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Tree-ring analysis of sub-fossil kauri (*Agathis australis*) from near Maitahi Road, Dargaville, Northland



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Tree-ring analysis of sub-fossil kauri (*Agathis australis*) from near Maitahi Road, Dargaville, Northland

This is a technical archive report describing recent dendrochronological analysis of sub-fossil kauri from Robert and Caroline Yates' property, near Maitahi Road, north of Dargaville. Although the primary application of data derived from this analysis is for palaeoclimate reconstruction, no attempt is made to provide discussion of standardisation techniques used to enhance the climate signal for dendroclimatology or offer any dendroclimatological interpretation. The report is concerned only with the development of tree-ring chronologies. Discussion and interpretation of data are limited to setting any chronologies in a broad environmental context.

Summary

Tree-ring analysis of sub-fossil kauri (*Agathis australis*) from a drained peat bog near Maitahi Road, Dargaville region, Northland, was undertaken as part of a dendroclimatology project: *El Nino history as recorded in kauri tree-rings*, which aimed to develop long chronologies for climate analysis. Eleven samples were obtained from trees which once grew at the site. Two samples were from milled slabs and the remaining samples were from remnant sections of trunks left on the paddock after the kauri had been recovered. A 1003 year chronology, **Maitahi**, was developed from three tree-sequences. When analysis of the Maitahi assemblage was undertaken the only other sub-fossil chronologies were from the Waikato Lowlands. **Maitahi** crossmatched against two Waikato chronologies, but there was a one-year difference between **Maitahi** and one chronology, **Whangape**, which could not be satisfactorily resolved at the time. Since then several new chronologies have been developed and the swamp kauri chronologies have been linked to the modern, calendar dated kauri master. Calendar dates have been applied extending back to 315 BC. However, the one-year difference between **Maitahi** and **Whangape** prevented application of calendar dates to all sub-fossil chronologies. Replication of **Maitahi** by other northland chronologies indicated that the one-year difference resulted from a false ring in **Whangape**. Resolution of this error enabled calendar dates to be applied to the entire suite of sub-fossil kauri chronologies. **Maitahi** was calendar dated to 576 BC – AD 427. A single tree-sequence, **MAI005**, was calendar dated to 1362 – 944 BC. The remaining samples were either unsuitable for analysis or did not crossmatch with any other site chronologies or tree-sequences. Two samples were identified as probably manoa (*Halocarpus kirkii* or *Lagarostrobos colensoi*). A tree-sequence was made from one manoa sample, but this did not crossmatch to any kauri chronologies, or sub-fossil manoa sequences from elsewhere in the Dargaville region.

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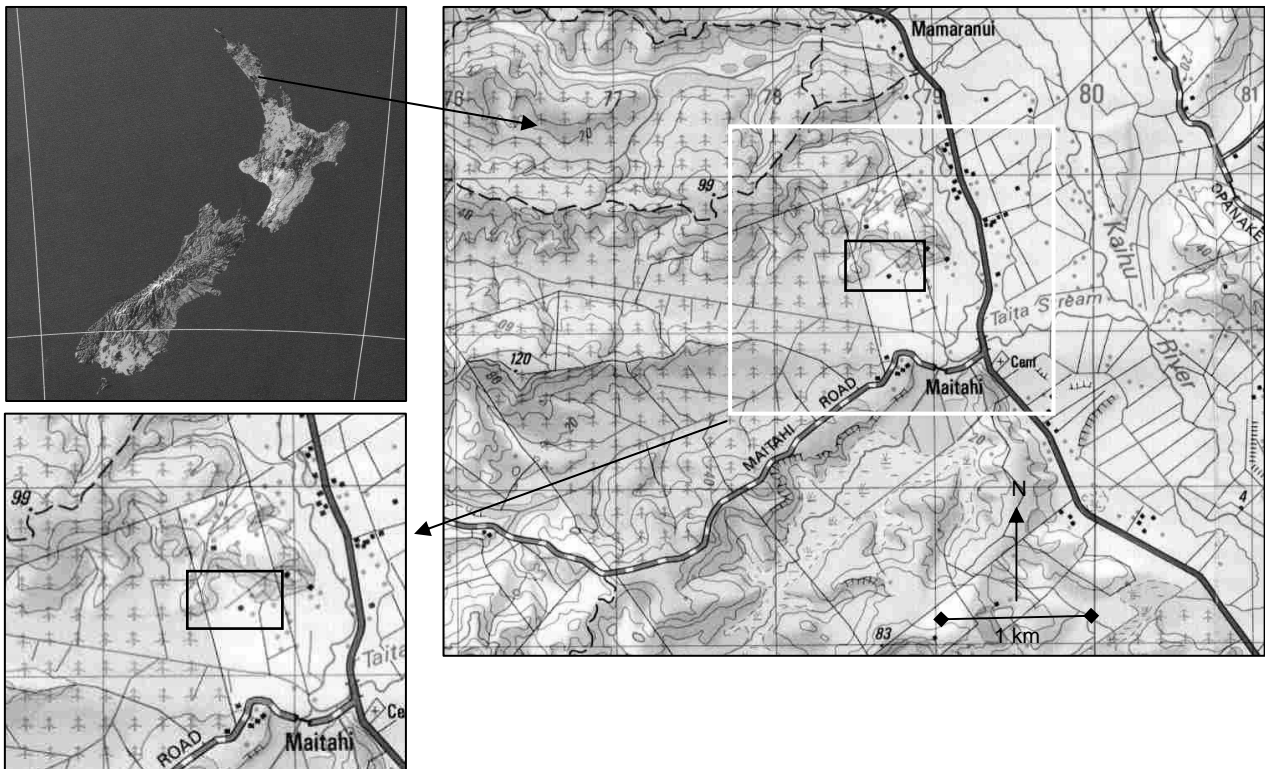
Introduction

Samples of milled sub-fossil kauri (*Agathis australis*) were supplied by Kevin Morris, Kaihu Valley Sawmill Ltd, Kai Iwi Lakes Road, for a Marsden funded tree-ring based palaeoclimatology project: *El Nino history as recorded in kauri tree-rings* (UOA108). The kauri had been extracted from a drained peat bog north of Maitahi Road, near Dargaville (Figure 1). Additional samples were obtained from sections of trees left at the site after milling during a visit to the Dargaville region in November 2002. The Maitahi wood is one of several assemblages of sub-fossil kauri from sites in the upper North Island where Holocene age kauri has been collected.

The sampling site was situated on the northern edge of the lower reaches of a former peat bog, characterised by Parore peaty sandy loam (Sutherland et al 1980), on Robert and Caroline Yates' property (Figure 1; NZMS 260-P07 786945). The remnant tree sections were near the edge of hills of well to moderately well drained Tangitiki sandy loam and sand, and imperfectly to poorly drained Te Kopuru sands (Sutherland et al 1980). The latter occurs in particular, in hills to the south of the swamp, along which Maitahi Road runs. The bog has been drained and converted to pasture and pine plantation. To the south of Maitahi road is a semi-wooded swamp where the stumps and trunks of past forest trees have been exposed as peat has shrunk.

Figure 1: Location of the swamp at Maitahi Road.

Inner box indicates the approximate where samples were obtained from the paddock.



Dendrochronology

Dendrochronology or tree-ring analysis is based on the measurement and comparison of patterns of tree-growth. The principles and methodology of tree-ring analysis are described in detail by Stokes and Smiley (1968), Fritts (1976) and Baillie (1982). In brief, each year trees lay down a growth ring, formed in the cambium directly under the bark. In many species, including kauri, these annual rings are clearly defined by a boundary formed at the end of the growing season, which separates one growth season from the next. The width of the annual ring is limited by climatic conditions, as well as being influenced by local environmental factors, previous growth years and genetic make-up of the tree. Because growth conditions change from year to year, ring-width also varies, creating a pattern of wide and narrow rings which unique in time, but common to trees that have grown at the same time under similar conditions. Therefore it is possible to compare the growth patterns of different trees and identify those which are contemporary. Comparison of many different living kauri from several sites throughout the upper North Island indicate that these trees have a common growth pattern in their rings (Fowler *et al* 2004).

Methods

A kauri log had been extracted from the site and removed to the Kaihu Valley Sawmill, Kai Iwi Lakes Road just off State Highway 12, north of Dargaville, where it was milled. A slice from the end of one slab was provided by Kevin Morris for tree-ring analysis. During a visit to the region in November 2002, further samples were collected from slabs at the sawmill, and Kevin Morris also cut several slices from remnant sections of kauri left on the paddock at the Maitahi site. The site has been assigned a site-code 'MAIT', since the area is crossed by Maitahi Road, and all the wood was labelled with a prefix 'MAI'.

The kauri slices were photographed and dimensions recorded prior to the samples being prepared for analysis (Appendix 1: Figure A1). Up to four radii were cut from each slice. The cross-sectional surface of all samples was sanded using progressively finer sandpaper to clearly reveal the ring sequence. Ring-widths were measured using a binocular microscope and travelling stage linked to a computer. The measurements were recorded in 'Dendro Input', a data capture program (Tyers 1999).

Crossmatching was undertaken using the CROS computer programs (Baillie and Pilcher 1973; Munro 1984), which are included in the Dendro for Windows suite (Tyers 1999). The ring-width series were compared against each other and the correlation coefficient (r) measured at every position of overlap. A Student's t value is also calculated, to provide a measure of the probability of the r value arising by chance (Baillie 1982). All reported t and r values are from CROS73.

Crossmatched radii from each tree sample were combined to produce a tree-sequence that was subsequently used for inter-tree crossmatching. All MAIT tree-sequences (derived from single measurements or multiple radii) were compared against each other statistically and visually and those that crossmatched were averaged together to create a mean ring-width chronology (referred to as a site chronology). This reduces the effect of local conditions on the ring-width data and strengthens the climate signal, on which crossmatching is dependant (Baillie 1982). The site chronology was compared with other sub-fossil kauri chronologies to identify any periods of overlap. At the time analysis of the Maitahi wood was

undertaken the modern kauri master extended to AD 911² and floating sub-fossil kauri chronologies had been derived from sites in the Waikato Lowlands, which were radiocarbon dated to between ca. 3500 – 1700 BP (Boswijk *et al* 2005). The sub-fossil kauri chronologies had been assigned Kauri Scale (KS) dates of 6167 – 8300 KS. This is an arbitrary scale used to align floating chronologies relative to each other, without continual revision of start and end dates. Samples from Maitahi were crossmatched to two Waikato chronologies, but for reasons described below the assemblage was set aside until further site chronologies were developed. New sub-fossil kauri chronologies have now been constructed from other sites in the Dargaville region and the calendar dated record extended back to 315 BC after the modern and sub-fossil chronologies were linked (Boswijk 2005a). This has improved prospects for obtaining calendar dates for the Maitahi samples.

All suggested matches (between radii, between tree-sequences and for chronologies against chronologies) were checked visually using plotted ring-width graphs. Ring-width graphs also aided the identification and resolution of any ring problems. Kauri can occasionally produce 'false' rings (the annual ring is divided by an apparent boundary) or locally absent rings (the annual ring is not complete around the tree circumference). Where a ring was absent on one radius, but present on other same-tree series, inspection of the sample usually located the ring merging into the ring boundary for the previous year. This allowed a measured value for the ring to be inserted into the series. If a ring was wholly absent from a radius, a zero value was inserted. If the location of missing rings could not be reliably resolved, the radius sequence was truncated.

Occasionally different samples may be highly correlated, and if supported by close visual agreement, this may indicate that they are derived from the same source tree. In these cases, samples were relabelled (wood and data files) to indicate same-tree provenance.

Results

Eleven samples were obtained from MAIT. These comprised a mix of end sections of slabs (**MAI001**, **MAI002**), incomplete round sections (**MAI003**, **MAI004**, and **MAI010**), a half section (**MAI006**) and fragments (**MAI005**, **MAI007**, **MAI009**, and **MAI011**). Five samples were from trunks, and two were possibly from head-logs or branch. Details of all the samples (dimensions, number of rings, average growth rates etc) are provided in Table 1.

One sample, **MAI003** was not measured as it had narrow rings and wide, very dark, patches of resin-filled cells, which obscured ring boundaries. Tree-sequences were made for six samples: **MAI001**, **MAI002**, **MAI004**, **MAI006**, **MAI008** and **MAI009**. The longest radius in this group, **MAI001a**, had 838 rings. The sample **MAI005** had broken into two sections. A tree-sequence was constructed from three radii from the inner part of the sample. The outer sections of **MAI005a**, **MAI005b** and **MAI005c** were also measured but only **MAI005b** and **MAI005c** could be crossmatched against each other. **MAI008** was notable as it had numerous locally absent rings on both radii.

² The annual growth ring relates to two calendar years, as the austral growing season crosses the change of year. For convenience the ring is labelled according to the year growth started.

After sample preparation, **MAI010** and **MAI011** were identified as probably manoa (*Halocarpus kirkii* or *Lagarostrobos colensoi*) rather than kauri. Manoa has obvious growth rings, with dark latewood (which forms at the end of the growing season) clearly defining the end of each season's growth. Sub-fossil manoa samples from Yakas farm, Babylon Coast Road, near Dargaville have also been analysed, although the samples did not crossmatch against each other or to kauri chronologies from the same site (Boswijk and Palmer 2004).

All tree-sequences were compared against each other to identify those that were contemporary. One group of five tree-sequences was identified. The remaining samples did not crossmatch with this group or with each other.

Maitahi

The Maitahi group initially included five tree-sequences: **MAI001**, **MAI002**, **MAI004**, **MAI006** and **MAI009**. High *t*-values and *r*-values strongly suggested that **MAI001**, **MAI004** and **MAI009** were from the same tree (Table 2, Figure 2; Appendix 2a). This was supported by the close visual agreement of line plots for these samples. Radii from **MAI004** and **MAI009** were renamed with the prefix **MAI001** and labelled sequentially from 'e' to 'l' (Table 1) and a new version of **MAI001** made. The **MAI001** tree-sequence spans 1003 years. A site chronology, **Maitahi**, was constructed from **MAI001**, **MAI002** and **MAI006**.

Table 2: Crossmatching between tree-sequences included in Maitahi

High *t*- and *r* values between **MAI001**, **MAI004** and **MAI009** are in *italics*. The application of calendar dates is described below.

| Filenames | - | - | MAI001 | MAI002 | MAI004 | MAI006 | MAI009 |
|---------------|-------|-------|---------------|---------------|---------------------|---------------|---------------------|
| - | start | dates | 571BC | 13BC | 576BC | 388BC | 469BC |
| - | dates | end | AD267 | AD315 | AD223 | AD135 | AD427 |
| MAI001 | 571BC | AD267 | * | 8.55 / 0.46 | <i>37.77 / 0.80</i> | 13.24 / 0.50 | <i>36.85 / 0.81</i> |
| MAI002 | 13BC | AD315 | * | * | 7.89 / 0.46 | 9.39 / 0.62 | 12.40 / 0.57 |
| MAI004 | 576BC | AD223 | * | * | * | 12.29 / 0.48 | <i>30.48 / 0.76</i> |
| MAI006 | 388BC | AD135 | * | * | * | * | 14.35 / 0.53 |

$n = 10$ min $t = 7.89$ max $t = 37.77$ mean $t = 18.32$ s.d. = 11.25

Figure 2: Position of overlap between tree-sequences in Maitahi

Each bar represents the measured span of one tree-sequence. The application of calendar dates used for the scale is described below.



Table 1: Details of the Maitahi samples

Key:**Sample** –MAI*** = tree-sequence used for chronology building; radii are listed below**Length** - radii length, measured from pith to edge, or edge to edge, x width when cut.**Pith** – C = centre; <5 = less than five to pith; 5-10 = 5 – 10 rings to pith; >10 = more than 10 rings to pith**Rings** – *n+ n = *extra inner rings* + measured rings; h = heartwood; n + n* = measured rings + extra outer rings; h = heartwood rings; s = sapwood rings; b= bark edge. Extra rings were either unmeasured or excluded from the series due to irresolvable problems.**Bark** – b = bark edge; bw = final ring complete (died winter); +½Bs = + ½ unmeasured ring to bark edge (died spring/summer). Extra sapwood rings were either unmeasured or excluded.**AGR** – average growth rate (mm per annum)**Date** – according to position in chronology or tree-sequence. May be calendar (AD/BC) or relative (rel = relates to position within the tree-sequence only). The application of calendar dates is described in the text.**Absent rings:** indicates years – calendar or rel – when there were locally absent rings in a series (i.e. rings not present on the measured radius).

| Sample | Species | Length (mm) | Pith | Rings | Bark | AGR | Date | Chronology | Absent rings | Comment |
|----------------------|-------------|-------------|------|------------------|------------|-------------|------------------------|----------------|-------------------------|--|
| MAI001 | AGAU | | | 1003 | | 0.63 | 576 BC – AD4 27 | Maitahi | | Mai001, 004 and 009 all same tree. |
| MAI001a | | 547 x 54 | >10 | 838 | | 0.62 | 571 BC-AD 267 | | | Mai001 was cut from a milled slab, |
| MAI001b | | 420 x 58 | >10 | 416 | | 0.76 | 501 BC-86 BC | | | MAI004 was a possible head-log or |
| MAI001c | | 350 x 56 | >10 | 358 | | 0.87 | 486 BC-129 BC | | | branch, and MAI009 from trunk remnant |
| MAI001d | | 420 x 58 | >10 | 642 | | 0.55 | 511 BC-AD 131 | | | on the paddock. |
| MAI001e (ex MAI004a) | | 350 x 70 | C | 502 | | 0.47 | 576 BC-75 BC | | | |
| MAI001f (ex MAI004b) | | 420 x 76 | C | 799 | | 0.48 | 576 BC-AD 223 | | 109 BC | |
| MAI001g (ex MAI004c) | | 312 x 74 | >10 | 767 | | 0.40 | 548 BC-AD 219 | | 227; 109 BC; AD 33; 208 | |
| MAI001h (ex MAI004d) | | 294 x 74 | C | 504 | | 0.44 | 576 BC-73 BC | | 226; 136; 109 BC | |
| MAI001i (ex MAI009a) | | 570 x 65 | >10 | 587 | | 0.94 | 160 BC-AD 427 | | | |
| MAI001j (ex MAI009b) | | 750 x 70 | >10 | 742 | | 0.98 | 422 BC-AD 320 | | | |
| MAI001k (ex MAI009c) | | 700 x 68 | >10 | 804 | | 0.85 | 452 BC-AD 352 | | | |
| MAI001l (ex MAI009d) | | 702 x 72 | >10 | 820 | | 0.83 | 469 BC-AD 351 | | | |
| MAI002 | AGAU | | | 328 | | 1.11 | 13 BC – AD 315 | Maitahi | | |
| MAI002a | | 360 x 71 | C | 5h+328 | | 1.09 | 13 BC-AD 315 | | | |
| MAI002b | | 351 x 72 | C | 7h+300 | | 1.14 | 13 BC-AD 287 | | | |
| MAI003 | AGAU | | | | | | | | | Not measured: small sample from head- |
| MAI003a | | 245 x 70 | <5 | | | | | | | log or branch, with narrow rings and |
| MAI003b | | 280 x 70 | C | | | | | | | dark, wide resin patches on A, B, C and, |
| MAI003c | | 282 x 70 | C | | | | | | | to a lesser extent, on C. Retained |
| MAI003d | | 258 x 75 | C | | | | | | | sapwood but outer edge weathered. |
| MAI005I | AGAU | | | 419+ h409 | +Bs | 0.90 | 1362 BC-944 BC | Mai005 | | Slice from trunk. Only the inner section of |
| MAI005ai | | 738 x 70 | >10 | 15h + 417+6h | | 0.94 | 1362 BC-946 BC | | 1032 BC | MAI005 was could be crossmatched. |
| MAI005ao | | 738 x 70 | | 180 | | 1.17 | 1-180 rel | | | Outer rings were measured but did not |
| MAI005bi | | 390 x 71 | >10 | 7h + 419 +17h | | 0.87 | 1362 BC-944 BC | | 1082; 1020 BC | crossmatch to other trees/chronologies. |
| MAI005bo | | 634 x 70 | | 281 +h111 | +½Bs | 0.99 | 1-281 rel | | | B retained bark with early wood visible. |
| MAI005ci | | 358 x 70 | >10 | 423 +27h | | 0.86 | 1339 BC-944 BC | | | |
| MAI005co | | 342 x 70 | | 210 | | 1.50 | 114-323 rel | | | |
| MAI006 | AGAU | | | 523 | | 0.95 | 388 BC – AD 135 | Maitahi | | Slice from trunk near base |
| MAI006a | | 650 x 70 | C | 84h+523 | | 1.04 | 388 BC-AD 135 | | | |
| MAI006b | | 457 x 72 | >10 | 467 | | 0.96 | 388 BC-AD 79 | | | |

| | | | | | | | | |
|---------------|-------------|--------------|-----|------------|-------------|---------------|--|------------------------------------|
| MAI006c | | 394 x 70 | >10 | 463 | 0.83 | 396 BC-AD 67 | AD 9 | |
| MAI006d | | 544 x 64 | C | 84h+523 | 0.88 | 388 BC-AD 135 | 207 BC | |
| MAI007 | AGAU | | | | | | | Slice, probably trunk |
| MAI007a | | 0 x 0 | | 122 | 1.23 | 1-122 rel | | |
| MAI007b | | 0 x 0 | | 306 | 0.97 | 1-306 rel | | |
| MAI008 | AGAU | 0 x 0 | | 647 | 0.79 | 1-647 rel | | Slice, probably near base of trunk |
| MAI008a | | 506 x 67 | >10 | 608 | 0.80 | 40-647 rel | 219; 223; 411; 418; 427 rel | |
| MAI008b | | 514 x 72 | >10 | 550 | 0.81 | 1-550 rel | 74; 131; 169; 171; 176; 286; 307; 308; 365; 386 rel | |
| MAI010 | LGCO | | | | | | | |
| MAI010A | | 310 x 71 | C | 346 | 0.89 | 1-346 rel | | |
| MAI010B | | 215 x 68 | <5 | 292 | 0.74 | 1-292 rel | | |
| MAI010C | | 170 x 71 | <5 | 260 | 0.66 | 1-260 rel | | |
| MAI010D | | 176 x 71 | <5 | 244 | 0.71 | 1-244 rel | | |
| MAI011 | LGCO | | | | | | | |
| MAI011A | | 246 x 71 | C | 345 | 0.63 | 1-345 rel | | |
| MAI011B | | 140 x 72 | >10 | 175 | 0.74 | 1-175 rel | | |
| MAI011C | | 95 x 73 | >10 | 94 | 0.93 | 1-94 rel | | |

Calendar dating Maitahi

Maitahi crossmatched with one chronology from the lower Waikato lowlands: **Furniss1** (7577 – 8300 KS; $t = 10.20$; $r = 0.36$) at 7316 – 8318 KS. The position of overlap between these two chronologies indicated that **Maitahi** should also crossmatch to another Waikato chronology, **Whangape** (6711 – 7761 KS). However, low t -values indicated that there was a problem. Visual comparison of line plots suggested that there was either a missing ring in Maitahi, or an extra ring in Whangape. Initially the problem was thought to be between 7510 – 7535 KS. However inspection of all samples spanning this period did not find evidence of either an extra ring on the six Whangape series, or a missing ring on the two Maitahi tree-sequences, which span this period. Further replication of the match between **Maitahi** and the Waikato chronology was deemed essential to resolve the ring issue, so the chronology was set aside until other Northland sites had been analysed.

Replication of **Maitahi** was provided by chronologies from four northland sites (**Chitty1**, **Harding1**, **Harding2** and **Yakas1**) and a tree-sequence, **TIK001**. No one chronology completely spanned **Maitahi** but collectively the record was independently replicated by at least one other chronology apart from **Whangape** for its whole length. In particular, **Chitty1** spanned 904 years of **Maitahi** and **Harding2** overlapped with the inner 100 years of **Maitahi**. (**Chitty1** and **Harding2** have a 41 year overlap). Combined, **Chitty1** and **Harding2** also span the entire length of **Whangape**.

When **Harding2** was constructed and crossmatched, it was suggested by Boswijk (2005a) that **Whangape** should be reviewed from 7410 KS to 7535 KS. Sample depth in the Dargaville chronologies is low across this period. **Harding2** is based on one tree-sequence, as is **Maitahi** (albeit internally well replicated) and **Chitty1** has two tree-sequences. However, all the Dargaville chronologies showed good agreement to each other. They were combined into a single chronology. Comparison of **Whangape** against the combined chronology determined that there was an extra ring in the Whangape record.

When **Whangape** was constructed, it was noted by Boswijk and Palmer (2003) that the chronology had a weak period between 7416 – 7420 KS. All samples, except for **HAM001a**, had a locally absent ring within this four year period. The inserted rings were removed from each radii/tree-sequence and crossmatching between eight tree-sequences from the Whangape group was reassessed. Each tree-sequence was also checked individually to contemporary chronologies from Northland. All series except **HAM001a** showed good agreement. **HAM001a** was out of sequence by one year. On this radius, ring 7420 KS was very narrow, and appeared to be splitting out from the previous ring. It was only visible on part of **HAM001a** and was not present at all on **HAM001b**. After careful consideration of the nature of the ring and the balance of evidence (not present on any other Whangape, Chitty, Harding or Maitahi sample) it was determined that ring 7420 KS was a false ring. The series was amended and the **Whangape** chronology was remade. This brought the Northland and Waikato site chronologies into agreement.

The impact of this was significant. Recent additions to the modern kauri record (Boswijk 2004b, Lorrey et al 2004) and construction of two northland site chronologies, **Harding1** (Boswijk 2004c) and **Yakas1** (Boswijk and Palmer 2004) had resulted in the sub-fossil record being linked to the modern kauri master. Calendar dates had been applied to several swamp kauri chronologies/tree-sequences, back to 315 BC – the start of the **Furniss1** chronology (Boswijk 2005a). The one-year difference between **Maitahi** and **Whangape** had

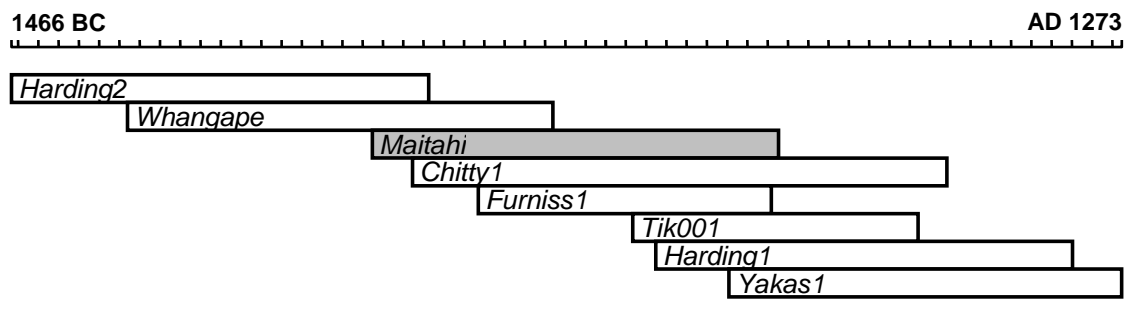
prevented calendar dates being applied to the entire swamp kauri chronology. Resolution of the problem removed this barrier. The Maitahi chronology spans the period 576 BC – AD 427 (Table 3; Figure 3). The chronology listing is presented in Appendix 2.

Table 3: Crossmatching of *Maitahi* against other site chronologies/tree-sequences from Northland and Waikato (*t* and *r* values)

| Region | Filenames | start dates | dates end | Maitahi 576BC AD427 | References |
|-----------|-----------|----------------|--------------|---------------------------|-------------------------|
| Northland | Chitty1 | 477BC | AD842 | 18.84 / 0.53 | Boswijk 2005b |
| | Harding1 | AD124 | AD1152 | 5.87 / 0.32 | Boswijk 2005a |
| | TIK001 | AD67 | AD771 | 9.31 / 0.44 | Boswijk 2004b |
| | Harding2 | 1466BC | 437BC | 7.22 / 0.53 | Boswijk 2005a |
| | Yakas1 | AD304 | AD1273 | 4.40 / 0.38 | Boswijk and Palmer 2004 |
| Waikato | Furniss1 | 315BC | AD409 | 10.20 / 0.36 | Boswijk et al 2001 |
| | Whangape | 1180BC | 131BC | 7.26 / 0.33 | Boswijk and Palmer 2003 |

$n = 7$ min $t = 4.40$ max $t = 18.84$ mean $t = 9.01$ s.d. = 4.40

Figure 3: Crossdated position of *Maitahi* with other site chronologies/tree-sequences from Northland and Waikato



Single kauri tree-sequences

MAI005 and **MAI008** were initially tested against the Waikato chronologies. **MAI005** crossmatched with two Waikato chronologies, *Pukekapia* and *Whangape*, at 6499 – 6917 KS, but **MAI008** did not crossmatch. The tree-sequences were retested as the database of swamp kauri chronologies expanded. The crossmatched position of **MAI005** was confirmed by the addition of the *Harding2* and *Yakas2* chronologies, and a tree-sequence from Pouto (POU001). The application of calendar dates indicates that **MAI005** spans the period 1362 – 944 BC (Table 4; Figure 4). It should be noted that this represents only the inner 419 rings of the tree. The addition of 407 excluded and unmeasured rings plus bark edge indicates that the died tree after 535/534 BC. (As there may be missing rings in the outer section, the end date of 535/534 BC does not represent a precise death date for this tree). **MAI008** did not crossmatch to any other chronologies/tree-sequences, and remains undated.

Table 4: Crossmatching of MAI005 against other site chronologies/tree-sequences
t and *r* values are listed.

| Region | Filenames | | | MAI005 |
|-----------|-----------|----------------|--------------|-----------------|
| | | start dates | dates end | 1377BC 917BC |
| Northland | Chitty2 | 1257BC | 676BC | 8.22 / 0.42 |
| | Harding2 | 1466BC | 437BC | 8.44 / 0.40 |
| | POU001 | 1315BC | 741BC | 7.54 / 0.37 |
| | Yakas2 | 1547BC | 961BC | 10.01 / 0.45 |
| Waikato | Whangape | 1180BC | 131BC | 4.26 / 0.27 |
| | Pukekapia | 1724BC | 922BC | 8.06 / 0.37 |

$n = 6$ $\min t = 4.51$ $\max t = 9.19$ $\text{mean } t = 7.81$ $\text{s.d.} = 1.56$

Figure 4: crossmatched position of MAI005 against site chronologies/tree-sequences

Wide bars represent the measured span of the chronologies/tree-sequences. Narrow bars indicate unmeasured rings.

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Manoa

Only one manoa tree-sequence was constructed, **MAI010**. This was tested against the entire kauri database, and against manoa samples from Yakas, Babylon Coast Road. However, the sample did not crossmatch to anything.

Discussion

Tree-ring analysis of the Maitahi kauri has produced a three-tree site-chronology, **Maitahi**, dated to 576 BC – AD 427, and a single tree-sequence, **MAI005**, dated to 1362 – 944 BC. These are useful contributions to the suite of sub-fossil kauri chronologies and tree-sequences which have been developed over the past few years from the Dargaville region and the lower Waikato Lowlands. In particular, the Maitahi chronology identified a problem with the Waikato chronology, **Whangape**, which has now been rectified. This highlights the importance of replication of site chronologies by other chronologies, to ensure that the tree-ring record is correct. This is particularly important when developing tree-ring chronologies from a species which can produce false rings, and/or have locally absent rings.

Although based on few samples, the temporal position of **MAI005** and **Maitahi** suggests that there were at least two phases of kauri in the locality over 1800 years. This is similar to the pattern observed at other sites in the region, such as Yakas (Babylon Coast Road), Chitty (Colville Road), and Harding (near Hilliam Road), where at least two phases of kauri growth have been identified. The length of tree-sequences, such as the 1003 year sequence **MAI001**, is also similar to trees included in the Yakas and Harding assemblages. The actual location of the trees relative to the peat bog is unknown as the material was no longer *in-situ* when sampled. It is possible that kauri were growing on the edge of the bog, or perhaps were situated on the nearby hill, before falling into the peat where the trunks were preserved.

The lack of any crossmatching between the manoa sample and the kauri chronologies, or other manoa from the region is not wholly surprising. Two manoa samples from Yakas, Babylon Coast Road, did not crossmatch against each other or to the kauri chronologies. It is possible that kauri and manoa have different responses to environmental factors, so that the growth pattern is dissimilar between species.

Alternatively, the **MAI010** tree-sequence may be flawed; without other samples to provide replication it is not possible to identify such problems.

Conclusion

Tree-ring analysis of kauri and manoa from a drained bog near Maitahi Road, has resulted in one calendar dated site chronology and a calendar dated tree-sequence. These are useful contributions to the suite of swamp kauri chronologies being developed for palaeoclimate studies. In particular, the construction of the Maitahi chronology resulted in identification of an error in a Waikato chronology, **Whangape**. Resolution of this problem enabled calendar dates to be applied to all swamp kauri chronologies developed in the past few years. The calendar dated tree-ring record from kauri now extends back to 1724 BC.

Acknowledgments

Kevin Morris is thanked for his generosity in providing the kauri samples, and for taking us out to the site and cutting additional samples. Robert and Caroline Yates are thanked for access to their farm. The wood was cut into radial strips and prepared for analysis by Peter Crossley. The Maitahi samples were collected by John Ogden, Anthony Fowler, Gretel Boswijk and Drew Lorrey, and analysed by Gretel Boswijk, as part of the *El Nino history as recorded in kauri tree-rings* project, supported by the Royal Society of New Zealand Marsden fund (UOA108). Radiocarbon dating of MAI008 was by Alan Hogg, Radiocarbon Dating Laboratory, The University of Waikato. All the wood and offcuts are archived in the Tree-ring Laboratory Woodstore, School of Geography and Environmental Science, University of Auckland.

Addendum

Since this report was written, a 10-ring block of wood spanning rings 561-570 from **MAI008** has been submitted to the Radiocarbon Dating Laboratory at the University of Waikato for ^{14}C dating. The sample from **MAI008** was ^{14}C dated to ca. 890 -1030 cal AD (WK 15529: 1059 \pm 42 BP). This was younger than anticipated, and indicates that **MAI008** mostly likely has ring problems which prevented it from being crossmatched to other tree-ring chronologies that span the late first millenium and early second millennium AD. The radiocarbon date for this sample also indicates that several generations of kauri were present in the area over ca. 2000 years, and until at least until late in the first millenium AD.

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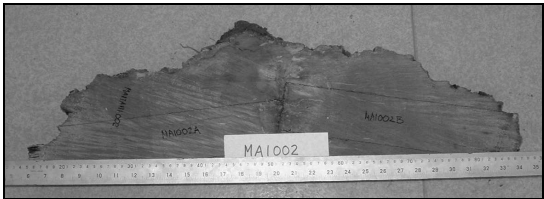
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Appendix 1:

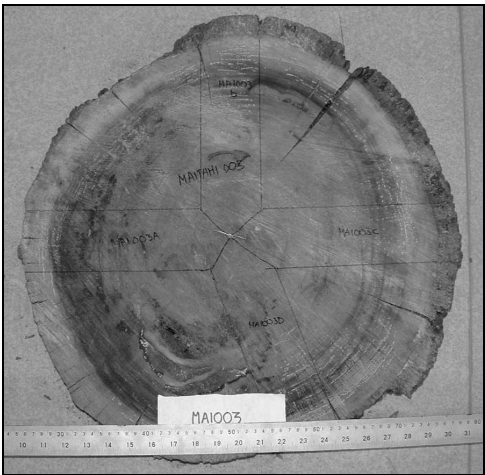
Figure A1: Maitahi tree-ring samples
Black lines mark where radii were cut.

MAI001 No image

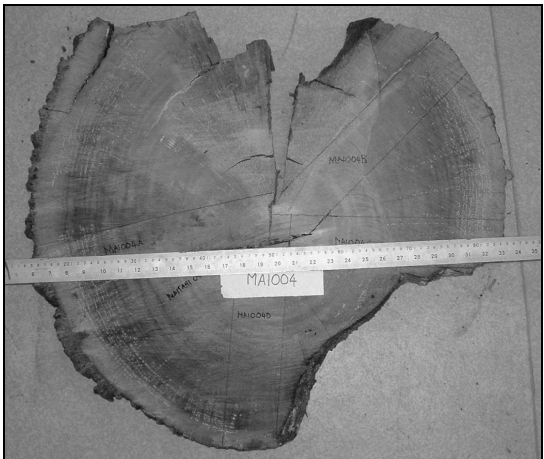
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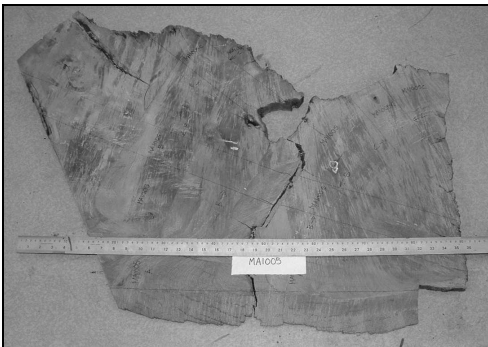
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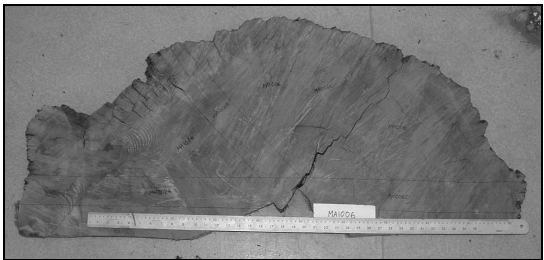
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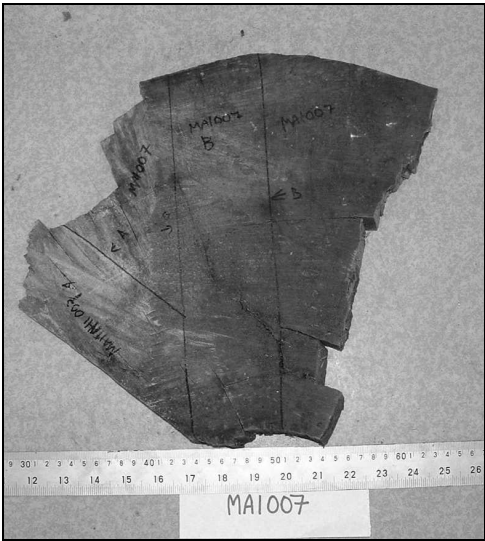
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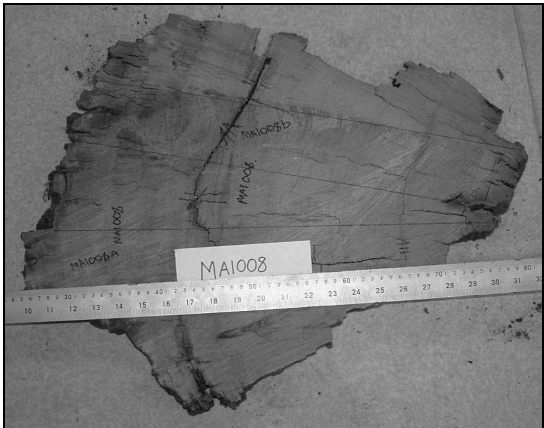
MAI006



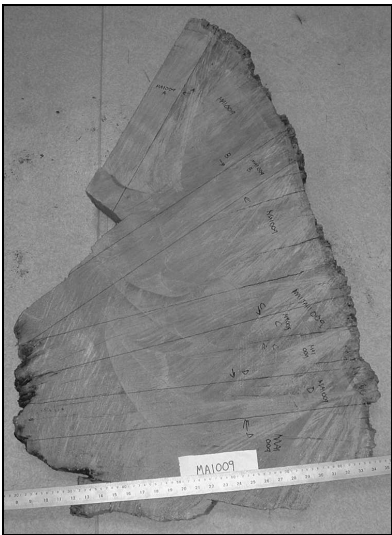
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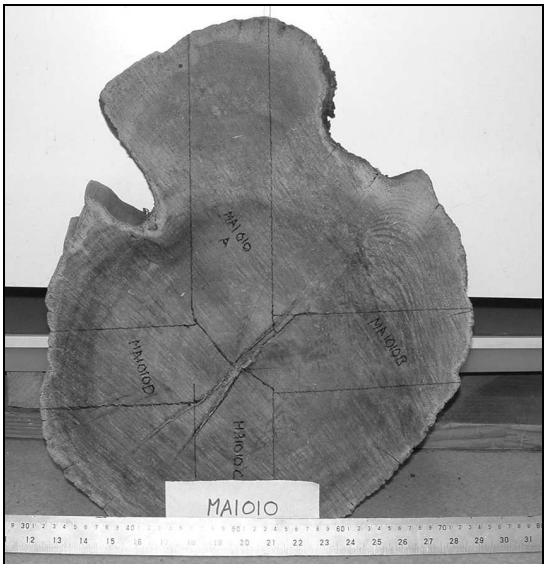
MAI008



MAI009



MAI010



MAI011

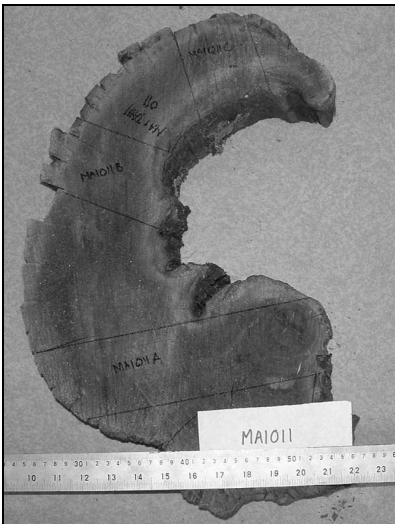


Table A1: intra- and inter-tree crossmatching for the Maitahi samples

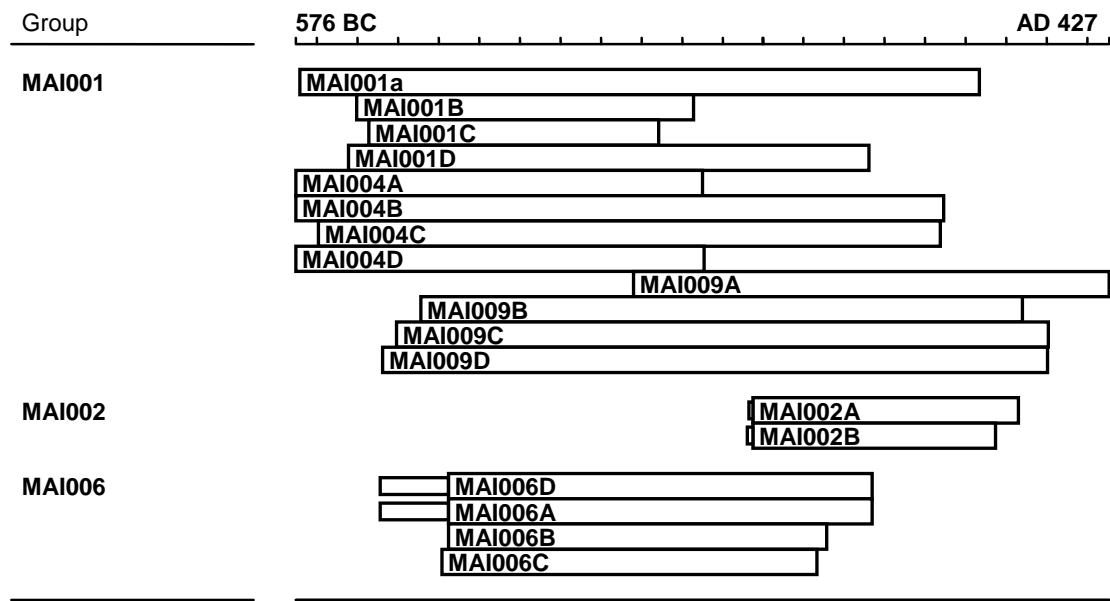
\ = overlap < 15 years; - = t-values less than 3.00; * = empty triangle

Note: radii from MAI004 and MAI009 have been relabelled MAI001e – MAI001l.

| | - | - | Mai 001a | MAI 001b | MAI 001c | MAI 001d | MAI 001e | MAI 001f | MAI 001g | MAI 001h | MAI 001i | MAI 001j | MAI 001k | MAI0 01l | MAI 002a | MAI 002b | MAI 006a | MAI 006b | MAI 006c | MAI 006d |
|---------|-------|-------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| - | start | dates | 571BC | 501BC | 486BC | 511BC | 576BC | 576BC | 548BC | 576BC | 160BC | 422BC | 452BC | 469BC | 13BC | 13BC | 388BC | 388BC | 396BC | 388BC |
| - | dates | end | AD267 | 86BC | 129BC | AD131 | 75BC | AD223 | AD219 | 73BC | AD427 | AD320 | AD352 | AD351 | AD315 | AD287 | AD135 | AD79 | AD67 | AD135 |
| MAI001a | 571BC | AD267 | * | 26.74 | 35.65 | 35.83 | 22.39 | 29.65 | 21.24 | 20.42 | 18.48 | 21.79 | 28.88 | 27.51 | 8.33 | 7.87 | 10.93 | 9.94 | 9.93 | 10.49 |
| MAI001b | 501BC | 86BC | * | * | 21.27 | 24.45 | 20.71 | 22.56 | 13.86 | 18.25 | 12.05 | 23.24 | 24.57 | 23.95 | \ | \ | 9.75 | 7.61 | 8.04 | 6.87 |
| MAI001c | 486BC | 129BC | * | * | * | 20.49 | 21.51 | 18.78 | 11.22 | 15.96 | 15.27 | 25.67 | 21.93 | 19.66 | \ | \ | 7.66 | 6.91 | 7.75 | 5.18 |
| MAI001d | 511BC | AD131 | * | * | * | * | 23.07 | 29.97 | 19.55 | 19.47 | 16.82 | 21.22 | 25.53 | 26.97 | 5.73 | 4.76 | 12.17 | 10.75 | 12.25 | 11.25 |
| MAI001e | 576BC | 75BC | * | * | * | * | * | 24.38 | 21.05 | 33.67 | 5.92 | 16.11 | 16.03 | 16.64 | \ | \ | 7.49 | 6.02 | 6.50 | 4.81 |
| MAI001f | 576BC | AD223 | * | * | * | * | * | * | 22.05 | 20.59 | 13.38 | 17.56 | 25.18 | 26.79 | 7.05 | 6.38 | 11.09 | 9.75 | 9.60 | 10.27 |
| MAI001g | 548BC | AD219 | * | * | * | * | * | * | * | 17.83 | 10.69 | 11.86 | 15.58 | 15.54 | 5.47 | 5.18 | 7.66 | 6.22 | 6.64 | 6.88 |
| MAI001h | 576BC | 73BC | * | * | * | * | * | * | * | * | 6.85 | 14.30 | 14.65 | 14.78 | \ | \ | 6.17 | 5.28 | 5.40 | 4.80 |
| MAI001i | 160BC | AD427 | * | * | * | * | * | * | * | * | * | 14.68 | 17.89 | 16.27 | 6.79 | 6.46 | 7.10 | 7.70 | 7.49 | 8.87 |
| MAI001j | 422BC | AD320 | * | * | * | * | * | * | * | * | * | * | 38.13 | 27.89 | 10.61 | 7.46 | 9.09 | 8.89 | 9.06 | 9.51 |
| MAI001k | 452BC | AD352 | * | * | * | * | * | * | * | * | * | * | * | 42.09 | 12.28 | 10.07 | 11.80 | 10.86 | 11.01 | 11.62 |
| MAI001l | 469BC | AD351 | * | * | * | * | * | * | * | * | * | * | * | * | 12.39 | 10.26 | 14.62 | 14.06 | 12.43 | 14.52 |
| MAI002a | 13BC | AD315 | * | * | * | * | * | * | * | * | * | * | * | * | * | 23.12 | 8.91 | 6.58 | 5.56 | 10.36 |
| MAI002b | 13BC | AD287 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | 7.18 | 5.18 | 4.10 | 8.53 |
| MAI006a | 388BC | AD135 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | 34.17 | 30.07 | 23.97 |
| MAI006b | 388BC | AD79 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | 32.86 | 21.82 |
| MAI006c | 396BC | AD67 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | 19.58 |
| MAI006d | 388BC | AD135 | | | | | | | | | | | | | | | | | | * |

n = 145 min t = 4.10 max t = 42.09 mean t = 15.07 s.d. = 8.38

Figure A1: Crossmatched position of each Maitahi radius



Appendix 2: Chronology listing

MAITAHĪ 3 timber mean

1003 years length dated 576BC to AD427

Average ring width 71.24 Sensitivity 0.29

| Year | Mean ring width | | | | | | | | | | Number of samples | | | | | | | | | |
|---------------|-----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------------------|---|---|---|---|---|---|---|---|---|
| 576 BC | | | | | 123 | 111 | 124 | 157 | 113 | 73 | | | | | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 135 | 99 | 74 | 76 | 74 | 82 | 58 | 132 | 124 | 104 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 50 | 121 | 62 | 66 | 96 | 41 | 84 | 87 | 64 | 73 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 550 BC | 67 | 45 | 94 | 70 | 60 | 64 | 34 | 80 | 76 | 57 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 73 | 85 | 83 | 37 | 108 | 65 | 40 | 59 | 59 | 50 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 79 | 90 | 60 | 82 | 72 | 85 | 54 | 120 | 85 | 65 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 69 | 59 | 59 | 36 | 53 | 24 | 61 | 65 | 63 | 106 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 47 | 84 | 69 | 54 | 73 | 63 | 54 | 77 | 73 | 60 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 500 BC | 58 | 35 | 68 | 76 | 53 | 32 | 53 | 36 | 56 | 55 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 102 | 49 | 70 | 74 | 102 | 98 | 43 | 100 | 85 | 114 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 105 | 72 | 94 | 96 | 84 | 58 | 87 | 61 | 39 | 89 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 64 | 64 | 101 | 65 | 116 | 65 | 70 | 101 | 101 | 72 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 65 | 30 | 77 | 74 | 76 | 101 | 57 | 105 | 126 | 91 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 450 BC | 89 | 76 | 72 | 78 | 78 | 64 | 64 | 64 | 60 | 91 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 135 | 87 | 55 | 74 | 97 | 80 | 103 | 99 | 58 | 82 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 63 | 64 | 88 | 80 | 82 | 90 | 130 | 82 | 89 | 94 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 67 | 99 | 69 | 47 | 100 | 79 | 73 | 79 | 70 | 124 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 88 | 41 | 99 | 87 | 100 | 68 | 83 | 47 | 71 | 66 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 400 BC | 56 | 93 | 100 | 97 | 86 | 71 | 77 | 69 | 73 | 81 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 69 | 74 | 64 | 40 | 54 | 55 | 54 | 91 | 101 | 81 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 55 | 73 | 66 | 79 | 91 | 58 | 68 | 60 | 50 | 65 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 67 | 82 | 103 | 94 | 57 | 76 | 65 | 67 | 68 | 37 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 53 | 71 | 67 | 49 | 77 | 70 | 43 | 47 | 46 | 58 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 350 BC | 42 | 56 | 58 | 49 | 44 | 67 | 71 | 68 | 49 | 61 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 44 | 74 | 63 | 43 | 80 | 66 | 59 | 64 | 55 | 72 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 70 | 67 | 68 | 60 | 46 | 47 | 64 | 48 | 79 | 75 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 65 | 78 | 72 | 70 | 80 | 65 | 86 | 56 | 39 | 60 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 67 | 73 | 81 | 86 | 54 | 99 | 77 | 92 | 105 | 78 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 300 BC | 102 | 74 | 81 | 109 | 116 | 62 | 101 | 84 | 62 | 58 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 52 | 86 | 100 | 50 | 98 | 92 | 97 | 73 | 79 | 67 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 81 | 82 | 75 | 70 | 66 | 91 | 72 | 88 | 54 | 83 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 87 | 61 | 96 | 127 | 122 | 64 | 81 | 79 | 76 | 92 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 70 | 76 | 49 | 111 | 74 | 79 | 60 | 93 | 80 | 81 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 250 BC | 65 | 100 | 80 | 109 | 81 | 55 | 76 | 83 | 33 | 84 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 99 | 82 | 113 | 117 | 86 | 76 | 44 | 79 | 127 | 107 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 75 | 118 | 114 | 95 | 44 | 115 | 83 | 69 | 116 | 92 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 119 | 121 | 102 | 64 | 84 | 96 | 65 | 101 | 68 | 95 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 25 | 103 | 120 | 94 | 110 | 61 | 77 | 105 | 105 | 90 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 200 BC | 75 | 102 | 36 | 79 | 73 | 124 | 87 | 103 | 95 | 101 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 142 | 118 | 150 | 119 | 106 | 108 | 90 | 137 | 86 | 187 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 159 | 71 | 139 | 101 | 164 | 174 | 128 | 136 | 102 | 134 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 131 | 136 | 97 | 94 | 160 | 152 | 105 | 125 | 92 | 115 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 96 | 110 | 117 | 69 | 115 | 72 | 102 | 78 | 137 | 110 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 150 BC | 85 | 126 | 80 | 136 | 91 | 123 | 88 | 171 | 152 | 133 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 72 | 137 | 137 | 135 | 96 | 102 | 89 | 118 | 84 | 132 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 84 | 71 | 94 | 89 | 161 | 103 | 141 | 84 | 92 | 65 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 63 | 80 | 129 | 93 | 113 | 96 | 98 | 49 | 67 | 55 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 92 | 41 | 111 | 82 | 91 | 73 | 53 | 101 | 92 | 64 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 100 BC | 96 | 88 | 108 | 97 | 60 | 55 | 77 | 101 | 74 | 65 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 40 | 85 | 109 | 85 | 80 | 73 | 66 | 45 | 88 | 128 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 51 | 77 | 105 | 132 | 103 | 77 | 27 | 77 | 80 | 78 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 88 | 100 | 116 | 39 | 95 | 89 | 63 | 76 | 57 | 132 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

| | | | | | | | | | | | | | | | | | | | |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|---|---|---|---|---|---|---|---|---|
| - | 119 | 110 | 77 | 75 | 71 | 85 | 111 | 95 | 99 | 65 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 50 BC | 89 | 71 | 93 | 63 | 105 | 76 | 67 | 79 | 45 | 109 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 83 | 104 | 64 | 49 | 63 | 83 | 72 | 55 | 94 | 38 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 74 | 66 | 72 | 84 | 75 | 32 | 82 | 40 | 83 | 99 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 61 | 103 | 60 | 65 | 61 | 61 | 64 | 60 | 35 | 97 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| - | 86 | 115 | 91 | 102 | 68 | 67 | 103 | 109 | 89 | 97 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| AD 1 | 69 | 90 | 56 | 96 | 70 | 64 | 108 | 79 | 43 | 92 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| - | 81 | 100 | 89 | 71 | 63 | 101 | 60 | 116 | 109 | 81 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| - | 136 | 81 | 120 | 71 | 164 | 90 | 113 | 79 | 110 | 64 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| - | 112 | 87 | 113 | 127 | 120 | 85 | 92 | 94 | 69 | 99 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| - | 72 | 126 | 87 | 99 | 65 | 105 | 47 | 131 | 114 | 117 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| AD 51 | 62 | 115 | 105 | 118 | 67 | 93 | 62 | 120 | 119 | 115 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| - | 75 | 97 | 63 | 105 | 113 | 58 | 83 | 84 | 78 | 42 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| - | 74 | 100 | 117 | 65 | 81 | 49 | 68 | 73 | 103 | 92 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| - | 90 | 59 | 84 | 95 | 59 | 131 | 115 | 86 | 129 | 109 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| - | 50 | 84 | 61 | 104 | 67 | 122 | 89 | 81 | 66 | 58 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| AD 101 | 77 | 66 | 145 | 98 | 89 | 87 | 78 | 65 | 109 | 93 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| - | 122 | 78 | 99 | 82 | 46 | 85 | 56 | 96 | 82 | 118 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| - | 112 | 58 | 92 | 93 | 76 | 83 | 95 | 85 | 85 | 50 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| - | 100 | 117 | 64 | 84 | 43 | 60 | 65 | 83 | 71 | 70 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 |
| - | 84 | 63 | 79 | 70 | 71 | 97 | 91 | 65 | 90 | 75 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| AD 151 | 93 | 103 | 82 | 98 | 57 | 77 | 74 | 73 | 83 | 73 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 85 | 61 | 84 | 85 | 77 | 103 | 62 | 114 | 120 | 118 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 95 | 72 | 100 | 106 | 85 | 72 | 90 | 102 | 83 | 112 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 103 | 91 | 93 | 85 | 74 | 90 | 72 | 111 | 97 | 122 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 105 | 58 | 76 | 100 | 74 | 97 | 50 | 71 | 77 | 89 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| AD 201 | 67 | 63 | 85 | 66 | 79 | 79 | 52 | 48 | 83 | 63 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 99 | 105 | 61 | 86 | 58 | 102 | 113 | 105 | 84 | 73 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 109 | 61 | 93 | 83 | 64 | 41 | 72 | 77 | 70 | 77 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 90 | 85 | 95 | 43 | 86 | 96 | 90 | 70 | 47 | 58 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 62 | 51 | 56 | 61 | 59 | 61 | 67 | 50 | 32 | 79 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| AD 251 | 63 | 61 | 48 | 53 | 47 | 43 | 56 | 53 | 29 | 75 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 76 | 68 | 85 | 88 | 93 | 97 | 92 | 73 | 77 | 54 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 83 | 78 | 62 | 69 | 85 | 74 | 67 | 74 | 43 | 65 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 98 | 99 | 73 | 78 | 55 | 64 | 56 | 38 | 60 | 43 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 55 | 70 | 65 | 55 | 73 | 81 | 58 | 82 | 85 | 87 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| AD 301 | 82 | 41 | 86 | 103 | 114 | 123 | 56 | 87 | 84 | 95 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| - | 128 | 104 | 133 | 135 | 73 | 63 | 68 | 54 | 40 | 58 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| - | 57 | 43 | 57 | 40 | 54 | 22 | 73 | 66 | 62 | 55 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 45 | 46 | 46 | 49 | 49 | 120 | 97 | 56 | 69 | 100 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 44 | 77 | 68 | 59 | 41 | 54 | 39 | 25 | 53 | 41 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| AD 351 | 42 | 39 | 104 | 105 | 34 | 75 | 46 | 57 | 55 | 42 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | 44 | 42 | 63 | 37 | 43 | 71 | 55 | 28 | 40 | 39 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| - | | | | | | | | | | | | | | | | | | | |