

Climate Research

Running rings around climate change

Drew Lorrey explains how interpreting tree rings can extend climate records into the distant past and give clues to the impacts of climate change.

If you've ever chopped firewood or closely examined a sawn tree stump, you probably noticed that trees' annual growth rings vary in width from one year to the next. Dendrochronology (tree + time-study) is the science of using patterns of narrow and wide annual tree rings to establish growing conditions – including climate – during the tree's lifetime. These growth patterns are unique in time, and they can be similar between trees due to regional-scale climate changes. Many long-lived tree species are climatically sensitive enough to be used in dendrochronology, which is useful for New Zealand records because instrumental climate data only go back to about 1850. In many cases, the ring width patterns correspond to a climate variable so closely they can be substituted for it back past the instrumental coverage. In this case, the rings become a proxy – or stand in – for instrumental climate data. A dendrochronologist can become a kind of climate detective, using tree-ring records as clues to past climate changes from long before people were around to measure them.

Written in the kauri

NIWA scientists are involved in several tree-ring projects that aim to reconstruct different aspects of past climate. One such project, led by the University of Auckland, is climate reconstruction from kauri (*Agathis australis*) tree rings and speleothems (calcium carbonate cave deposits). The Auckland team recently produced a world-class calendar-dated kauri chronology extending back to 1724 BC. This record, one of a handful of multi-millennial-length chronologies in the world, is the second longest in the southern hemisphere. The kauri chronology is iconic due to its length and the sheer size of the trees it comes from.

In addition, a pilot study funded by the Royal Society of New Zealand and Harvard University in 2007 has investigated the climatic meaning of kauri tree-ring cellulose chemistry. One finding was a correlation between the oxygen isotope signal and temperature changes, and we now may be able to reconstruct past temperature with extraordinary precision from kauri tree rings.

Massive kauri trees found buried in Northland bogs have also yielded some of the world's oldest tree-ring records. High-precision radiocarbon dating indicates some of the swamp kauri is about 30 000–60 000 years old, and the trees lived within a span known as Oxygen Isotope Stage Three (OIS3). This era is recognised as a period of unusually unstable climate, and as a key transition after which *Homo sapiens* emerged as the sole human species on earth. The ancient kauri chronologies are not yet all linked, but collectively they cover more than 15 000 years within OIS3. These records may provide us with a series of windows through which we can peer into the past to study climate change, assess if abrupt climate changes were synchronous for the northern and southern hemispheres, and help understand the role climate change has on the development of life.

Telling climate by the trees

- Annual growth rings record growing conditions (including climate) over the lifetime of a tree.
- Once the rings' variations are deciphered, they can help determine climate for times when there are no records.
- Research projects around New Zealand are using dendrochronology to improve climate records.

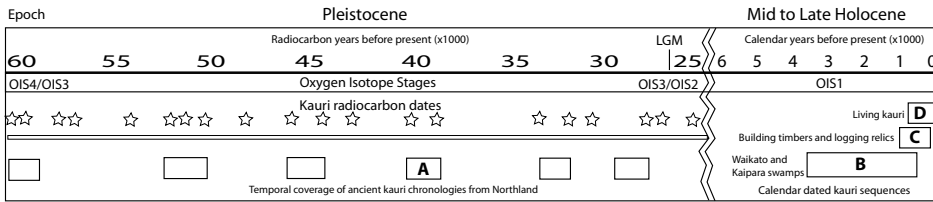
Ancient trees, like this kauri at Manaia Sanctuary, Coromandel Peninsula, have recorded centuries of climate variation within their annual growth rings. Here, Professor John Ogden takes a core near the base of the tree.

Drought recorded in beech trees

We recently began another project to see if tree rings could be used to reconstruct past drought. This pilot study was funded through the NIWA Innovative Seed Fund, and is using *Nothofagus solandrii* (beech) samples from the Craigieburn Range in Canterbury as a proxy for drought. Previous work from the early 1980s indicated the ring-width patterns in Craigieburn beech trees correlated to periods of low river flow. However, the samples for the earlier project were insufficient to push a drought reconstruction beyond 1880, and also missed out on some severe El Niño events and regional droughts that occurred since 1977. Thus far, we have updated that record to 2006, and have now gathered enough samples to push a climate reconstruction back to 1850. Cores recently collected from living trees also extend back to the early 1800s, showing promise that with more work a longer record is possible.



Photo: Tony Bewlay



Photos: A. & B. Drew Lorrey; C. Gretel Boswijk; D. Joelle Gergis

Kauri chronologies

The time line shows the distribution of New Zealand kauri chronologies, and corresponds to four types of wood sources from which kauri tree-ring records are constructed. The Late Holocene kauri chronology – a composite of living trees, building timbers, and sub-fossil wood – is calendar-dated (on the right-hand end of the scale); the older OIS3 kauri chronologies – all sub-fossil – are relatively dated by radiocarbon. Stars indicate radiocarbon dates on kauri wood not presently incorporated in any chronology.

Clockwise from top left:

- A. A sub-fossil kauri log, about 50 000 years old, from Omaha Flats. Diameters in excess of 3 m are commonplace for ancient kauri, and this stump was severed from the log before extraction.
- B. Kaihu Kauri Sawmill owner Nelson Parker cuts a series of 'biscuit' samples from some trees that were extracted from a swamp near Dargaville.
- C. Tree ring sequences from kauri buildings, such as this kauri dam, can be used for constructing chronologies.
- D. Jonathan Palmer removes a core from a kauri tree in Northland. The only living tissue in the entire pencil-sized core is a small section 5 mm in diameter and typically less than 2 mm thick, just under the bark. The living trees are not harmed in the process of taking core samples.

left: Cores from two kauri trees with the annual rings aligned; the ring from 1900 is marked.



We aim to push the record back to 1750 by collecting more cores from living trees and sub-fossil material (recently dead and partially buried trees) on scree slopes and in alluvium. In addition, we will examine more detailed structures within the rings, like individual vessel diameters, to see if they can improve drought reconstruction. More important, the techniques used in this project can potentially be employed on other chronologies that presently cover New Zealand to examine the severity and spatial patterns of past drought. This information will help fill major knowledge gaps in New Zealand climate science and will be useful for improving climate model results.

A forest of possibilities

There are many opportunities for examining past climate variations using tree-ring records. New Zealand dendrochronology records can be used to reconstruct periods of drought, storminess, flood, precipitation and temperature fluctuation, frost, atmospheric circulation, and seasonal extremes. The potential of tree-ring proxies can help us better understand the nature of climatic processes, the value of which cannot be overstated. This natural resource also provides detailed information with unparalleled resolution and age control, which is important for

outlining the full range of natural climate variations that need to be understood for successful adaptation to climate changes. **W&A**



Pockets of beech trees cling to the slopes of Purple Hill above Lake Pearson at the Craigieburn Sheep Station in Canterbury. This is one of our study sites for reconstructing drought records from growth-ring variations.



Photos: Drew Lorrey

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