Dendrochronologia 40 (2016) 50–63

Contents lists available at ScienceDirect

Dendrochronologia

journal homepage: www.elsevier.com/locate/dendro

Original article

Stable oxygen isotope signatures of early season wood in New Zealand kauri (*Agathis australis)* tree rings: Prospects for palaeoclimate reconstruction

Andrew M. Lorrey[a,*], Tom H. Brookman[h], Michael N. Evans[b], Nicolas C. Fauchereau[c], Cate Macinnis-Ng[d], Margaret M. Barbour[e], Alison Criscitiello[f], Greg Eischeid[g], Anthony M. Fowler[d], Travis W. Horton[h], Daniel P. Schrag[g]

[a] *National Institute of Water and Atmospheric Research Ltd., National Climate Centre NIWA, 41 Market Place, Viaduct Precinct, Auckland, 1011, New Zealand*
[b] *Department of Geology, University of Maryland, United States*
[c] *National Institute of Water and Atmospheric Research LTD, Hamilton, New Zealand*
[d] *School of Environment, University of Auckland, New Zealand*
[e] *Faculty of Agriculture and Environment, University of Sydney, Australia*
[f] *Department of Geography, University of Calgary, Canada*
[g] *Department of Earth and Planetary Sciences, Harvard University, United States*
[h] *Department of Geological Sciences, University of Canterbury, New Zealand*

ARTICLE INFO

Article history:
Received 11 October 2015
Received in revised form 2 March 2016
Accepted 23 March 2016
Available online 1 June 2016

Keywords:
Kauri
Agathis australis
New Zealand
Dendroclimatology
Isotopes
Mechanistic modelling

ABSTRACT

One of the longest Southern Hemisphere tree ring chronologies that has potential to provide past climate reconstructions has been produced using New Zealand kauri (*Agathis australis*). Work to date on kauri has been limited to reconstructions from whole-ring width analysis. In this study, we present the first replicated stable oxygen isotopic composition of early season alpha-cellulose from calendar-dated kauri tree rings within the natural growth range of the species. We also use newly established kauri physiology information about stomatal conductance and a mechanistic model to place initial interpretations on kauri $\delta^{18}O$ signatures.

Kauri early season $\delta^{18}O$ has a range from 26 to 34‰ (V-SMOW) for a site located at Lower Huia Dam in west Auckland, and the mean $\delta^{18}O$ chronology from that site is significantly correlated ($p < 0.05$) to October-December vapor pressure, May-December relative humidity and other associated hydroclimatic variables. The observed statistical relationships are consistent with mechanistic $\delta^{18}O$ simulations using the forward model of Barbour et al. (2004) that incorporates a leaf temperature energy balance model to calculate transpiration as forced with local meteorological variables and a range of physiological parameters. The correlation results and mechanistic model simulations suggest kauri $\delta^{18}O$ early season wood has the potential to provide new quantitative past climate information for northern New Zealand, and also complement whole ring-width reconstructions of past regional climate variability – a component of which is previously established as sensitive to El Niño-Southern Oscillation activity. Additional work is required to determine whether the observed relationships are consistent across the growth range of kauri and what the optimum sample depth is before long isotope-based palaeoclimate reconstructions from modern and sub-fossil kauri sites are undertaken.

1. Introduction

1.1. Background

Kauri (*Agathis australis*) is a long-lived endemic canopy emergent conifer native to northern New Zealand (Ecroyd, 1982). Mature kauri commonly attain diameters greater than 1.5 m at breast height and ages of 600–1000 years (Ogden 1983; see Fig. 1 for example), which has supported the development of long dendrochronology records (Dunwiddie, 1979; Palmer, 1982; Fowler, 1984; Boswijk et al., 2006, 2014). Tree ring records developed thus far from kauri have been employed in palaeoclimatic and ecological studies during the past few decades (Ogden, 1983; Boswijk et al., 2002, 2006; Fowler et al., 2008). Recent work has also demonstrated the potential of kauri tree rings for palaeoclimate reconstruction of El Niño-Southern Oscillation activity (ENSO) from a New

* Corresponding author.
E-mail address: a.lorrey@niwa.co.nz (A.M. Lorrey).

http://dx.doi.org/10.1016/j.dendro.2016.03.012
1125-7865/

Fig. 1. An example of a living kauri (*Agathis australis*) from Trounson Kauri Park, Northland New Zealand. The specimen is approximately 1.65 m diameter at breast height.

Zealand perspective (Fowler et al., 2000, 2008, 2012). There are also several pre-Holocene millennial-length sub-fossil kauri chronologies (Lorrey and Ogden, 2005; Lorrey et al., 2005; Palmer et al., 2006; Lorrey et al., 2007) that could provide unique insights into climatic changes during the Holocene and the late Pleistocene from a region where palaeo-proxies are under-represented (McCarroll and Loader, 2004; Jansen et al., 2007; Neukom and Gergis, 2012).

Kauri dendroclimatology has previously relied on – and has been limited to – master ring-width chronology variance changes as a means of exploring past regional climate variability and atmospheric circulation changes (Fowler et al., 2012). Prior work also