How old is that Rainforest Tree … and why might it matter?

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Poster produced October 2019. Contact: Denise.Bond@macadamias.org

Introduction

Macadamias are a rare Australian Proteaceae genus of four species, all threatened with extinction (Mast et al., 2008). Now restricted to remnant forest within 50km of the east coast from the Richmond River in NSW to Bulburin National Park in Queensland, they are threatened by habitat loss, global warming, invasive weeds and loss of genetic diversity. Post invasion and the widespread clearing that followed, their closed forest habitat has been reduced by over 80% (Powell et al., 2014).

Commercial interests

Two macadamia species are farmed for their seeds (macadamia nuts), making macadamia one of the few international food crops to have been developed from either the basal eudicots, or the Australian flora (Nock et al, 2019). Most other commercial nut species have been cultivated and bred for hundreds of generations resulting in a body of written observations and experimental results.

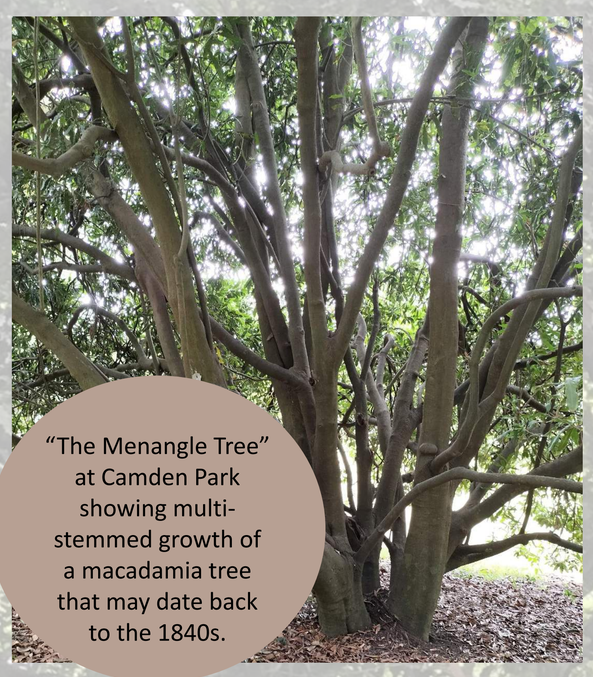
Lack of data on macadamia natural and cultural history

Little is known about the basic ecology of macadamia species. Even being able to determine the age of macadamia trees would have three benefits:

- Improved understanding of cultural heritage associated with macadamias
- Improved understanding of natural distribution of macadamias to inform conservation planning
- Greater understanding of macadamia physiology, with implications for both conservation planning and the macadamia industry.

166 years old and going strong

The oldest known macadamia is the Walter Hill tree, planted in the Brisbane Botanic Gardens in 1858. The background image of this poster shows the tree in 2018, then 160 years old. Another contender for oldest living macadamia is the tree below, planted at Camden Park in the gardens established by Sir William MacArthur. Known as "The Menangle Tree", it grows in a section of garden established in the 1840s. Detailed planting records have not survived, so the origin and date of planting of this tree is unknown, although genetic testing shows it to be related to trees from south of the Brisbane River (Nock, C. 2020 unpublished).



"The Menangle Tree" at Camden Park showing multi-stemmed growth of a macadamia tree that may date back to the 1840s.

For many Northern Hemisphere tree species, it is possible to obtain an approximate age through counting annually formed rings, or bands in the tree. However, macadamias, like many non-deciduous trees of closed, wet forests do not have clearly visible annual growth rings, making it difficult to establish the age of individuals using counts of bands, or rings.

We therefore tested band counts in three sets of samples of the species of known, or approximately known, age, against dates obtained through AMS ^{14}C dating. If band counts provide a consistent approximation of years, this method could be used to assess the approximate age of many individual trees.

Method

Two 'live' trees scheduled to be removed from an old orchard were selected for sampling. These two trees (Trees 1 & 2) were:

- planted in 1946
- single stemmed
- the same *M. integrifolia* cultivar
- experienced the same environment and management history

A dead tree (the historical "Jordan" tree) thought to be around 170 years old and also *M. integrifolia* was selected (Tree 3) to see if band counts could be used as a reasonable age estimate in older as well as younger trees.

Sample	Tree 1	Tree 2	Tree 3
Status at collection	Alive	Alive	dead
Collection date	Aug 2023	Aug 2023	Oct 2021
Presumed age from historical records	77	77	> 168
Source location	Decommissioned orchard, Gympie		Remnant tree in paddock

Disc samples were cut from each tree, as close to the ground as possible while avoiding trunk wedging or defects. The disc from the older tree was obtained from some way up the stem to avoid decay. Discs were dried slowly and finely sanded to reveal growth bands. Bands were counted and then a wedge cut from each disk. The wedges were sent to the Australian Nuclear Science and Technology Organisation (ANSTO) for radiocarbon dating. Two samples were extracted from Trees 1 and 2, either side of the band estimated (by band counting) to be 1965, the peak of ^{14}C content in the Southern Hemisphere. This peak is due to testing of nuclear bombs and means it is possible to date samples to a precise year. Five samples were extracted from Tree 3 to estimate its age. Cellulose from the samples was combusted to CO_2 then reduced to graphite (Hua et al., 2001) for AMS ^{14}C analysis (Fink et al., 2004). Calendar age associated with each radiocarbon date was achieved using the Bayesian "sequence" model of the OxCal program (Bronk Ramsey, 2008) and the SHCal20 calibration curve (Hogg et al., 2020) extended to the recent time using the SH zone 1-2 bomb radiocarbon data (Hua et al., 2022).

Results

The results suggest that band counting cannot be used to provide a consistently reliable estimate of macadamia tree age.

Note some issues that may have impacted modelled age for Tree 3:

- stem sampled may not have been the oldest trunk of the tree
- disc was taken from at least a metre above ground as stem had rotted and fallen over
- initial growth of trees under canopy can be very slow.

Sample trees	Tree 1	Tree 2	Tree 3
Age from historical sources	77 years	77 years	Estimated 168 years
Band Count	75 years	60 years	Not possible
Radiocarbon dating	Suggested band count accurate to within 2 years	Suggests 15 to 22 missing bands	Modelled age of 127 years (103-196 years, 68% Confidence Interval) Based on 5 samples and the death date (see Figure 2)

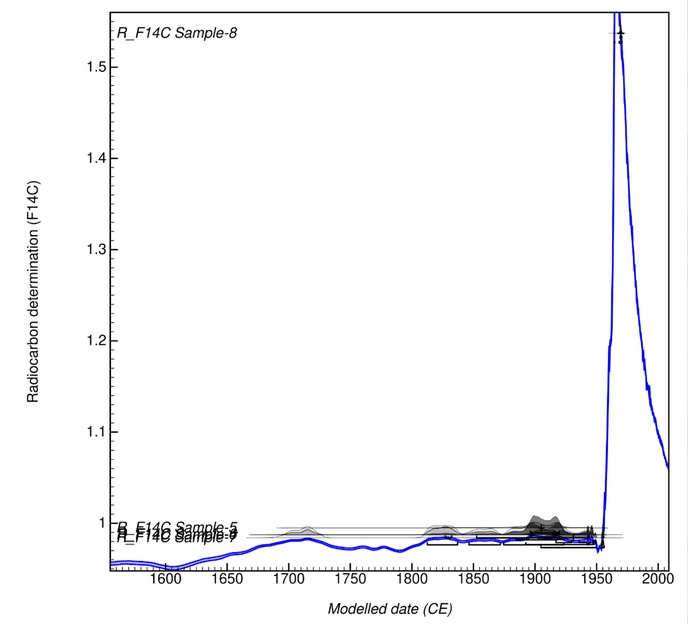


Figure 2 - Curve plot showing radiocarbon dating of Tree 3 based on 5 samples in sequence and the year the tree died (2020).

Discussion

The results from these three samples illustrate some of the challenges to using either band counting or radiocarbon dating to determine the age of macadamia trees.

Factors relating to macadamia growth habit	Implications for determining tree age
Rate of growth is highly dependent on access to sunlight - shaded seedlings may remain small for decades	During periods of slower growth, annual bands may not be visible
Trunks are seldom circular and can have pronounced wedging	Wedging results in expansion and contraction of bands making them difficult to count accurately
Trees may grow multiple stems in response to disturbance and can resprout after damage to the main trunk resulting in stems of multiple ages	The living trunk may not be the first stem grown by the tree
Trees can continue to grow with quite extensive damage to trunk	Older tree trunks may include decay and stress fractures

Tree dating techniques such as AMS ^{14}C dating are expensive and involve extraction of living tissue (unless the tree is already dead). These results show that growth-band counting is not consistently reliable for macadamias, so radiocarbon dating of a series of ^{14}C dates from a sequence or bomb ^{14}C dating may be the only technique currently available for dating old macadamia trees. Locating the oldest tissue of an individual macadamia tree for radiocarbon dating may be a challenge if there are multiple stems and fungal or insect damage at the base of the tree.

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Thanks to the following for contributing to this project:

- QDAF (for extracting and transporting Tree disc samples)
- Private landholders (for allowing access to trees and extraction of samples)
- ANSTO Portal grant AP14574 for AMS ^{14}C analysis

Background image of the Walter Hill tree in 2018 - Credit MCT