A dendrometer band study of the seasonal pattern of radial increment in kauri (Agathis australis)

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Abstract  Simple dendrometer bands were used to measure the radial increment of kauri (Agathis australis Salisb.) at 3 sites to the south and east of Auckland during the 1980-81 growing season. Diameter increment cores taken from some of the trees at the beginning and end of the study showed that the radial expansion measured by the bands correlated significantly (P<0.001) with the width of the annual ring formed over the same period. A reduction in tree growth rate during summer drought was recorded at 2 mid-altitude sites, but not near the altitudinal limit of kauri. These growth patterns were attributed to the different soil moisture conditions at the different sites.

Keywords  dendrometer; kauri; Agathis australis; wood anatomy; ecology; New Zealand vegetation

INTRODUCTION

Dendrometers have been widely used to detect the seasonal growth patterns of trees because they provide an easy and convenient way for measuring changes in the diameters of tree trunks (Bormann & Kozlowski 1962). Several types of dendrometer are available, and reviewed by Fritts (1976). However, the only reported study in which band type dendrometers, measuring circumferential changes, have been used to study the growth of indigenous New Zealand trees in natural environments is that of Benecke & Havranek (1980) on Nothofagus solandri var. cliffortioides.

Dendrometer bands were placed on kauri (Agathis australis Salisb.) trees at 3 sites to the south and east of Auckland. One site (Kon 1) was located in the Hunua Range to the south of Auckland. The site vegetation included a group of kauris of mature form (mostly c. 50-80 cm diam.) covering about 1 ha on an old slip surface. There were 2 larger kauri trees on the outer margin of the slip, but otherwise the site was surrounded by tawa (Beilschmiedia tawa) – podocarp forest. The other 2 sites (Moe 1 and Moe 2) were on Mount Moehau, at the northern end of the Coromandel Peninsula, about 60 km east of Auckland. The lower of these 2 sites (Moe 2) was on a steep northerly slope similar to Kon 1, but carried fewer but larger kauri trees. The canopy was open and the understorey dominated by Leptospermum ericoides indicating disturbance (probably fire) last century. The vegetation of the higher site (Moe 1) comprised scattered kauris in mossy montane forest dominated by Weinmannia silvicola and Dacrydium cupressinum. Kauri trees of all sizes occur in the area, although most of the larger trees (c. 1 m diam.) are prostrate. The date of fall of 8 of these trees was estimated by dendrochronological methods and the results suggested site disturbance by storms during the first half of last century (Palmer 1982). Only erect trees were banded. More precise site details and characteristics are outlined in Table 1 and given in greater detail in Palmer (1982). The dendrochronological characteristics of the Hunua Range site have been described by Dunwiddie (1979) and LaMarche et al. (1980). The general features of the Mt Moehau sites were described by Cranwell & Moore (1936) although some changes in the montane vegetation have occurred since then (Mason & Chambers 1950; Moore, L. B. pers. comm.). One of these sites (Moe 1) is of particular interest for the growth of kauri, because the species is here close to its highest altitudinal limit (810 m; Ecroyd 1982).

METHODS

The dendrometer type used was a band of aluminium held in place by a spring (Fig. 1). Increase in trunk diameter causes the band to move, and this movement is measured on a vernier scale. Dendrometers of this type are described by Hall (1944) and Liming (1957), but the design used was suggested by the Forest Research Institute, Rotorua (Mr A. Katz, pers. comm.). The bands were assembled in the field. Resin flowing down the trunk caused the band to stick but this was overcome by placing a strip of polythene sheet between the trunk and the band and leaving sufficient free polythene on the upper edge to fold over the band. This modification also protected the spring and scale.
Table 1 Site descriptions and sample characteristics.

<table>
<thead>
<tr>
<th>Site characteristics</th>
<th>Kon 1</th>
<th>Moe 1</th>
<th>Moe 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Hunua Range</td>
<td>Mount Moehau</td>
<td>Mount Moehau</td>
</tr>
<tr>
<td>Latitude; Longitude</td>
<td>37°04’; 175°08’</td>
<td>36°32’; 175°25’</td>
<td>36°31’; 175°24’</td>
</tr>
<tr>
<td>Grid reference</td>
<td>N48; 708359</td>
<td>N39; 914986</td>
<td>N35; 900015</td>
</tr>
<tr>
<td>Altitude (m)</td>
<td>335</td>
<td>750</td>
<td>450</td>
</tr>
<tr>
<td>Topography (aspect)</td>
<td>Steep slope (NE)</td>
<td>Gentle slope or flat (NE)</td>
<td>Steep slope (NW)</td>
</tr>
<tr>
<td>Main canopy tree*</td>
<td>Agathis australis</td>
<td>Weinmannia silvicola</td>
<td>Agathis/Weinmannia</td>
</tr>
<tr>
<td>Total basal area (m²/ha)</td>
<td>100</td>
<td>43</td>
<td>75</td>
</tr>
<tr>
<td>Total density (no/ha)</td>
<td>698</td>
<td>841</td>
<td>758</td>
</tr>
<tr>
<td>Number of banded trees</td>
<td>33</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>Diameter range of banded trees (cm)</td>
<td>18–172</td>
<td>14–71</td>
<td>41–139</td>
</tr>
</tbody>
</table>

*Stems of all species greater than 10 cm diam. at 1.2 m above ground level. Density and basal area values derived from point-centred quarter sampling (Cottam & Curtis 1956).

Results

Measurements by dendrometer bands include stem swelling caused by moisture changes in the bark and xylem as well as increases in diameter consequent upon cambial activity and cell expansion (Fritts et al. 1965). The possibility that the measurements recorded at the study sites reflect stem shrinkage and swelling rather than changes in growth rate cannot be ruled out. However, the close correlation \( r = 0.9163; n = 12; P < 0.001 \) between the total radial increment measured by the bands, and the mean ring width (measured from cores, up-slope and down-slope aspects) indicates that total radial growth was accurately recorded (Fig. 2). The one instance in which the dendrometer reading was greater than the direct core measurement probably resulted from 2 upslope cores being taken as the downhill side of the tree was inaccessible. As in most gymnosperms the annual rings of kauri are normally wider on the down-slope side (Fritts 1976, p. 220).

Because of the small sample size, no statistically significant difference in diameter growth could be demonstrated among trees of different diameters (and ages) on any one site. Consequently the individual tree data were averaged to obtain the mean pattern of growth at each site (Fig. 3). Rapid
Fig. 2 Comparison of radial increment from dendrometer bands (open circles) with measurements from 2 cores per tree (vertical bars). The core measurements were thought to represent the maximum and minimum ring width increment.

Fig. 3 Change in growth rate between sample periods. Kon 1 (circles); Moe 1 (triangles); Moe 2 (diamonds). Standard error bars omitted for clarity; see text.

Table 2 Radial growth of kauri (Agathis australis) at the 3 sites.

<table>
<thead>
<tr>
<th>Site names</th>
<th>Kon 1</th>
<th>Moe 1</th>
<th>Moe 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cores analysed</td>
<td>44</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td>Mean annual ring width (mm)</td>
<td>1.937*</td>
<td>1.081</td>
<td>1.229</td>
</tr>
<tr>
<td>Standard error (mm)</td>
<td>0.098</td>
<td>0.080</td>
<td>0.097</td>
</tr>
</tbody>
</table>

*This mean value is significantly (P<0.001) greater than that at Moe 1.

circumference growth began in early November and peaked, at all sites, from December to February. At the 2 lower altitude sites there was a rapid decline in the growth rate during February, but some later recovery to a second peak during May. There was no evidence of a second peak at the higher altitude site. The cumulative growth curve was sigmoidal at all sites.

The growth rates determined from increment cores are given in Table 2. The mean rates are slightly below most of those published (see Ecroyd 1982); possibly this reflects the montane nature of the sites. Although growth at the high altitude site is generally less than at the lower altitudes, this was not so during the 1980–81 season; the high altitude trees grew relatively better than those at the lower sites. This is noteworthy in view of the supposedly degenerate state of the high altitude kauri stand on Mt Moehau (Ecroyd 1982).

The 1980–81 summer was dry, with below average rainfall being recorded in the Auckland region. In January, February, and March 1981, rainfall was
47% below normal*. A slight excess of evapo-
transpiration over precipitation may be frequent in
the Hunua Ranges in January but soil moisture
deficits extended for 3 months during this study
period. Recharge only occurred after exceptionally
heavy rainfall in April (Fig. 4).

DISCUSSION
The results obtained by using simple dendrometers
accurately reflect the radial increment associated
with the formation of an annual ring. However, the
dendrometer band measurements were generally
slightly smaller than the mean of the ring width
estimated from the 2 increment cores (Fig. 2). This
may indicate an initial period of 'taking up the slack'
before the bands registered growth. Growth was not
uniform at all sites throughout the season, but the
mid-summer growth check was not associated with
the formation of a 'false ring' or wider than average
latewood.

Previous studies on kauri diameter growth have
suggested that growth occurs through most of the
year, ceasing only in June, July, and August (I.
Barton pers. comm.). A second, late season leaf and
height growth flush has been recorded for kauri
seedlings (R. C. Lloyd, in Ecroyd 1982) and
occasionally for mature trees (I. Barton pers.
comm.). The similar bimodal diameter growth
patterns imply that some common variable affected
growth at the lower altitude sites. This effect did not
however extend to the higher altitude site where
there was no indication of a second growth peak.

Water shortage during summer is known to be one
of the most important environmental factors
influencing cambial activity (Studhalter et al. 1963).
Furthermore, if water stress is alleviated by late-
season rainfall radial growth may resume until
limited again by declining temperatures (Zahner
1968). The dry summer and associated soil moisture
deficit in the Hunua Ranges seems a plausible
reason for growth cessation. Both of the lower sites
are at medium altitudes on steep, dry slopes. In
contrast, the higher altitude site is mainly flat,
boggy, and is situated on the leeward side of the
summit of Mt Moehau (888 m). This summit is
frequently enveloped in cloud (Cranwell & Moore
1936); condensation and 'fog drip' may contribute
substantially to the total moisture available even in
years of below average rainfall.

The exceptionally good growth of kauri at the
upper site in the warm sunny summer of 1980-81
may imply that, in common with other tree species
growing near their altitudinal limits, low tempera-
tures may limit growth more frequently than does
soil moisture at high altitude sites.

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*Analysis of records from Station A64871 (Albert Park)
given in Climatological Tables in Supplements to the New
Zealand Gazette for the relevant months.
REFERENCES


