New Zealand Tree-ring Site Reports

An Update of Modern Northland Kauri (*Agathis australis*) Tree-ring Chronologies 1: Puketi State Forest

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An Update of Modern Northland Kauri (*Agathis australis*) Tree-ring Chronologies 1: Puketi State Forest

This is a technical archive report describing the recent sampling of living kauri trees from Puketi State Forest as part of an update of four sites in Northland, New Zealand. This report is only concerned with the development of a revised tree-ring chronology to be used in improving pre- AD 1600 sample depth and updating the modern master kauri database to AD 2002. As such, no palaeoclimatic interpretation related to this material is presented.

Summary

Living kauri trees were sampled from Puketi State Forest, Northland as part of an update of kauri tree-ring chronologies to be used for El Niño-Southern Oscillation research. Tree ring chronologies were first developed from two sites, Puketi South and Onekura Bluff, by Ahmed (1984). The area was revisited in October 2003 and resulted in the resampling of two original sites: Loop Track Southern Puketi and Onekura Bluff, and the rejection of Te Harua in Puketi South as a sampling location. 39 samples from 15 trees were obtained from the Loop Track and 40 samples from 15 trees were sampled from Onekura Bluff. However, a chronology was not built from the material collected from Onekura Bluff due to time restrictions. The material from the Loop Track was analysed to update and extend the original chronology available for southern Puketi Forest. The original chronology which spanned AD 1780- AD 1981, was comprised of 19 radii from 10 trees. After analysis, the chronology was extended by a total of 297 years through the addition of 27 radii from 12 trees. This revision resulted in a 47 radii/22-tree chronology representing the fourth longest chronology in the modern kauri database, spanning AD 1504 to AD 2002.

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Introduction

Over twenty years of research on living kauri (*Agathis australis* D. don Salisb.) in New Zealand has resulted in a quality tree-ring master chronology that is now being used for high-resolution palaeoclimate applications. The first known tree-ring work on kauri was undertaken by Bell and Bell (1958), however, substantial work leading to the development of chronologies began with the investigations of Dunwiddie (1979) and La Marche *et al.* (1979). A significant phase of work on living trees in the 1980's followed (Ahmed, 1984; Ahmed and Ogden, 1985; 1987; Fowler, 1984; Palmer, 1982). In the 1990's, a major review of the modern kauri database resulted in the development of the first kauri master chronology (Buckley *et al.*, 2000).

Further work on modern kauri (living and standing dead trees) has been undertaken since Buckley *et al.* (2000), which has included the addition of new sites, extension back in time of some existing sites, and detailed quality control of all existing material (Boswijk *et al.*, 2002; Fowler and Boswijk, 2003; Fowler *et al.*, 2004). Recently completed work on the quality of the modern kauri master chronology concluded that there were problems associated with low sample depth prior to AD 1600 and in the late Twentieth Century (Fowler and Boswijk, 2003; Fowler *at al.*, 2004). The was no pre-AD 1600 coverage from Northland, and post-1982 coverage was only available from four southern sites (Kawhia, Cascades, Huapai, Katikati and Manaia Sanctuary) in the Auckland and Waikato regions (Boswijk *et al.*, 2002). Hitherto, no data from Northland (Puketi Forest, Puketi Bluff, Trounson Kauri Park and Warawara) was available for incorporation into the modern master record for these periods (Figure 1).

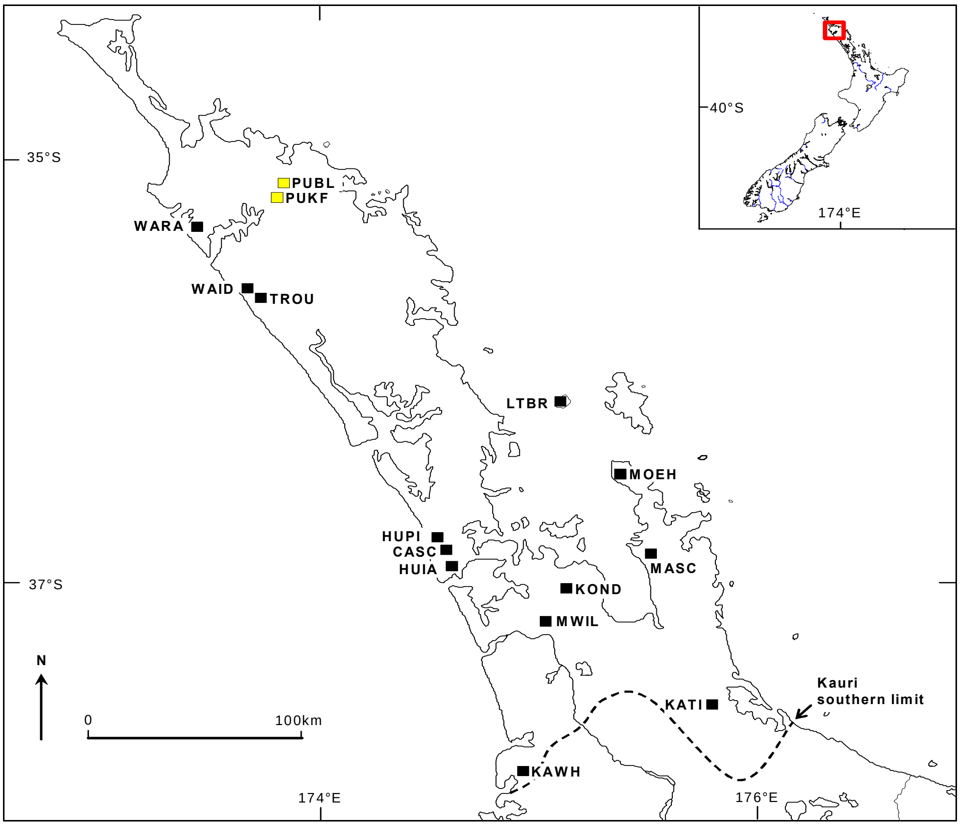
This report presents the results of analysis of kauri samples obtained from living trees at Puketi State Forest, Northland. Tree-ring analysis of kauri in Puketi State Forest was originally carried out by Ahmed (1984) as part of a wider ecological and dendrochronological study of kauri from sites across the upper North Island. Ahmed (1984) sampled two stands of kauri from the southern part of Puketi (Loop track and Te Harua stream) and one stand at Onekura Bluff, in the northern part of Puketi Forest. In 2003, an update of Northland kauri study sites including Puketi Forest was undertaken to improve pre-AD 1600 and post-AD 1980 coverage of the modern kauri record for the purpose of El Niño Southern Oscillation (ENSO) reconstruction (Fowler *et al.*, 2000). In October 2003, the area was visited and two original sites, the Loop Track in southern Puketi and Onekura Bluff, were resampled. A third site, Te Harua in Puketi South, was rejected as a sampling site. 39 samples from 15 trees were obtained from the Loop Track and 40 samples from 15 trees were sampled from Onekura Bluff. Dendrochronological analysis was carried out on the material from the Loop Track to construct a revised chronology for southern Puketi Forest. The results presented here as a technical archive report are part of a review of kauri sites used for research related to the Royal Society of New Zealand Marsden Fund 01-UOA-053: *El Niño history as recorded in kauri tree-rings* and the UNSW faculty grant *Late Twentieth Century El Niño-Southern Oscillation (ENSO) Variability in the Context of Holocene Climate Change*.

Puketi State Forest

Puketi State Forest is located between the Hokianga and Whangaroa harbours in eastern Northland, New Zealand (Figure 1). The forest encloses the Waipapa River catchment which drains into the Hokianga Harbour at Rangiahua (Ahmed, 1984). The topography of the region is comprised of rugged, undulating terrain, with steep-moderately steep valleys and numerous relatively flat ridges elevated between 150-460m above sea level (Ahmed, 1984). In the past, the area is known to have suffered disturbances such as logging, gum digging, gum bleeding, burning and grazing (Ahmed, 1984). Although the area has suffered disturbance, the forest still contains over 10% of the total mature kauri stands remaining in New Zealand (Department of Conservation, 2003).

Puketi and the adjacent Omahuta Forest form one of the largest continuous tracts of native forest in Northland. A number of large kauri trees still exist in the area, Te Tangi o te Tui in Puketi is the fourth largest kauri in the country with a height of 50.9 m (167'), a diameter of 3.94 m (12.9'), and a clean bole at more than 30m (98.4') (Adams, 1989; Department of Conservation, 2003). Puketi is an important bird conservation area, providing a breeding habitat for the endangered kokako, North Island brown kiwi and kaka (Adams, 1989; Department of Conservation, 2003).

Figure 1: Distribution of kauri site chronologies in New Zealand derived from living trees. Puketi South (PUKF) and Puketi Bluff (PUBL) are lightly shaded.

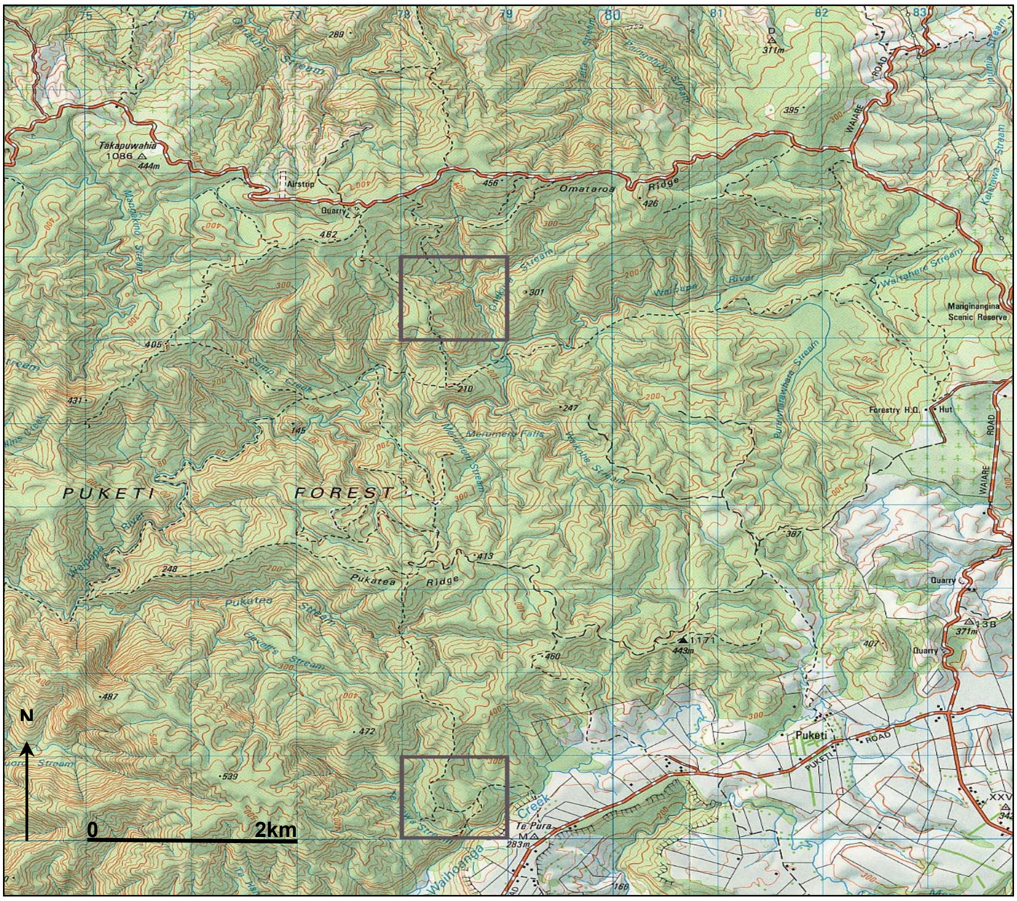


(i) Loop Track, Puketi South.

The original location of the Loop Track was vaguely described by Ahmed (1984) as being "close to the Te Harua Stream", 3km from the Te Harua site (Ahmed, 1984). Kauri was noted as the most abundant species found at the site, with 16% of trees falling into 10-30cm diameter at breast height (dbh) size class and a further 10% in the 60-80cm dbh range.

Other species associated with kauri in the closed canopy included *Beilschmiedia tawa*, *Dacrydium kirkii* and *Elaeocarpus dentatus*. A few large, dead trees were observed in the sampling area, leaving the canopy relatively open in places. The sub-canopy of the original sample site was described as consisting of *Beilschmiedia tarairi*, *Dacrydium kirkii* and *Elaeocarpus dentatus*, with *Gahnia xanthocarpa*, *Astelia trinervia*, *Blechnum capense* and *Freycinetia banksii* common understorey species. A number of kauri poles, rickers and seedlings were also recorded and observed around the sample area. In October 2003, 15 trees were sampled from the "Loop Track" in the Waihoanga Gorge Kauri Walk in southern Puketi Forest (Latitude: 35^{o} 15' 32'' S, Longitude: 173^{o} 44' 40'' E), shown in Figure 2.

Figure 2: Resample locations in Puketi State Forest South, October 2003. The Loop Track (NZMS 260 P05 787 602) sampling region is the larger area highlighted in the south, with Onekura Bluff located in northern Puketi (NZMS 260 P05 663 784).
Source: NZMS 260 P05, Land Information New Zealand (1999).



The track is accessed from Puketi Road, traverses through farmland before crossing Waihoanga Creek on a signposted trail (Plate 1). Trees were sampled predominately from a northeast facing ridge approximately 320m above sea level close to the Te Tawa Stream near Waihoanga Creek (Plate 2). All trees sampled were in the 1.1-2.1m dbh range. The low dbh values noted by Ahmed (1984) for the original sample site suggests that a relatively immature stand was likely to have been sampled compared with the mature stand sampled in 2003. A detailed map of sampled tree locations can be found in Appendix 1a.

Plate 1: Accessing the "Loop Track", Waihoanga Gorge, southern Puketi Forest.

Plate 2: Ridge site, Loop Track, Waihoanga Gorge, southern Puketi Forest.

(ii) Te Harua, Puketi South

The original sample plot was described by Ahmed (1984) as being located at about 305m on top of a north-facing ridge near Te Harua Stream at the southern end of Puketi State Forest. Kauri was observed on two ridges and slopes but were most abundant on top of the north-facing ridge. The area was noted as containing a relatively young stand of kauri but two large kauris of approximately 2m dbh were recorded in the sampling site (Ahmed, 1984). Kauri was noted as being the dominant species of the area, in association with the canopy species *Phyllocladus trichomanoides* and *Dacrydium cupressinum* (Ahmed, 1984).

Twenty-two percent of the kauri sampled by Ahmed (1984) was reported to be in the 10-30cm dbh size range, while 21% were classified as being within the 60-80cm dbh bracket, again suggesting a rather youthful stand. The canopy and sub canopy were described by Ahmed (1984) as being irregular, however, a few *Podocarpus hallii*, *Elaeocarpus dentatus* and *Ackama rosaefolia* were noted.

Reconnaissance of the area in October 2003 resulted in the site being excluded from further resampling for a variety of reasons. Firstly, the site was situated atop a very steep sided/near vertical ridge in an inaccessible valley. Additionally, Ahmed's (1984) description of the site indicated that the stand was mostly comprised of juvenile trees, and crossmatching results of the material sampled from the area were not outstanding. Consequently, the site was considered unsuitable for sampling.

Plate 3: Te Harua Stream site, Waihoanga Gorge, southern Puketi Forest.

(iii) Onekura Bluff, Puketi North

Ahmed (1984) reported that Onekura Bluff was located on a steep north-facing slope in the forest at an elevation of 305m. Kauri accounted for 83% of the biomass of the sample plot. Other canopy species included *Ackama rosaefolia*, *Beilschmiedia tawa*, *Podocarpus ferrugineus*, and *Podocarpus hallii* (Ahmed, 1984). Approximately 22% of kauri occupied the 10-30cm dbh size class, with a further 17% of individuals falling into the 60-80 cm size bracket (Ahmed, 1984). The sub-canopy was dominated by *Pittosporum tenuifolium*, *Phyllocladus glaucus* and *Elaeocarpus dentatus,* while *Gahnia xanthocarpa*, *Astelia trinervia* and *Dicksonia lanata* were the most common species found in the understorey (Ahmed, 1984). Ahmed (1984) also noted that the canopy was broken by large dead trees in places. Established kauri seedlings were found in 35% of the plots studied and a few pole and ricker sized individuals were observed in the stand and surrounding area. Furthermore, Ahmed (1984) noted countless seedlings were also observed in patches of the forest floor.

In 2003, 15 trees were sampled from Onekura Bluff in northern Puketi (see Figure 2 and Plate 4). The site was accessed from the quarry site on the Mokau Ridge Road approximately 2km along the Onekura Route trail (NZMS 260 P05 663 784) at an average elevation of 320m. Large trees were sampled on a very steep slope (30^{o}-50^{o}) and those trees sampled for the purpose of updating the modern end of the master were located together in a distinctive grove on the southern side of the bluff. Eight of the fifteen trees had aluminium tags, the numbers of which were recorded (see Appendix 2). All trees sampled from the area ranged in size between 1.0-2.3m dbh. A detailed map of sampled tree locations can be found in Appendix 2b.

Plate 4: Typical understorey at Onekura Bluff, northern Puketi Forest, containing regenerating stands of kauri.

Method

Living trees were sampled from the Loop Track and Onekura Bluff using a hand-held increment corer, producing cores up to 79cm in length and approximately 5mm in diameter. Five trees from each site were sampled twice; one short (<30cm) core, and one deep core to a maximum depth of 79cm in an attempt to capture pre AD 1600 growth rings. Three short radii were sampled from 10 trees for the purpose of updating sequences to the end of the 2002-03 growing season. Note that since the Southern Hemisphere's growing season straddles the change of the calendar year, the date of the annual ring is assigned to the year ring formation began. Thus, the last complete ring for the trees sampled from Puketi in October 2003 represents the 2002 growth ring.

The diameter of each tree at breast height (dbh) was recorded and photographs of the crown and surrounding canopy were taken to facilitate the reidentification of trees and post-sampling monitoring. Core samples were taken at mean breast height at a slightly upward slope to encourage the sample hole to fill with natural resin. In addition, all core holes were treated with the horticultural disinfectant *Vercon* to prevent bacterial infections. Resample cores were labelled with a prefix of "PKF" and ID number beginning with a 3 to denote sampling in 2003. All core angles, compass direction of each hole and sample height from litter mound were recorded (Appendix 2). All core holes were photographed for each tree, in accordance with the Department of Conservation's permit requirements (Appendix 4).

After being air-dried, the cores were glued to wooden mounts with the tracheids vertically aligned. Surfaces were sanded using an industrial sander fitted with a fine-grained belt to clearly reveal the ring sequence. Ring widths were then measured to 0.01mm using a binocular microscope and a travelling stage linked to a computer. All data was entered into the "Dendro for Windows" package (Tyers, 1999). Computerised crossmatching was undertaken using the tree-ring cross dating program XMATCH developed by Fowler (1998) which provides an on-screen running correlation coefficient (R values) between two samples. The position of best fit remain high while the series are correctly crossdated and decline when mismatched due missing or false rings (Fowler, 1998). Discrepancies displayed in the best-fit anomaly panel suggested areas either side of the current year that required further examination of ring width plots and wood samples.

Dunwiddie (1979) observed that kauri has some notable growth anomalies that can affect crossdating of samples. Kauri, like many conifers, can occasionally produce 'false' rings where an indistinct boundary is formed during the growing season or a locally absent ring which occurs when an annual ring is not formed around the entire circumference of the tree (Dunwiddie, 1979; Stokes and Smiley, 1968). Where a ring was found to be present on part of one radius or off the measuring track (i.e. locally absent), a measured value for the ring was inserted into the series (Stokes and Smiley, 1968). If a ring was wholly absent from a radius (i.e. a missing ring), a value of one was inserted (Baillie, 1982; Stokes and Smiley, 1968). If the location of problematic rings could not be reliably resolved, the radius sequence was truncated.

The most recent modern kauri master chronology (Fowler *et al.*, 2004) was used in conjunction with the original site chronologies to facilitate the resolution of the crossmatching issues suggested by XMATCH. All samples were first internally cross checked using XMATCH, then compared to the original site master chronology produced by Ahmed (1984) and the kauri master chronology

(Fowler *et al.*, 2004). The use of the kauri master chronology enabled temporally unreplicated periods in the new material from long cores to be independently cross verified. A XMATCH profile displaying the correlation of each sample to the original site and kauri spline 20 master chronologies was produced for each sample for the Tree-Ring Laboratory's paper archive.

To further verify the crossdating suggested by XMATCH, intra- and inter-tree crossmatching and statistical comparison of site chronologies was undertaken using CROS 73 (Baillie and Pilcher, 1973) contained within the Dendro for Windows package (Tyers 1999). Ring-width series are compared against each other and the correlation coefficient (r) measured at every position of overlap (Baillie and Pilcher, 1973). Significant matches are expressed statistically using Student's *t*-value, which calculates the degree of similarity between pairs of samples at every position of overlap along a given tree-ring sequence (Baillie, 1982; Baillie and Pilcher, 1973). Following this, sequences were plotted as line graphs and visually compared to assist the resolution of crossmatching difficulties, particularly for the low sample depth periods targeted in this study.

All series were then standardised using the program ARSTAN (Holmes *et al.*, 1986) to remove the effects of biological growth in preparation for climate analysis. Two sets of tree-ring indices were derived using splines with a 50% frequency response at 20 and 200 years suitable for high frequency (ENSO, sunspots) and long-term climate trend analyses (global warming applications) (Fowler and Boswijk, 2003) respectively. All standardised series were combined into tree means which were then averaged to produce spline 20 and 200 versions of the Puketi South chronology.

A quality control procedure was initiated to test the merit of including each crossdated series in the construction of the updated site chronology (Fowler and Boswijk, 2003). This was assessed using the Expressed Population Signal (EPS) statistic (Briffa and Jones, 1990). The "chronology stripping" procedure discussed by Fowler and Boswijk (2003) involves iteratively removing poor series which lower the chronology EPS. The EPS statistic is calculated from the sample size and the mean within and between tree correlations, and has a possible range from zero to one, where one represents a hypothetical perfect chronology.

Results

(i) Loop Track, Puketi South

Characteristics of Original Loop Track, Puketi South

Ahmed (1984) described the Loop Track and Te Harua Ridge sites as having similar ring width patterns. As a result, data obtained only from those trees on the north-facing slopes from both sites were pooled to increase sample size of an overall site chronology for Puketi South (PUKF). Mean ring width was 1.56mm and mean sensitivity was 0.2, representing the relative high frequency variance of a series (periods <2 years in length) (Fritts, 1991).

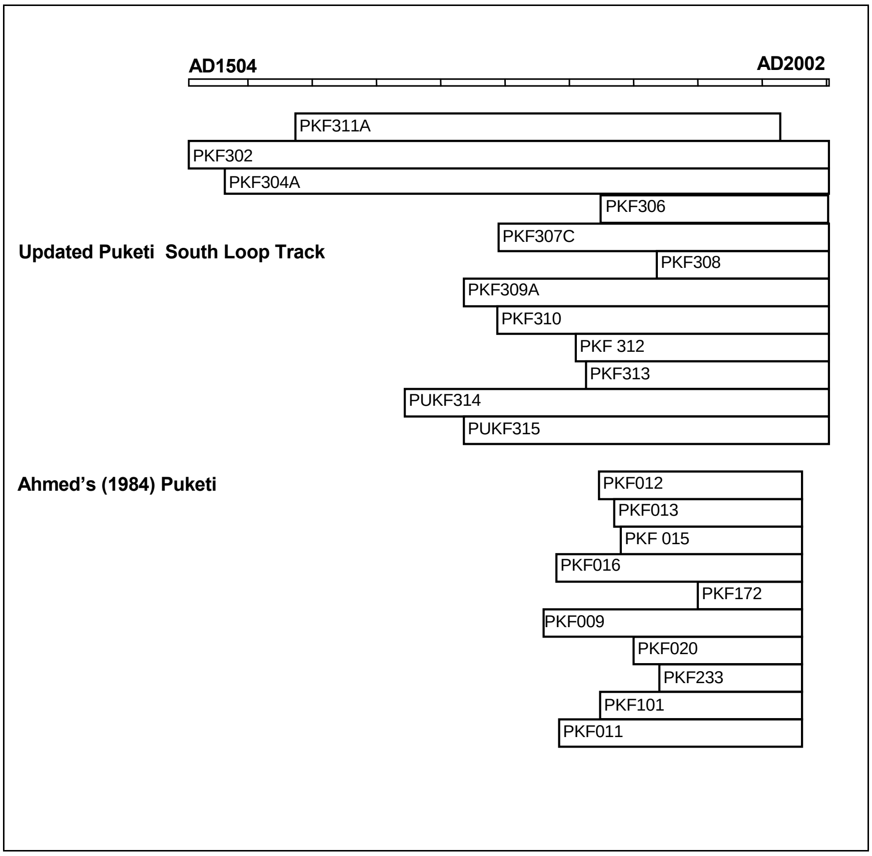
Characteristics of 2003 Resampled Loop Track, Puketi South

Of the 39 samples collected in 2003, 22 radii from 12 trees were incorporated into an updated site chronology for southern Puketi Forest (see Figure 3). There was consistently good intra and inter-tree crossmatching as seen in Tables 1 and 2. Tree PKF315 showed the strongest relationships with all trees included in the chronology, with *t*-values ranging from a low of 3.6 with PKF304 to 14.6 with PKF306 (Table 2). Lowest *t*-values were observed for PKF304, however due to the samples relative length (AD 1532), there was reluctance to omit the tree from the chronology on the grounds of low sample depth noted for this period.

Trees PKF301, PKF303 and PKF305 either had poor internal or inter-tree correlations and thus were rejected from inclusion in the final site chronology as they were considered to be potentially problematic for subsequent climatic analyses. PKF311 was the only tree truncated due to narrow rings which resulted in unreliable dating. Inter-tree comparisons between Ahmed's (1984) set and the 2003 material also revealed consistently good *t*-values, the strongest relationship of *t*=11.12 noted between PKF312 and PKF012 (Table 2).

The revised chronology incorporating both data sets includes 22 trees and spans AD 1504 to AD 2002 (Figure 3). The 499 year combined chronology has an average ring width of 1.69 mm, with mean sensitivity of 0.18. Sample depth peaks at 22 timbers between AD 1900- AD 1964, with 11 trees extending beyond 1981 to 2002 (Appendix 2). Three trees (PKF302, PKF304, PKF311) extended back beyond AD 1600. The longest was PKF302 which dated to AD 1504- AD 2002.

Figure 3: Tree sequences used in the revised Puketi South site chronology (AD 1504-AD 2002).



A statistical comparison of the original, resampled and revised chronologies for Puketi South were checked against the modern kauri master chronology (excluding the original Puketi South record) and individual site chronologies to verify crossdating. Table 4 indicates the notable improvement in the statistical robustness of both the resample and revised chronologies when compared to the original chronology of Ahmed (1984).

T-values improved practically in all instances with individual site chronologies. The decreases noted were considered negligible. The minimum *t* value of 7.60 was noted with the temporally short Waipoua standing dead chronology. The revised chronology showed greatest affinity for Manaia Sanctuary (*t*= 13.41), Puketi Bluff (*t*= 12.72) and Cascades (*t*= 12.12). There was an overall improvement of the *t*-value statistic from *t*= 14.95 to a high *t*= 18.63 with the modern master, implying a discernable improvement from the incorporation of resampled material (Table 4).

The overall EPS results for both standardised chronologies are presented in Table 5. The conservative effect of the spline 200 standardisation was apparent, reducing the length of the high quality period by 76 years and overall EPS statistic by up to 0.04. Overall the chronology was found to be of a high quality (EPS remained above 0.927 with no series removed) and the effects of stripping were found to be negligible, particularly in the case of the spline 20 standardisation. As a result, all crossdated series were considered suitable for chronology construction. The inclusion of all series in the final chronology suggests agreement with the conclusion of Fowler and Boswijk (2003) that crossdating alone does indeed provide an effective implicit quality control for kauri tree-ring chronologies.

(ii) Onekura Bluff, Puketi North

Characteristics of Original Onekura Bluff, Puketi North

Ahmed (1984) sampled 45 cores from 16 trees from Onekura Bluff, however only 20 cores from eight trees were used to establish the original Puketi Bluff (PUBL) chronology. Trees growing on the top of the ridge were reported to be fast growing with complacent rings, and abrupt changes in ring width and false rings were found to be common to these trees. Sensitive ring sequences occurred in trees growing on north-facing slopes and good cross-matching was achieved by Ahmed (1984) amongst these trees. Mean ring width was 1.6mm, first order auto-correlation value was low at 0.23, and mean sensitivity (0.31) was noted as being the highest correlated among all the crossmatched sites analysed by Ahmed (1984).

Characteristics of 2003 Resample Onekura Bluff, Puketi North

No chronology was established from the 40 cores sampled from 15 trees at Onekura Bluff due to time restraints. All samples were, however, dried, mounted, sanded and labelled for subsequent analysis. Visual inspection of the material collected suggests sensitive sequences highly suitable for future chronology construction. Sample details for the area can be found in Appendix 3.

Discussion and Conclusion

Living kauri trees were sampled from Puketi State Forest as part of an update of Northland tree ring chronologies to be used for El Niño-Southern Oscillation research. The area was revisited in October 2003 and two original sites were resampled: Loop Track Southern Puketi and Onekura Bluff. A third site, Te Harua in Puketi South, was rejected as a sampling location. 39 samples from 15 trees were obtained from the Loop Track and 40 samples from 15 trees were sampled from Onekura Bluff. A chronology was not built from the material collected from Onekura Bluff due to time restrictions, however visual inspection of the material suggests that sensitive ring patterns are suitable for chronology development to be used for future climate analysis.

Resampling of Puketi State Forest in 2003 resulted in the development of a robust, site chronology being established from 44 radii from 22 trees from southern Puketi. The original chronology for southern Puketi (AD 1780-AD 1981) was extended by a total of 297 years through the addition of 27 radii from 12 trees, to span AD 1504-2002.

Overall, material from this site was non problematic and of a high quality. This was reflected in the strong relationships noted between all other modern chronologies from Auckland, Waikato and Northland and high EPS statistics. The strong relationship noted with Manaia Sanctuary (AD 1269-1998) and Cascades (AD 1559-1982) is likely to reflect the length of overlap between these two long chronologies. The slight decrease in the statistical relationship between the original and revised PUKF chronologies and nearby Puketi Bluff (AD 1623-1983) is perhaps a reflection of the latter's relatively short series length.

Overall, the revised site chronology for Puketi was replicated in its entirety by other independent site chronologies and was thus considered to be of a suitably high standard to be included in the kauri modern master record. Importantly, Puketi is the first of the Northland chronologies to extend past AD 1982, and the first of the 16 modern kauri chronologies to provide all of the Twentieth century. Importantly, the revised chronology from Puketi will facilitate the assessment of climate extremes experienced in the post-1980 period associated with ENSO and global climate change.

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Table 1: Internal Crossmatching for Puketi Loop Resample Trees PKF301-PKF310.

t-values over 3.00 shown.\ = overlap < 15 years, - = t-values less than 3.00, * = empty triangle. min t = 0.77 max t = 12.90, mean t = 6.05 s.d. = 2.20

Sample I.D.	Start Dates (AD)	End Dates (AD)	PKF302b AD1737 AD2002	PKF304a AD1532 AD2002	PKF306a AD1834 AD2002	PKF306b AD1825 AD2002	PKF306c AD1850 AD2002	PKF307c AD1745 AD2002	PKF308b AD1868 AD2002	PKF308c AD1895 AD2002	PKF309a AD1880 AD2002	PKF309b AD1747 AD2002	PKF309c AD1718 AD2002	PKF310a AD1744 AD2002	PKF310b AD1769 AD2002	PKF310c AD1863 AD2002
PKF302a	AD1504	AD2002	12.66	6.00	9.54	6.40	7.85	5.84	6.26	7.76	4.79	6.13	5.65	7.82	5.62	5.59
PKF302b	AD1737	AD2002	*	4.28	7.00	6.06	6.22	5.79	6.31	5.43	3.17	6.83	6.63	6.45	5.75	3.55
PKF304a	AD1532	AD2002	*	*	4.77	3.38	4.30	4.51	-	3.60	-	5.98	4.52	4.67	3.87	3.83
PKF306a	AD1834	AD2002	*	*	*	12.15	11.34	7.59	7.49	7.01	6.29	9.04	6.62	7.29	7.05	6.89
PKF306b	AD1825	AD2002	*	*	*	*	12.46	6.28	7.05	5.28	5.41	8.66	6.74	7.51	7.76	7.18
PKF306c	AD1850	AD2002	*	*	*	*	*	5.41	7.12	6.03	5.55	5.86	5.47	7.57	6.79	6.40
PKF307c	AD1745	AD2002	*	*	*	*	*	*	3.74	4.57	-	6.38	4.53	5.42	6.38	3.74
PKF308b	AD1868	AD2002	*	*	*	*	*	*	*	7.63	7.22	8.22	4.27	4.66	4.75	6.23
PKF308c	AD1895	AD2002	*	*	*	*	*	*	*	*	5.62	5.65	3.89	-	4.47	3.29
PKF309a	AD1880	AD2002	*	*	*	*	*	*	*	*	*	8.01	4.48	4.89	3.01	6.34
PKF309b	AD1747	AD2002	*	*	*	*	*	*	*	*	*	*	9.26	6.77	5.21	5.06
PKF309c	AD1718	AD2002	*	*	*	*	*	*	*	*	*	*	*	6.63	5.57	4.27
PKF310a	AD1744	AD2002	*	*	*	*	*	*	*	*	*	*	*	*	9.17	10.17
PKF310b	AD1769	AD2002	*	*	*	*	*	*	*	*	*	*	*	*	*	7.98
PKF310c	AD1863	AD2002	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PKF311a	AD1587	AD1964	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PKF312a	AD1903	AD2002	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PKF312b	AD1805	AD2002	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PKF312c	AD1830	AD2002	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PKF313b	AD1813	AD2002	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PKF313c	AD1849	AD1960	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PKF314a	AD1771	AD2002	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PKF314b	AD1716	AD2002	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PKF314c	AD1672	AD1961	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PKF315a	AD1729	AD2002	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PKF315b	AD1718	AD2002	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PKF315c	AD1760	AD2002	*	*	*	*	*	*	*	*	*	*	*	*	*	*

continued overleaf...

Table 1 continued: Internal Crossmatching for Puketi Loop Resample Trees PKF311-PKF315.

t-values over 3.00 shown.\ = overlap < 15 years, - = t-values less than 3.00, * = empty triangle. min t = 0.77 max t = 12.90 mean t = 6.05 s.d. = 2.20

Sample I.D.	**Start Dates (AD)**	**End Dates (AD)**	**PKF311a** AD1587 AD1964	**PKF312a** AD1903 AD2002	**PKF312b** AD1805 AD2002	**PKF312c** AD1830 AD2002	**PKF313b** AD1813 AD2002	**PKF313c** AD1849 AD1960	**PKF314a** AD1771 AD2002	**PKF314b** AD1716 AD2002	**PKF314c** AD1672 AD1961	**PKF315a** AD1729 AD2002	**PKF315b** AD1718 AD2002	**PKF315c** AD1760 AD2002
PKF302a	AD1504	AD2002	9.91	5.44	5.84	6.96	8.08	7.04	5.81	8.46	3.88	7.06	10.18	10.01
PKF302b	AD1737	AD2002	8.40	4.89	4.90	5.23	7.76	6.28	5.35	7.47	3.60	8.00	8.33	8.41
PKF304a	AD1532	AD2002	5.19	-	3.50	3.92	4.53	5.51	-	-	3.31	-	3.93	5.98
PKF306a	AD1834	AD2002	8.25	5.13	8.63	6.64	6.87	6.49	4.31	8.74	3.94	10.38	9.30	9.90
PKF306b	AD1825	AD2002	6.74	3.90	7.25	5.59	6.81	5.59	3.94	7.92	4.72	9.63	9.24	8.81
PKF306c	AD1850	AD2002	6.13	4.15	6.62	4.75	5.23	5.92	4.10	7.65	3.37	8.12	8.28	9.11
PKF307c	AD1745	AD2002	10.40	3.76	5.73	4.40	3.58	4.73	5.17	6.02	4.22	9.12	10.09	7.52
PKF308b	AD1868	AD2002	4.29	5.41	5.10	5.43	5.26	3.95	3.92	5.76	3.97	6.55	5.29	7.77
PKF308c	AD1895	AD2002	6.49	5.20	4.65	3.41	5.05	4.90	4.10	6.18	-	5.60	7.11	10.38
PKF309a	AD1880	AD2002	-	4.35	3.66	3.16	4.49	-	-	3.36	3.61	4.90	3.42	5.12
PKF309b	AD1747	AD2002	7.66	-	6.48	5.32	8.58	6.62	3.85	8.32	8.64	10.00	7.77	8.80
PKF309c	AD1718	AD2002	7.86	4.26	4.83	3.49	3.79	-	3.52	6.21	5.83	6.75	6.11	7.65
PKF310a	AD1744	AD2002	8.14	-	3.38	3.45	7.89	4.81	4.22	10.01	5.22	7.13	8.01	7.64
PKF310b	AD1769	AD2002	7.58	-	4.73	4.01	6.17	5.43	5.03	8.91	5.87	8.26	8.03	7.96
PKF310c	AD1863	AD2002	4.42	3.01	4.01	-	5.81	3.54	3.68	5.31	4.12	6.07	5.27	7.08
PKF311a	AD1587	AD1964	*	4.12	7.03	6.75	8.85	6.98	4.51	8.37	6.31	9.37	12.20	10.09
PKF312a	AD1903	AD2002	*	*	5.43	3.59	3.01	-	3.28	3.06	-	3.85	4.32	6.67
PKF312b	AD1805	AD2002	*	*	*	8.56	6.99	7.37	4.76	5.37	4.15	7.65	6.60	6.65
PKF312c	AD1830	AD2002	*	*	*	*	7.79	5.15	-	4.45	3.92	6.90	6.12	6.96
PKF313b	AD1813	AD2002	*	*	*	*	*	9.96	3.61	7.96	4.55	8.47	9.18	8.62
PKF313c	AD1849	AD1960	*	*	*	*	*	*	4.28	6.34	4.54	6.56	6.89	5.92
PKF314a	AD1771	AD2002	*	*	*	*	*	*	*	8.64	4.71	4.45	5.66	10.67
PKF314b	AD1716	AD2002	*	*	*	*	*	*	*	*	5.94	8.34	10.17	10.99
PKF314c	AD1672	AD1961	*	*	*	*	*	*	*	*	*	5.84	5.54	6.40
PKF315a	AD1729	AD2002	*	*	*	*	*	*	*	*	*	*	12.17	12.90
PKF315b	AD1718	AD2002	*	*	*	*	*	*	*	*	*	*	*	10.87
PKF315c	AD1760	AD2002	*	*	*	*	*	*	*	*	*	*	*	*

Table 2: 2003 Puketi Loop Resample Inter-tree Comparison.

t-values over 3.00 shown.\ = overlap < 15 years, - = t-values less than 3.00, * = empty triangle. t = 3.26 max t = 14.67 mean t = 7.84 s.d. = 2.56

Sample I.D.	**Start Dates (AD)**	**End Dates (AD)**	**PKF304a**	**PKF306**	**PKF307c**	**PKF308**	**PKF309**	**PKF310**	**PKF311a**	**PKF312**	**PKF313**	**PKF314**	**PKF315**
			AD1532 AD2002	AD1825 AD2002	AD1745 AD2002	AD1868 AD2002	AD1718 AD2002	AD1744 AD2002	AD1587 AD1964	AD1805 AD2002	AD1813 AD2002	AD1672 AD2002	AD1718 AD2002
PKF302	AD1504	AD2002	6.18	9.56	6.59	7.66	8.51	8.15	11.20	6.77	9.33	9.08	12.83
PKF304a	AD1532	AD2002	*	4.21	4.51	3.41	5.34	5.16	5.19	3.77	4.97	3.26	3.60
PKF306	AD1825	AD2002	*	*	7.63	9.42	10.18	10.77	8.10	9.05	8.94	7.27	14.67
PKF307c	AD1745	AD2002	*	*	*	4.48	5.87	6.49	10.40	5.98	4.17	7.51	10.54
PKF308	AD1868	AD2002	*	*	*	*	7.66	5.56	5.70	7.46	5.74	6.56	10.44
PKF309	AD1718	AD2002	*	*	*	*	*	9.24	8.74	7.06	6.92	7.85	11.91
PKF310	AD1744	AD2002	*	*	*	*	*	*	8.60	5.80	8.47	8.82	11.39
PKF311a	AD1587	AD1964	*	*	*	*	*	*	*	8.13	9.52	8.12	13.29
PKF312	AD1805	AD2002	*	*	*	*	*	*	*	*	8.03	6.11	9.86
PKF313	AD1813	AD2002	*	*	*	*	*	*	*	*	*	5.96	11.38
PKF314	AD1672	AD2002	*	*	*	*	*	*	*	*	*	*	12.62

Table 3: Inter-tree Comparison of Ahmed's (1984) trees and 2003 Puketi Loop Resample Trees (ID numbers starting with 3).

t-values over 3.00 shown.\ = overlap < 15 years, - = t-values less than 3.00, * = empty triangle. min t = 2.85 max t = 14.67 mean t = 6.87 s.d. = 2.26

Sample I.D.	**Start Dates (AD)**	**End Dates (AD)**	**PKF009**	**PKF010**	**PKF011**	**PKF012**	**PKF013**	**PKF015**	**PKF016**	**PKF0172**	**PKF020**	**PKF0233**
			AD1780 AD1981	AD1824 AD1981	AD1792 AD1981	AD1823 AD1981	AD1835 AD1981	AD1840 AD1981	AD1790 AD1981	AD1900 AD1981	AD1850 AD1981	AD1870 AD1981
PKF302	AD1504	AD2002	5.75	6.76	8.82	11.12	7.92	6.21	9.91	4.58	5.34	4.89
PKF304a	AD1532	AD2002	3.60	3.74	5.33	4.12	4.12	3.39	4.28	3.49	-	3.13
PKF306	AD1825	AD2002	10.13	9.69	9.98	9.57	9.21	7.81	10.59	5.44	5.83	4.65
PKF307c	AD1745	AD2002	7.28	6.83	7.58	6.59	4.65	4.39	5.98	-	3.04	3.53
PKF308	AD1868	AD2002	8.77	6.41	6.26	6.19	6.36	4.50	6.71	5.34	5.52	3.16
PKF309	AD1718	AD2002	7.17	7.44	8.14	7.26	6.39	4.43	7.54	7.87	3.82	3.09
PKF310	AD1744	AD2002	8.60	9.85	6.92	7.86	6.20	6.94	7.01	5.15	5.22	4.11
PKF311a	AD1587	AD1964	6.43	7.03	9.17	8.90	6.57	5.13	8.55	3.55	5.20	6.24
PKF312	AD1805	AD2002	7.40	6.48	7.94	6.67	6.60	5.02	7.56	4.03	3.50	5.22
PKF313	AD1813	AD2002	5.96	6.42	8.31	8.05	8.90	5.74	7.72	3.84	4.43	5.20
PKF314	AD1672	AD2002	10.75	6.98	8.10	6.18	6.17	6.82	6.79	3.18	5.32	3.65
PKF315	AD1718	AD2002	11.99	8.68	11.01	9.81	8.94	7.84	10.33	6.80	5.78	6.59

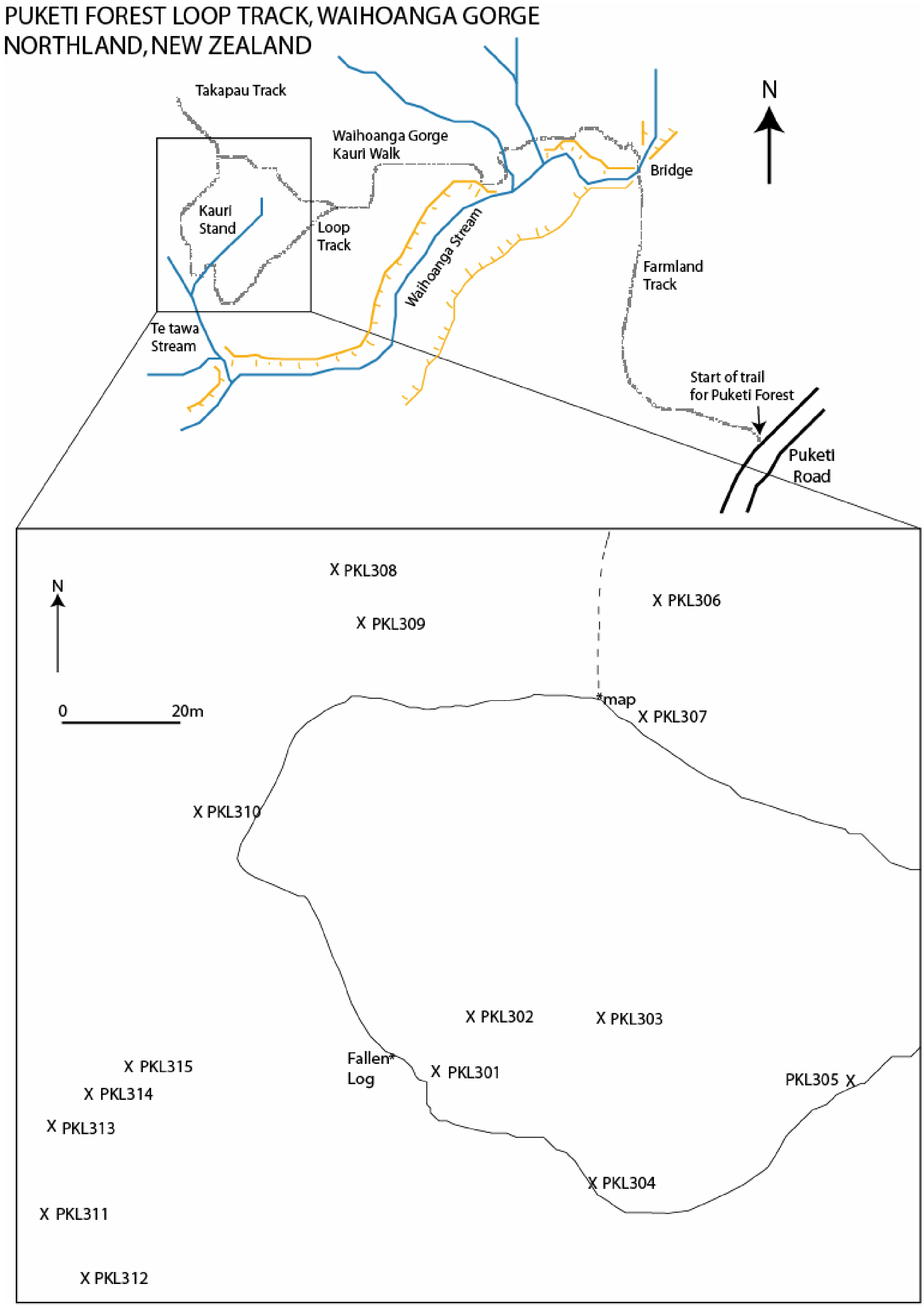
Table 4: Intra-site comparison of original, resampled and revised Puketi Chronologies with all modern kauri site chronologies by region.

	Start Dates	**End Dates**	**Original Puketi Loop** AD 1780 AD 1981	**Resampled Puketi Loop** AD 1504 AD 2002	**Revised Puketi Loop** AD 1504 AD 2002
Kauri master (ex. Puketi)	AD 1269	AD 1998	14.95	17.82	18.63
Auckland					
Cascades	AD 1559	AD 1982	7.01	12.15	12.12
Hidden Valley	AD 1679	AD 1997	6.19	10.10	9.61
Huapai	AD 1483	AD 1997	6.81	12.04	11.87
Huia	AD 1720	AD 1981	9.67	10.60	10.53
Konini Forks	AD 1770	AD 1976	10.73	9.03	10.55
Little Barrier	AD 1790	AD 1981	10.63	10.53	11.41
Waikato/Bay of Plenty					
Katikati	AD 1698	AD 1996	10.90	10.04	11.10
Manaia	AD 1269	AD 1998	11.05	12.74	13.41
Moehau	AD 1360	AD 1980	6.64	10.47	10.74
Mount William	AD 1580	AD 1981	9.02	10.24	10.95
Northland					
Puketi Bluff	AD 1675	AD 1981	13.76	12.41	12.72
Trounson	AD 1668	AD 1980	6.01	8.13	8.34
Waipoua Dead	AD 1628	AD 1903	4.35	7.56	7.60
Warawara	AD 1660	AD 1979	9.32	9.50	10.32

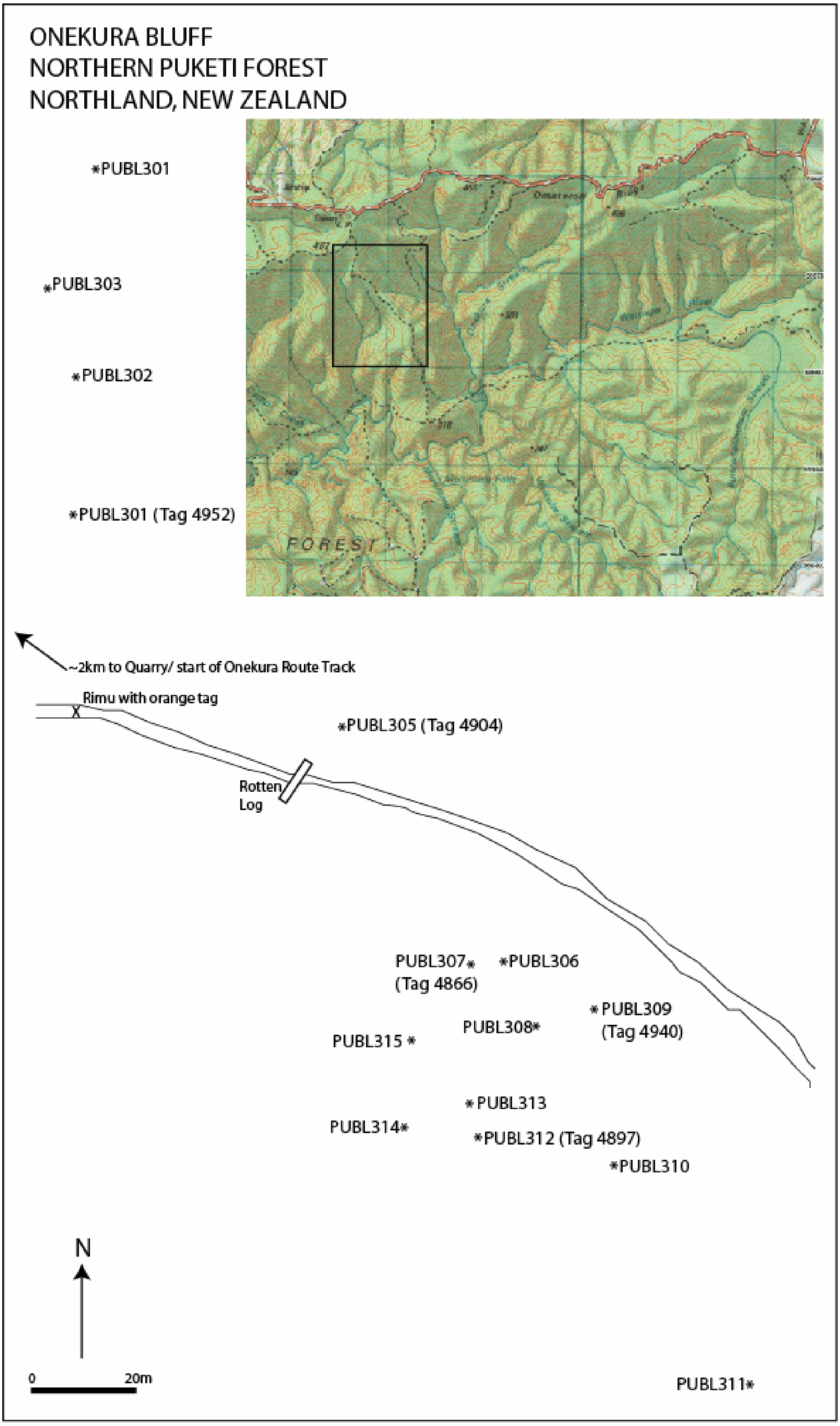
Table 5: Revised chronology stripping Expressed Population Signal (EPS) results for southern Puketi.

Standardisation	**EPS Value (All Series)**	**Highest Quality Period (EPS≥0.80)**	**Most Significant Series Removal**	**EPS Improvement**
Spline 20	0.959	1737-2002	PKF310A	+0.959 to +0.959
Spline 200	0.927	1813-2002	PKF312A	+0.919 to +0.921

Appendix 1a: Tree location map for Kauri sampled from Waihoanga Gorge Loop Track, Southern Puketi Forest.



Appendix 1b: Tree location map for Kauri sampled from Onekura Bluff, Northern Puketi Forest.



Appendix 2a: Puketi 2003 Resample field data requirements for Department of Conservation Permit NO-13215 RES.

Tree ID	DBH	Series ID	No. Rings	Av. Growth Rate	Dates (AD)	Tree ID	Series ID	No. Rings	Av. Growth Rate	Dates (AD)
PKF302	2.10		499	1.55	1504- 2002	**PKF009**		202	1.43	1780- 1981
		PKF302A	499	1.45	1504- 2002		PKF0091	172	1.33	1810- 1981
		PKF302B	266	0.93	1737- 2002		PKF0093	202	1.50	1780- 1981
PKF304	2.06		471	1.47	1532- 2002	**PKF010**		158	0.91	1824- 1981
		PKF304A	471	1.47	1532- 2002		PKF0101	158	0.91	1824- 1981
PKF306	1.65		178	1.22	1825- 2002	**PKF011**		190	1.32	1792- 1981
		PKF306A	169	1.11	1834- 2002		PKF0111	132	1.83	1850- 1981
		PKF306B	178	1.07	1825- 2002		PKF0112	172	1.20	1810- 1981
		PKF306C	153	1.40	1850- 2002		PKF0113	190	1.05	1792- 1981
PKF307	1.36		258	0.99	1745- 2002	**PKF012**		159	1.22	1823- 1981
		PKF307C	258	0.99	1745- 2002		PKF0122	159	1.36	1823- 1981
							PKF0123	82	0.55	1900- 1981
PKF308	1.16		135	1.10	1868- 2002					
		PKF308B	135	1.18	1868- 2002	**PKF013**		147	1.49	1835- 1981
		PKF308C	108	1.01	1895- 2002		PKF0131	147	1.24	1835- 1981
							PKF0133	137	1.78	1845- 1981
PKF309	1.10		285	0.97	1718- 2002					
		PKF309A	123	0.96	1880- 2002	**PKF015**		142	1.93	1840- 1981
		PKF309B	256	1.02	1747- 2002		PKF0151	142	1.88	1840- 1981
		PKF309C	285	0.86	1718- 2002		PKF0152	134	1.87	1848- 1981
PKF310	1.39		259	1.15	1744- 2002	**PKF016**		192	1.66	1790- 1981
		PKF310A	259	0.97	1744- 2002		PKF0161	192	1.72	1790- 1981
		PKF310B	234	1.14	1769- 2002		PKF0162	162	1.52	1820- 1981
		PKF310C	140	1.17	1863- 2002		PKF0163	182	1.58	1800- 1981
PKF311	2.10		378	1.28	1587- 1964	**PKF017**		82	2.13	1900- 1981
		PKF311A	378	1.28	1587- 1964		PKF0172	82	2.13	1900- 1981
PKF312	1.60		198	1.37	1805- 2002	**PKF020**		132	1.66	1850- 1981
		PKF312A	100	1.85	1903- 2002		PKF0202	132	1.65	1850- 1981
		PKF312B	198	1.35	1805- 2002		PKF0203	122	1.69	1860- 1981
		PKF312C	173	1.23	1830- 2002					
						PKF023		112	1.66	1870- 1981
PKF313	1.40		190	1.04	1813- 2002		PKF0233	112	1.66	1870- 1981
		PKF313B	190	0.92	1813- 2002					
		PKF313C	112	1.09	1849- 1960					
PKF314	1.12		331	1.04	1672- 2002					
		PKF314A	232	1.12	1771- 2002					
		PKF314B	287	0.89	1716- 2002					
		PKF314C	290	0.89	1672- 1961					
PKF315	1.44		285	1.02	1718- 2002					
		PKF315A	274	0.96	1729- 2002					
		PKF315B	285	0.94	1718- 2002					
		PKF315C	243	1.12	1760- 2002					

Appendix 2b: All crossdated tree and sample details for revised PUKF chronology.

Tree ID	DBH (m)	Core ID	Core Bearing	Core Angle	Sample Height (m)	Core Length (cm)	Rot
PKF301	1.80	PKF301A	183	4.0	1.00	60.0	Yes
		PKF301B	70	80.0	1.30	27.4	No
PKF302	2.10	PKF302A	220	3.0	1.25	80.0	No
		PKF302B	135	8.0	0.80	28.4	No
PKF303	1.90	PKF303A	195	2.0	1.75	78.0	No
		PKF303B	283	8.0	1.15	27.4	No
PKF304	2.06	PKF304A	250	2.0	1.20	80.0	No
		PKF304B	325	5.0	1.10	28.0	No
PKF305	1.87	PKF305A	185	3.0	1.60	43.4	Yes
		PKF305B	255	2.0	1.65	28.6	No
PKF306	1.65	PKF306A	280	2.5	1.25	30.2	No
		PKF306B	000	5.0	1.2	30.0	No
		PKF306C	80	5.0	1.2	28.0	No
PKF307	1.36	PKF307A	190	?	1.05	29.0	No
		PKF307 B	130	5.0	1.25	28.4	No
		PKF307C	030	?	1.25	29.4	No
PKF308	1.16	PKF308A	000	9.0	1.35	28.4	No
		PKF308B	070	8.0	1.35	29.6	No
		PKF308C	270	10.0	1.35	29.6	No
PKF309	1.10	PKF309A	250	1.0	1.10	26.1	No
		PKF309B	045	10.0	1.00	30.0	No
		PKF309C	140	6.0	1.00	29.0	No
PKF310	1.39	PKF310A	275	15.0	1.35	29.0	No
		PKF310B	200	10.0	1.10	29.5	No
		PKF310C	125	1.0	1.30	20.0	No
PKF311	2.10	PKF311A	195	1.0	1.50	71.6	Yes
		PKF311B	85	10.0	1.10	29.8	No
PKF312	1.60	PKF312 A	260	2.0	1.25	21.6	No
		PKF312B	170	2.0	0.90	29.6	No
		PKF312C	210	7.0	1.00	27.6	No
PKF313	1.40	PKF313A	355	10.0	1.20	30.0	No
		PKF313B	270	11.0	1.30	28.0	No
		PKF313C	190	7.5	1.05	29.8	No
PKF314	1.12	PKF314A	315	4.0	1.05	30.0	No
		PKF314B	255	9.0	1.10	28.8	No
		PKF314C	205	10.0	1.25	29.0	No
PKF315	1.44	PKF315A	280	9.0	1.25	27.4	No
		PKF315B	260	4.0	1.05	30.0	No
		PKF315C	305	10.0	1.20	29.8	No

Appendix 2c: Onekura Bluff 2003 Resample field data requirements for Department of Conservation Permit NO-13215 RES.

Tree ID	DBH (m)	Core ID	Core Bearing	Core Angle	Sample Height (m)	Core Length (cm)	Rot	Comments
PUB301	2.20	PUB301A	140	2.0	1.10	79.0	No	AL tags 035
		PUB301B	265	2.5	1.30	38.2	No	and 4952
PUB302	2.30	PUB302A	035	10.0	1.30	40.2	Yes	
		PUB302B	120	7.0	1.00	35.0	No	
PUB303	2.02	PUB303A	000	5.0	1.20	75.4	No	
		PUB303B	073	4.0	1.00	33.2	No	
PUB304	1.70	PUB304A	250	2.5	1.45	36.0	No	AL tag 027
		PUB304B	028	4.0	1.15	75.0	No	
PUB305	1.80	PUB305A	280	7.0	1.28	73.0	No	AL tag 4984
		PUB305B	210	2.5	1.20	33.0	No	
PUB306	1.51	PUB306A	345	8.0	1.10	36.8	No	
		PUB306B	100	10.0	1.05	30.6	No	
		PUB306C	170	5.0	1.20	36.0	No	
PUB307	1.02	PUB307A	220	2.0	1.00	29.4	No	AL tag 4866
		PUB307B	030	9.0	0.82	32.0	No	
		PUB307C	135	8.0	1.25	27.5	No	
PUB308	1.07	PUB308A	144	10.0	1.10	32.0	No	
		PUB308B	055	5.0	1.10	28.0	No	
		PUB308C	275	5.0	1.10	27.8	No	
PUB309	1.22	PUB309A	168	12.0	1.20	30.4	No	AL tag 4940
		PUB309B	240	10.0	1.30	29.0	No	
		PUB309C	070	4.0	1.15	30.0	No	
PUB310	1.51	PUB 310A	140	?	1.25	29.0	No	
		PUB 310B	140	10.0	1.03	27.5	No	
		PUB 310C	305	11.0	1.10	28.0	No	
PUB311	1.45	PUB311A	220	10.0	1.20	30.4	No	
		PUB311B	130	15.0	1.15	30.0	No	
		PUB311C	325	5.0	1.20	28.6	No	
PUB312	1.10	PUB312A	198	7.0	1.05	27.5	No	AL tag 4897
		PUB312B	105	10.0	1.05	29.0	No	
		PUB312C	340	9.0	1.20	29.2	No	
PUB313	1.34	PUB313A	110	10.0	1.00	29.0	No	AL tag 4895
		PUB313B	115	5.0	1.05	25.4	No	
		PUB313C	010	8.0	1.10	28.6	No	
PUB314	1.28	PUB314A	165	9.0	1.25	27.6	No	AL tag 4888
		PUB314B	250	10.0	1.00	27.4	No	
		PUB314C	355	6.0	1.2	28.0	No	
PUB315	1.18	PUB315A	130	5.0	1.30	29.0	No	
		PUB315B	?	?	1.15	28.4	No	
		PUB315C	275	2.5	1.15	28.4	No	

Appendix 3: Sample depth details for revised unstandardised Puketi Loop Track chronology.

Revised 2003 Loop Track Puketi South Chronology
499 years length dated AD1504 to AD2002
22 timbers with average ring width =1.69mm, and mean sensitivity= 0.18

Year	Ring Widths (100=1mm)										Sample Depth (No. Trees)									
AD1504				366	346	409	429	255	233	222				1	1	1	1	1	1	1
-	206	186	209	303	368	435	328	315	191	202	1	1	1	1	1	1	1	1	1	1
-	180	252	348	474	541	514	536	324	295	259	1	1	1	1	1	1	1	1	1	1
-	212	235	284	237	236	230	236	333	369	248	1	2	2	2	2	2	2	2	2	2
-	313	285	279	232	208	265	285	311	270	237	2	2	2	2	2	2	2	2	2	2
AD1551	299	372	316	402	393	364	421	317	292	243	2	2	2	2	2	2	2	2	2	2
-	266	284	198	208	118	159	174	254	371	366	2	2	2	2	2	2	2	2	2	2
-	368	288	308	356	328	330	257	264	218	237	2	2	2	2	2	2	2	2	2	2
-	255	232	248	311	396	356	264	205	248	225	2	2	2	2	2	2	3	3	3	3
-	265	220	211	222	198	208	193	186	238	246	3	3	3	3	3	3	3	3	3	3
AD1601	377	286	319	315	230	229	238	231	172	231	3	3	3	3	3	3	3	3	3	3
-	172	189	186	177	185	179	204	203	239	234	3	3	3	3	3	3	3	3	3	3
-	278	208	178	122	178	153	177	224	174	155	3	3	3	3	3	3	3	3	3	3
-	173	134	145	155	107	121	139	171	179	165	3	3	3	3	3	3	3	3	3	3
-	172	154	145	128	137	122	121	126	107	134	3	3	3	3	3	3	3	3	3	3
AD1651	118	109	156	145	232	166	250	183	215	228	3	3	3	3	3	3	3	3	3	3
-	224	134	181	209	252	166	249	195	284	210	3	3	3	3	3	3	3	3	3	3
-	213	229	195	222	209	201	177	189	171	175	3	4	4	4	4	4	4	4	4	4
-	168	133	191	130	173	147	176	152	165	129	4	4	4	4	4	4	4	4	4	4
-	194	205	220	275	238	236	249	185	182	192	4	4	4	4	4	4	4	4	4	4
AD1701	158	155	167	135	163	144	89	133	133	168	4	4	4	4	4	4	4	4	4	4
-	157	183	200	206	166	156	138	124	192	150	4	4	4	4	4	4	4	6	6	6
-	187	141	174	71	136	142	136	150	119	132	6	6	6	6	6	6	6	6	6	6
-	123	132	162	193	159	184	150	98	124	112	6	6	6	6	6	6	6	6	6	6
-	102	134	97	168	112	164	137	134	145	88	6	6	6	7	8	8	8	8	8	8
AD1751	131	115	156	148	151	144	111	194	156	146	8	8	8	8	8	8	8	8	8	8
-	137	159	144	116	139	119	111	162	170	136	8	8	8	8	8	8	8	8	8	8
-	136	125	161	172	156	176	158	122	166	125	8	8	8	8	8	8	8	8	8	9
-	159	130	96	134	151	149	110	159	134	138	9	9	9	9	9	9	9	9	9	10
-	159	111	128	120	99	135	143	117	173	149	10	11	11	11	11	11	11	11	11	11
AD1801	103	109	138	129	100	118	140	138	183	184	11	11	11	11	12	12	12	12	12	12
-	180	162	164	144	137	157	138	127	115	123	12	12	13	13	13	13	13	13	13	13
-	137	135	101	135	96	149	121	143	169	135	13	13	14	15	16	16	16	16	16	16
-	186	156	193	194	187	159	174	189	85	167	16	16	16	16	17	17	17	17	17	18
-	141	150	157	161	160	95	127	113	108	147	18	18	18	18	18	18	18	18	18	19
AD1851	164	160	189	157	142	159	139	147	153	112	19	19	19	19	19	19	19	19	19	19
-	120	131	103	145	130	122	98	153	143	154	19	19	19	19	19	19	19	20	20	21
-	147	174	154	147	107	149	137	116	117	136	21	21	21	21	21	21	21	21	21	21
-	135	135	125	176	154	112	100	109	76	69	21	21	21	21	21	21	21	21	21	21
-	111	87	95	106	121	115	97	102	83	105	21	21	21	21	21	21	21	21	21	22
AD1901	111	124	86	154	171	103	88	98	87	85	22	22	22	22	22	22	22	22	22	22
-	132	95	133	102	59	54	98	143	171	124	22	22	22	22	22	22	22	22	22	22
-	142	117	89	115	86	78	95	70	88	103	22	22	22	22	22	22	22	22	22	22
-	108	94	93	91	66	110	88	105	125	179	22	22	22	22	22	22	22	22	22	22
-	128	148	110	131	84	84	95	100	113	76	22	22	22	22	22	22	22	22	22	22
AD1951	147	141	138	125	110	108	149	110	138	66	22	22	22	22	22	22	22	22	22	22
-	116	85	132	85	95	62	83	67	63	55	22	22	22	22	21	21	21	21	21	21
-	72	82	70	66	72	113	109	79	84	73	21	21	21	21	21	21	21	21	21	21
-	86	74	81	67	74	90	86	64	86	80	21	11	11	11	11	11	11	11	11	11
-	106	90	86	71	47	62	60	58	78	81	11	11	11	11	11	11	11	11	11	11
AD2001	79	92									11	11								