A-L, Vannière, B, Power, M J, Bartlein, P, Higuera, P, Blarquez, O, Brewer, S, Brücher, T, Feurdean, A, Gil-Romera, G, Iglesias, V, Maezumi, S Y, Magi, B, Courtney Mustaphi, C J and **Zhihai, T** 2015 Reconstructions of biomass burning from sediment charcoal records to improve data-model comparisons. *Biogeosciences Discussions*, 12: 18571–18623. DOI: http://dx.doi.org/10.5194/bgd-12-18571-2015

Mcclure, H A 1976 Radiocarbon chronology of late Quaternary lakes in the Arabian Desert. *Nature,* 263: 755–756. DOI: http://dx.doi.org/10.1038/263755a0

Millard, A R 2014 Conventions for reporting radiocarbon determinations. *Radiocarbon*, 56: 555–559. DOI: http://dx.doi.org/10.2458/56.17455

Morlan, R 1999 Canadian archaeological radiocarbon database: establishing conventional ages. *Canadian Journal of Archaeology*, 23: 3–10.

Power, M J, Marlon, J, Ortiz, N, Bartlein, P J, Harrison, S P, Mayle, F E, Ballouche, A, Bradshaw, R H W, Carcaillet, C, Cordova, C and **Mooney, S** 2008 Changes in fire regimes since the Last Glacial Maximum: an assessment based on a global synthesis and analysis of charcoal data. *Climate Dynamics*, 30: 887–907. DOI: http://dx.doi.org/10.1007/s00382-007-0334-x

Rull, V 2014 Time continuum and true long-term ecology: from theory to practice. *Frontiers in Ecology and Evolution*, 2: 75. DOI: http://dx.doi.org/10.3389/fevo.2014.00075

Shennan, S, Downey, S S, Timpson, A, Edinborough, K, Colledge, S, Kerig, T, Manning, K and **Thomas, M G** 2013 Regional population collapse followed initial agriculture booms in mid-Holocene Europe. *Nature Communications*, 4: 2486. DOI: http://dx.doi.org/10.1038/ncomms3486

Stuiver, M and **Polach, H A** 1977 Discussion; reporting of C-14 data. *Radiocarbon*, 19: 355–363.

Timpson, A, Colledge, S, Crema, E, Edinborough, K, Kerig, T, Manning, K, Thomas, M G and **Shennan, S** 2014 Reconstructing regional population fluctuations in the European Neolithic using radiocarbon dates: a new case-study using an improved method. *Journal of Archaeological Science*, 52: 549–557. DOI: http://dx.doi.org/10.1016/j.jas.2014.08.011

Torfing, T 2015 Layers of assumptions: A reply to Timpson, Manning, and Shennan. *Journal of Archaeological Science*, 63: 203–205. DOI: http://dx.doi.org/10.1016/j.jas.2015.08.017

Trumbore, S E 2000 Radiocarbon geochronology. In: Noller, J S, Sowers, J M and Lettis, W R (Eds.) *Quaternary geochronology: Methods and applications*. AGU, Washington DC, pp. 41–60.

Van Der Plicht, J and **Hogg, A** 2006 A note on reporting radiocarbon. *Quaternary Geochronology*, 1: 237–240. DOI: http://dx.doi.org/10.1016/j.quageo.2006.07.001

Willis, K J and **Birks, H J B** 2006 What is natural? The need for a long-term perspective in biodiversity conservation. *Science*, 314: 1261–1265. DOI: http://dx.doi.org/10.1126/science.1122667

How to cite this article: Courtney Mustaphi, C and Marchant, R 2016 A Database of Radiocarbon Dates for Palaeoenvironmental Research in Eastern Africa. *Open Quaternary*, 2: 3, pp. 1–7, DOI: http://dx.doi.org/10.5334/oq.22

Submitted: 16 March 2016 **Accepted:** 06 May 2016 **Published:** 20 May 2016

Copyright: © 2016 The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC-BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited. See http://creativecommons.org/licenses/by/4.0/.

]u[*Open Quaternary* is a peer-reviewed open access journal published by Ubiquity Press. OPEN ACCESS