

MODERN NEW ZEALAND TREE-RING CHRONOLOGIES

I. *Nothofagus solandri*

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ABSTRACT

Sixteen modern *Nothofagus solandri* tree-ring chronologies, developed from sites near the alpine timberline, South Island, New Zealand are presented. The statistical properties of the chronologies are similar, having high mean sensitivity values (mean of 0.34), moderate autocorrelation values (mean of 0.50), and high common variance values (mean of 42%). However, the chronologies are mainly less than 300 years in length. Examination of interchronology variation suggests that the similarity between two chronologies decreases with increasing distance. It is concluded that these chronologies offer considerable potential for reconstructing palaeoclimates, especially palaeotemperature.

Es werden 16 Jahrringchronologien von *Nothofagus solandri* von Standorten nahe der alpinen Baumgrenze auf South Island, Neuseeland, vorgestellt. Die statistischen Eigenschaften dieser Chronologien sind einander ähnlich. Die mittlere Sensitivität ist hoch (durchschnittlich 0.34), die Reihenkorrelation mäßig (durchschnittlich 0.50) und die gemeinsame Varianz der in den Chronologien enthaltenen einzelnen Jahrringfolgen ist hoch (durchschnittlich 42%). Die Chronologien sind jedoch zumeist weniger als 300 Jahre lang. Ein Vergleich der Variation zwischen den Chronologien deutet an, daß die Ähnlichkeit zwischen den Chronologien mit zunehmendem Abstand voneinander abnimmt. Es ist anzunehmen, daß diese Chronologien ein beträchtliches Potential zur Rekonstruktion des Paläoklimas, vor allem der Temperatur, darstellen.

16 chronologies modernes de *Nothofagus solandri* ont été obtenues dans des sites proches de la limite alpine des arbres en South Island, Nouvelle Zélande. Les propriétés statistiques de ces chronologies sont semblables avec une haute "sensitivity" moyenne (0.34) des autocorrélations modérées (moyenne de 0.50) et de hautes valeurs pour la variance commune (42%). Cependant les chronologies ne remontent qu'à 300 ans. L'examen des variations entre chronologies suggère qu'avec des distances croissantes, les ressemblances entre deux chronologies décroissent. On peut en conclure que ces chronologies constituent un potentiel considérable pour reconstruire les paléoclimats, spécialement les paléotempératures.

INTRODUCTION

Early attempts to develop crossdated tree-ring chronologies using indigenous New Zealand trees were largely unsuccessful. Detailed reviews of these studies are given in Burrows and Greenland (1979) and Ogden (1982). Much of the difficulty encountered by early workers arose in part from inappropriate species and site selection. Subsequent to this early work, a widespread sampling programme undertaken by the Laboratory of Tree-Ring Research, University of Arizona, and utilizing modern dendroclimatic techniques, has resulted in the development of 21 crossdated and replicated tree-ring chronologies for seven indigenous tree species from sites throughout New Zealand (Dunwiddie 1979; LaMarche et al. 1979a).

The present paper is the first of a series presenting modern New Zealand tree-ring chronologies developed since the work of Dunwiddie and LaMarche et al. As well as presenting the chronologies and their statistics, information on the species and sites sampled are included as this may be of value for future users of these chronologies. Sixteen tree-ring chronologies developed from *Nothofagus solandri* (nomenclature

follows Allan 1961) trees growing at sites near the alpine timberline, South Island, New Zealand are presented. Only one other *Nothofagus* chronology has previously been presented (*N. gunnii* in Tasmania, LaMarche et al. 1979b).

NOTHOFAGUS SOLANDRI

Nothofagus (Fagaceae), the southern beeches, occur in temperate South America, New Zealand, Australia, New Caledonia and New Guinea. Four species are endemic to New Zealand (Allan 1961): *N. fusca*, *N. menziesii*, *N. solandri* and *N. truncata* and hybrids occur (Cockayne 1926). The evergreen *N. solandri* trees can grow to heights of 25 m but are considerably reduced in stature at exposed sites (e.g. at the alpine timberline, Norton and Schönerberger 1984). The wood anatomy of *N. solandri* has been described by Meylan and Butterfield (1978); growth rings are distinct.

The ecology, life history and distribution of *Nothofagus solandri* has been described in detail by Cockayne (1926), Poole (1950) and Wardle (1970). *N. solandri* is particularly common in the closed forests of the central North Island and the eastern South Island (Figure 1) and is often the only tree species present. *N. solandri* forms timberline over much of its range. It seems that *N. solandri* is more tolerant of low rainfall, high altitude, low soil fertility and poor soil drainage conditions than most New Zealand tree species. However, it is a poor competitor with many other tree and shrub species when conditions are more favourable.

Nothofagus solandri trees commonly live to a maximum age of between 250 and 300 years (Wardle 1970). However, one tree sampled during the present study (in Fiordland, South Island) was approximately 380 years old.

Detailed study of shoot and radial growth in mature *Nothofagus solandri* trees (Norton 1984) has shown that growth is confined to the summer months. A delay in the start of growth and a shortening of the growth period occurred with increasing altitude. Changes in growth rates closely followed changes in temperature and it was concluded that growth ring formation is annual in *N. solandri*.

STUDY SITES

Sites were sampled in extensive *Nothofagus solandri* forests in Canterbury and Fiordland (Figure 1). Examination of *N. solandri* tree-ring chronologies developed from sites at different altitudes has shown that the most sensitive chronologies, that is those with the most year to year variation, could be developed from trees growing close to, but not forming, the alpine timberline (Norton 1983a). Trees were therefore sampled from sites close to the alpine timberline in the two areas.

A. Craigieburn Range

The Craigieburn Range lies in inland Canterbury (Figure 1) some 20 km to 30 km east of the main divide of the Southern Alps. The mountains, rising to over 2000 m, are composed of indurated interbedded Mesozoic sandstones and mudstones (Gregg 1964) and carry the imprint of Quaternary glaciation in the form of cirques and broad U-shaped valleys. The forest soils are predominantly high-country yellow-brown earths with some podzolic soils on terraces (Cutler 1977). The climate of the area has been described by McCracken (1980) and is dominated by westerly airflow. February is the warmest month and July the coldest. Precipitation exceeds 1600 mm and above timberline much of this falls as winter snow.

Nothofagus solandri forests occur from valley floor to timberline, at about 1350 m. These forests are often floristically simple with *N. solandri* the only tree species present. At lower altitudes and in wetter areas, shrubs and vines often form dense thickets

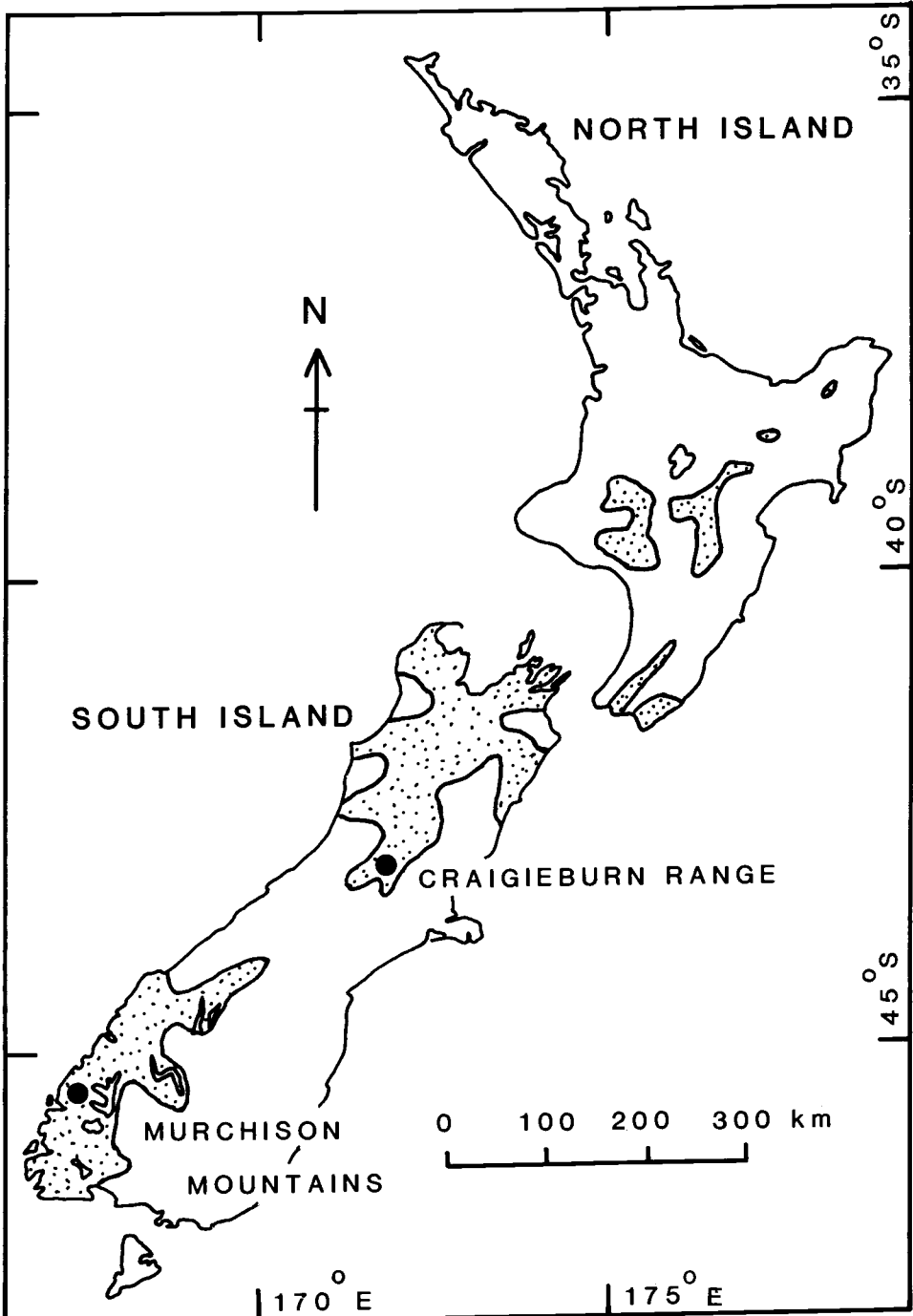


Figure 1. Location of study areas and the distribution of *Nothofagus solandri* (after Wardle 1970).

and herbs, ferns and mosses occur on the forest floor. As timberline is approached the forest understorey becomes sparse except where the canopy is open and here the shrubs *Podocarpus nivalis*, *Phyllocladus alpinus* and *Coprosma pseudocuneata* form thickets. The forests of the Craigieburn Range are described in more detail by Burrows (1977) and Norton and Schönerberger (1984). Fourteen of the 16 sites were sampled in this area.

B. Murchison Mountains

The Murchison Mountains lie between the Middle and South Fiords of Lake TeAnau in Fiordland (Figure 1). The area is a deeply dissected upland rising to 1800 m. The influence of Quaternary ice advances is pronounced with steep walled U-shaped valleys, deep fiords and high mountain cirques. The geology is complex; medium-grained weakly foliated microcline granites of Palaeozoic age, in places capped with Tertiary limestones, occur in the east and hornblende-plagioclase schists and paragneiss in the west (Wood 1962). Unpublished Wildlife Service data (R.B. Lavers pers. comm. 1982) show that January and February are the warmest months and July the coldest. Precipitation ranges from 4500 mm in the west to about 1000 mm in the east. Winter snowfall is important at higher elevations.

The forests of the area have been described by Wardle (1978). On the lower and mid-elevation slopes, tall *Nothofagus menziesii* forest, often in association with *N. fusca*, *N. solandri* and *Weinmannia racemosa*, is common. In the eastern valleys, mixed *N. menziesii* — *N. solandri* forest occurs above this and *N. solandri* forms timberline at about 1000 m to 1100 m. Elsewhere, pure *N. menziesii* forest forms timberline at a similar altitude. Both timberline types have a dense shrubby understorey of *Archeria traversii*, *Myrsine divaricata*, *Pseudopanax simplex* and various *Coprosma* species. The TKV and TST sites are located in the Murchison Mountains.

SAMPLING AND CHRONOLOGY DEVELOPMENT

Field sampling was undertaken during the austral summer of 1980-81. Site selection was based on three main criteria; proximity to the alpine timberline, site homogeneity, and the lack of recent site disturbance. In the closed mesic forests of New Zealand, the very old gnarled trees that have proved of most value in western North America are of least use, as ring wedging, with bands of locally absent rings, occurs (see Figure 3F in Dunwiddie 1979). For this reason, tall straight boled canopy trees were sampled here. Using a 7 mm Swedish increment borer, two cores were usually extracted from each of 10 to 15 trees at each site. Preparation of the cores followed standard procedures (Stokes and Smiley 1968).

Visual crossdating of the cores was greatly facilitated by the occurrence of many narrow signature rings. After crossdating, ring widths were measured to the nearest 0.01 mm using either an Addo-X or Bannister tree-ring measuring machine and the measurements transferred to the computer for subsequent analysis.

After the ring-width measurements were checked for preparation errors, the individual series were standardized using the INDEX computer program (Graybill 1979). Orthogonal polynomial and negative exponential curves and horizontal straight lines were used to standardize the individual series. One chronology was developed twice; once using only polynomial curves in standardization and once using only horizontal straight lines in standardization. Examination of filtered values for the resultant chronologies (Figure 2) show only small differences. It is thus considered that

the effect of using different standardization curves, for standardizing the individual tree-ring series in developing the site chronologies, is negligible.

After standardization, the individual tree-ring series for each site were combined together, using the SUMAC computer program (Graybill 1979), to form the site chronologies. Statistics characterizing these tree-ring chronologies were then calculated.

WITHIN-TREE GROWTH RING VARIABILITY

The patterns of narrow and wide growth rings were found to be similar in different parts of *Nothofagus solandri* trees. Four radii, at approximately 90° from each other, were measured at the same height in two trees. The average correlation coefficient (r) between the four radii in each tree was 0.78 ($n = 87$ years, range 0.76-0.83) and 0.69 ($n = 87$ years, range 0.53-0.79), respectively. Measurements made at 1 m intervals up a *N. solandri* tree were also very similar, with an average correlation coefficient (r) of 0.69 ($n = 140$ years, range 0.55-0.77).

CHRONOLOGY STATISTICS

Sixteen tree-ring chronologies were developed from the two areas. Brief details of the sites are given in Table 1 and the chronologies are plotted in Figure 3. Full site descriptions and the ring-width measurements for individual radii and the final chronology listings have been deposited in the International Tree-Ring Data Bank at the Laboratory of Tree-Ring Research, University of Arizona.

Tables 2 and 3 list the chronology statistics. Definitions of these are given in Fritts (1976) and Graybill (1982). The mean values and their standard deviations for all 16 chronologies are also given.

Nothofagus solandri chronologies are characterized by consistently high mean sensitivity and standard deviation values (mean values of 0.34 and 0.37 respectively) and moderate autocorrelation values (mean value of 0.50). Absent rings are common in all chronologies, being over 2% in some. In particular years (e.g. 1835), absent rings are common to some trees in all chronologies. Growth rates are slow as would be expected from trees near the alpine timberline (see review in Tranquillini 1979).

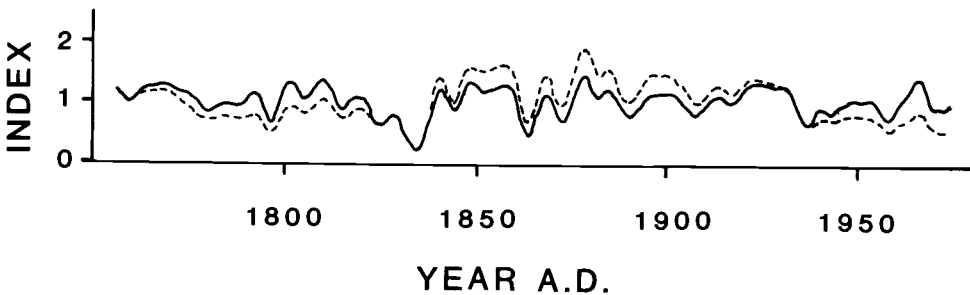


Figure 2. Filtered curves for the two chronologies developed from the same *Nothofagus solandri* tree-ring data. The chronology depicted by the solid line was developed using orthogonal polynomial curves in standardization and the chronology depicted by the broken line was developed using horizontal straight lines in standardization. The filtering was done using a low pass digital filter which removes variance of less than about 10 years frequency.

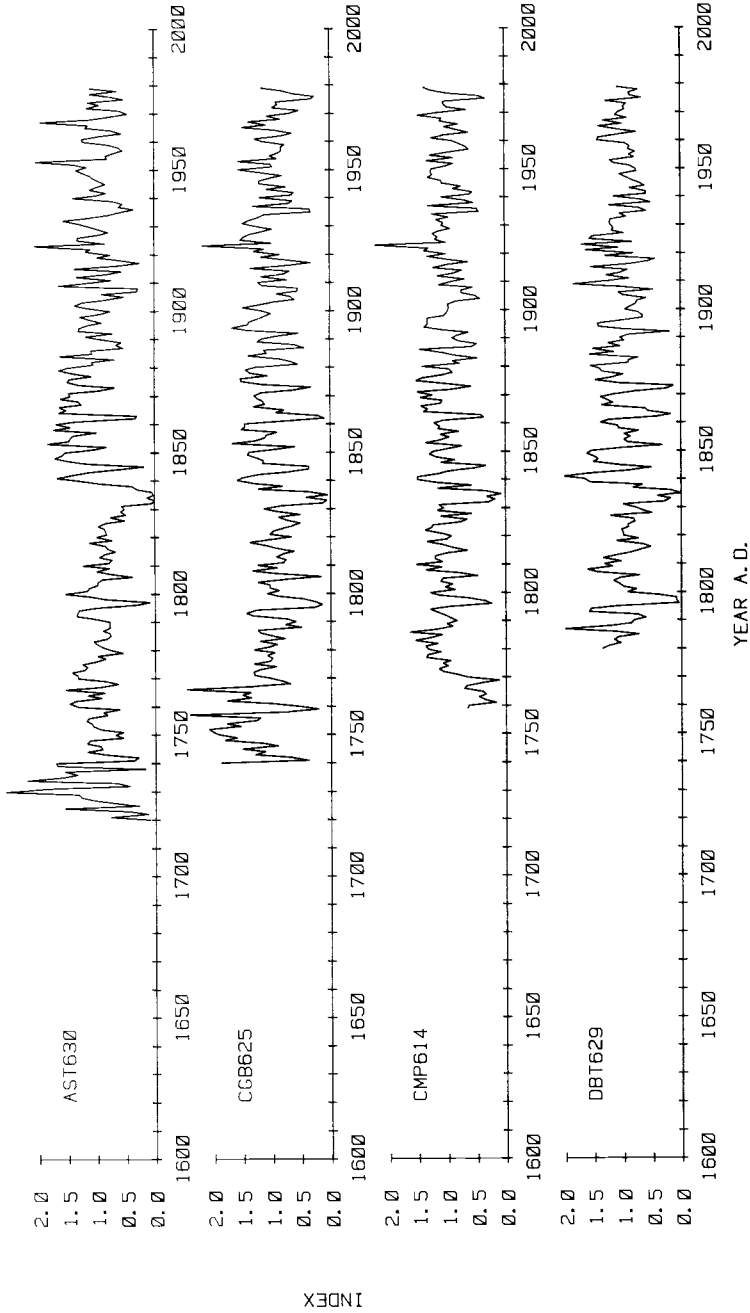


Figure 3. Plots of the 16 *Nothofagus solandri* chronologies.

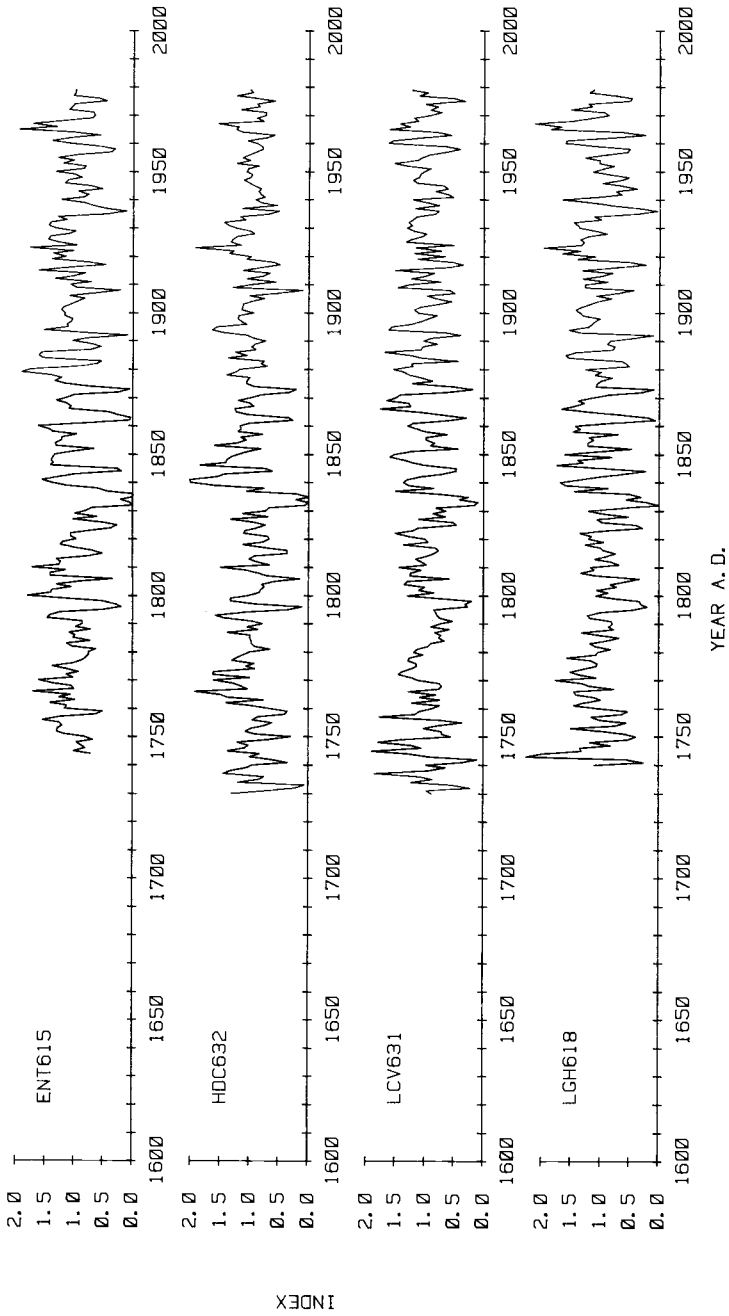


Figure 3, continued

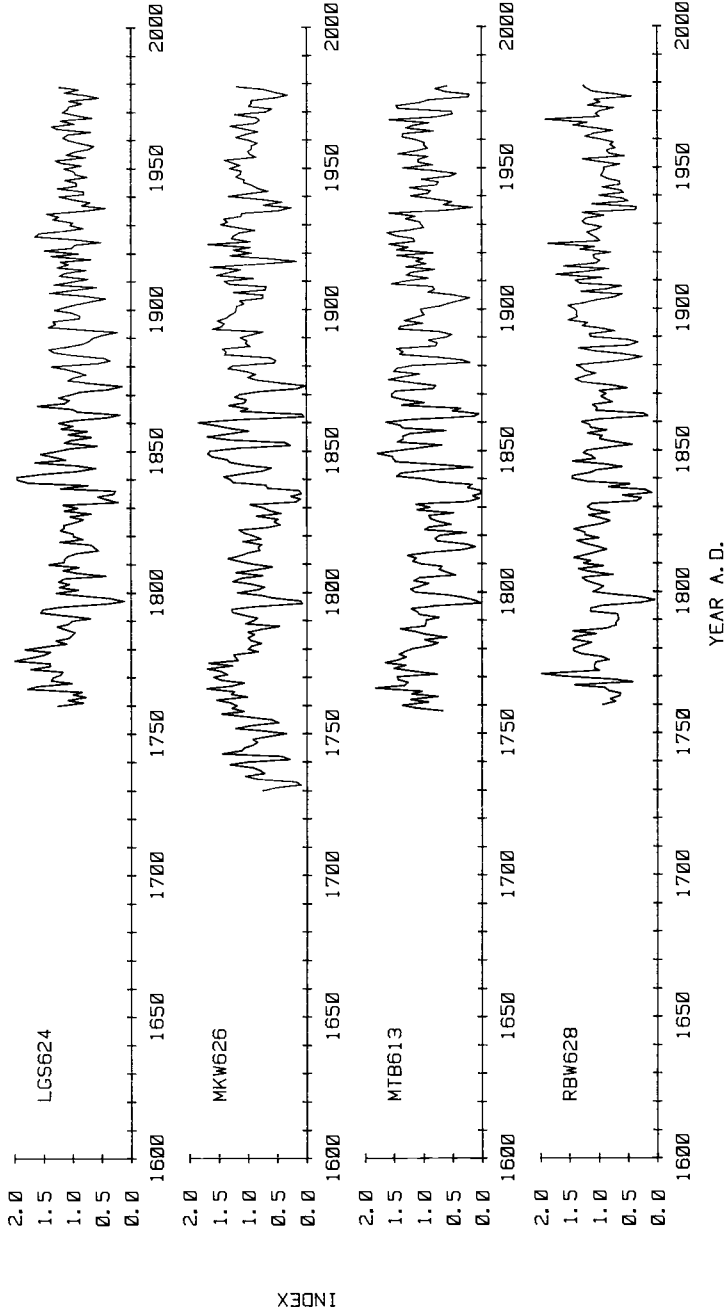


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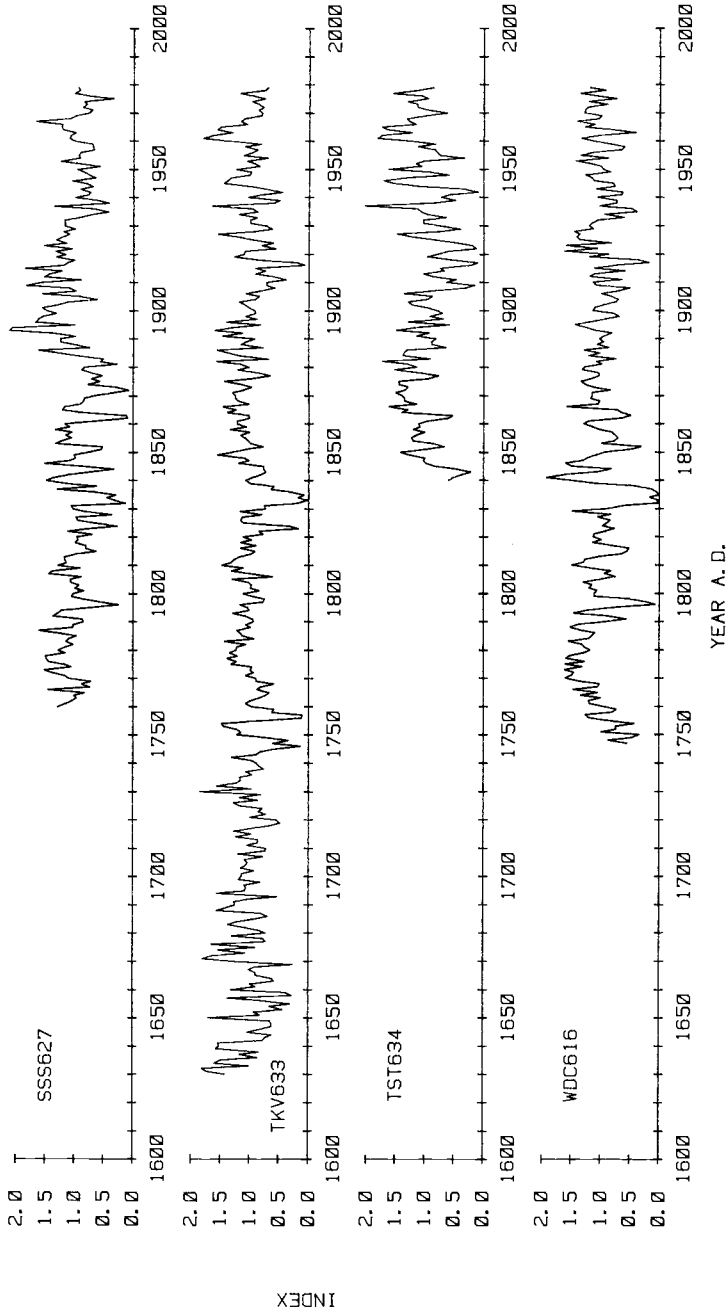


Figure 3, continued

The analysis of variance results (Table 3) show an average common variance of 42% (and in two chronologies greater than 50%). These are the highest common variance values yet obtained for an Australasian tree-ring chronology (see Ogden 1982). Variance due to differences between trees is low, suggesting good site homogeneity. Correlation coefficients are all high and like the other statistics for the species, differ little between chronologies.

Nothofagus solandri chronologies developed from sites near the alpine timberline are amongst the most sensitive chronologies developed in New Zealand. However, the relatively short life of the trees, usually under 300 years, prevents the development of long chronologies. The rarity of preserved wood (in alluvial or colluvial deposits, or peat) will limit the possibilities of extending these chronologies further back in time.

INTERCHRONOLOGY VARIATION

Two types of statistical analysis, correlation and cluster, were used to assist in interpreting variation between the *Nothofagus solandri* chronologies. These analyses also allowed comparison with chronologies developed from other species in the same area (Norton 1983 a, b).

Pearson product-moment correlation coefficients were calculated between the chronologies for the common period 1840-1978 using the SPSS statistical package (Nie et al. 1975). Cluster analysis, using the MINT numerical taxonomy system (Ward 1982), grouped the chronologies for this same time period. Average euclidean distance was used to determine the similarity between chronologies, and the unweighted pair group method using arithmetic averages to link chronologies in the clusters.

Distinct groupings of timberline *Nothofagus solandri* chronologies are apparent in the cluster analysis. The two Fiordland *N. solandri* chronologies cluster with the *N. menziesii* chronologies developed in Fiordland and South Westland. This pattern is also apparent in the correlation coefficients, with the Canterbury *N. solandri* chronologies being highly and significantly correlated with each other (all $P < 0.001$ and a mean r of 0.62 ± 0.10) but less strongly correlated with the two Fiordland *N. solandri* chronologies (only 7 out of 28 correlation coefficients significant at the $P < 0.001$ level and mean r of 0.18 ± 0.11). The two Fiordland *N. solandri* chronologies are, however, strongly correlated with each other ($r = 0.63$, $P < 0.001$) and correlate significantly with four of the five *N. menziesii* chronologies developed in Fiordland and South Westland. Both these analyses would suggest that although the two Fiordland *N. solandri* chronologies have similar statistical properties to the Canterbury *N. solandri* chronologies, the year to year ring width patterns differ. This could reflect an environmental difference; the sites are approximately 400 km apart (see below). However, in several years narrow rings do occur synchronously (e.g. 1830's).

Distinct groupings are apparent among the Canterbury chronologies in the cluster analysis. These groupings could relate to several factors: distance apart; aspect, altitude and slope; location in relation to rainfall and temperature gradients; stand history and age; soil drainage. These factors are now considered.

Figure 4 shows the spatial distribution of the chronologies with the clustering pattern superimposed. Some spatially close chronologies cluster together (e.g. LGH and ENT) but other equally close chronologies do not cluster (e.g. SSS and MKW). To investigate further the relationship between chronology similarity and distance, the correlation coefficients between each chronology and their distance apart were regressed and are plotted in Figure 5. A significant ($P < 0.001$) negative regression

line was fitted to the data but considerable variation would suggest caution in interpreting this. Nevertheless it would seem likely that as the distance between two chronologies increases, their similarity declines. This is clearly evident between the Canterbury and Fiordland *Nothofagus solandri* chronologies (see above) and is also suggested from the data in Figure 5. This type of relationship should be more evident when investigating chronologies separated by greater distances. For example, Fritts (1976) observed a similar pattern in *Pinus ponderosa*, *P. edulis* and *Pseudotsuga men-*

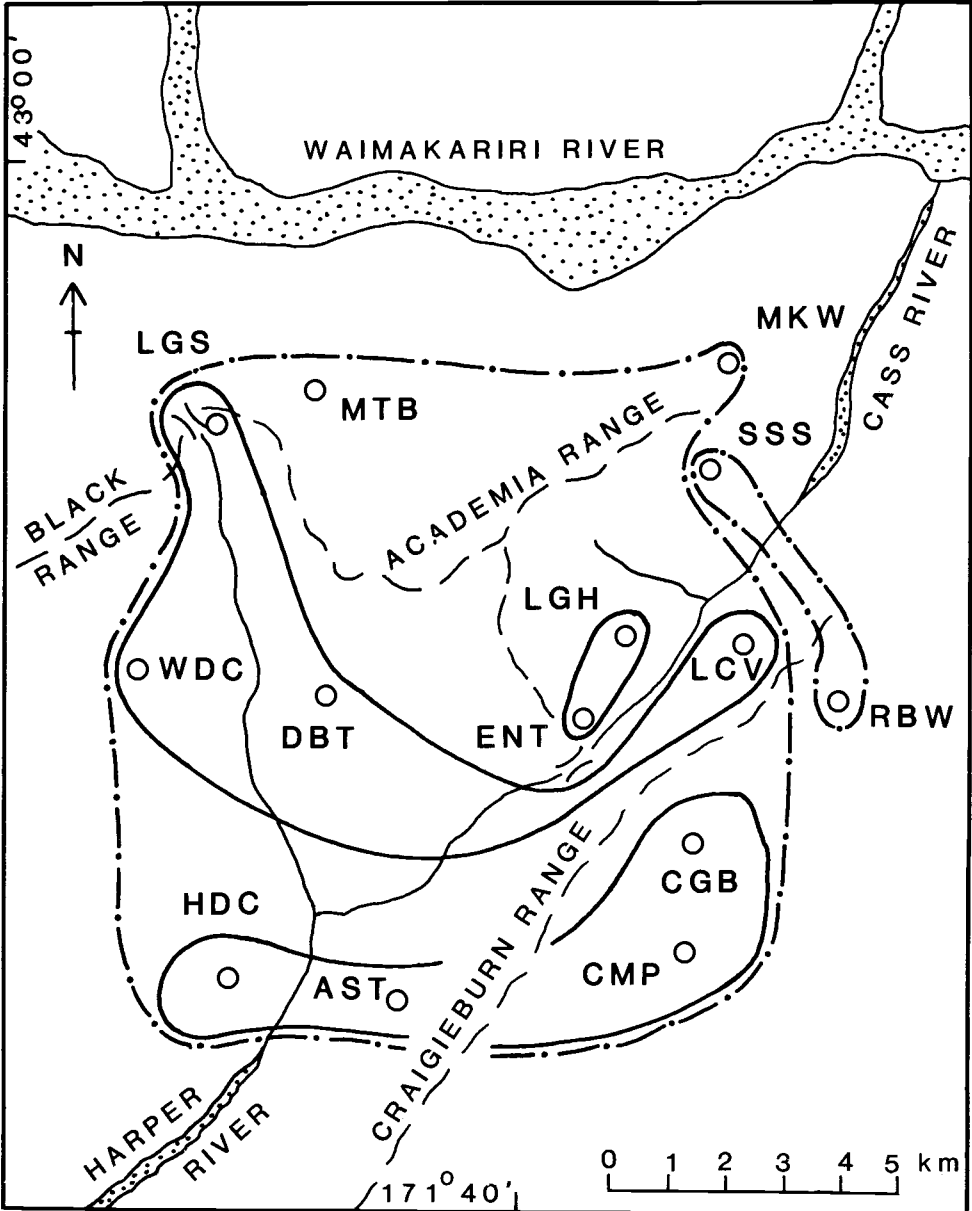


Figure 4. Craigieburn Range *Nothofagus solandri* tree-ring chronology sites with the clustering pattern superimposed. The chronologies enclosed by solid lines cluster more closely than those enclosed by broken lines.

ziesii chronologies in western North America over a distance of 150 km. This relationship was most evident with the high frequency (year to year) variance and was less evident in the lower frequencies. Some low frequency variation is common between the Canterbury and Fiordland *N. solandri* chronologies, but more chronologies are needed before this can be tested properly. It seems plausible that, as differences in site and local climate conditions become greater with increasing distance apart, long term trends reflecting regional climatic patterns (e.g. temperature) can still remain similar. Salinger (1979) has clearly shown that, although local differences occur in individual climate station temperature records throughout New Zealand, the overall patterns are similar.

Although aspect, altitude and slope differ between the 14 Canterbury timberline sites (Table 1), it is difficult to interpret the cluster patterns in terms of these as no clear relationships are apparent. However, in the cluster analysis, the four sites farthest from the central axis of the South Alps (HDC, AST, CMP, CGB) cluster together. It is possible that this may be due to rainfall and temperature gradients across the South Island. Actual climatic data are not available for comparison but from personal observations, periods of strong northwest airflow (the predominant airflow) result in rain in the Academia Range (including the Cass Valley and upper Harper Valley) but usually no rain in the lower Craigieburn Range (CGB, CMP) or in the lower Harper Valley (HDC, AST) (Figure 4). However, it is more difficult to account for other groupings in this way.

Other explanations for the observed clustering pattern could relate to stand history and stand age factors. Most of the stands are of similar age because of the selection bias towards old stands but the observed differences could relate to some stand history event such as insect epidemic or snow damage. Such events could have affected trees in some areas and not others. However, the occurrence of such events is difficult to detect. Soil features, especially drainage, could also be important but several anomalies (e.g. the wet LGS site clustering with the dry WDC site) suggest this is unlikely to be the overriding control.

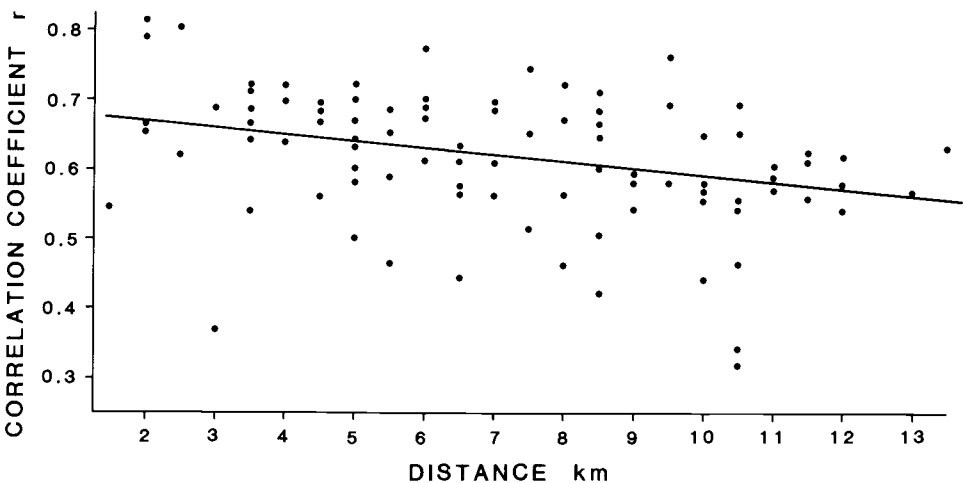


Figure 5. Regression of the correlation between Craigieburn Range *Nothofagus solandri* chronology pairs and their distance apart. $Y = 0.691 - 0.011X$, $r = -0.340$, $n = 91$, $P < 0.001$.

It would seem that no one factor alone influences all the sites in the same way, rather a combination of both local and more regional phenomena influence tree growth at each site. It is evident that the distance between two sites has a pronounced effect on the similarity of the chronologies but a wide range of other factors are also important. As well as variations in tree-ring patterns with altitude (Norton 1983a), variation occurs depending on the site location in relation to synoptic weather patterns. Changes in the characteristics of timberline *Nothofagus solandri* chronologies almost certainly will occur as sites further to the east and west are sampled. Despite these differences, *N. solandri* chronologies at the alpine timberline have very similar tree-ring statistics and afford an opportunity to examine the tree-growth-climate relationship over a wide spatial area using chronologies with similar characteristics.

CONCLUSIONS

Except for a short chronology developed from *Nothofagus gunnii* trees in Tasmania (LaMarche et al. 1979b), these are the first *Nothofagus* chronologies to be presented and indicate a new genus with considerable potential for chronology development. The occurrence of *Nothofagus* in temperate South America, Australia, New Caledonia and New Guinea as well as New Zealand presents the possibility of a widespread network of *Nothofagus* chronologies. The genus *Nothofagus* is also the first angiosperm genus from which tree-ring chronologies have been developed in the Southern Hemisphere.

The large amount of common variance and high mean sensitivity values in the *Nothofagus solandri* chronologies suggests that they are particularly sensitive to variation in environmental factors. The proximity of the sites to the alpine timberline, an ecotone of known temperature limitation to tree growth (see review in Tranquillini 1979), suggests that temperature may be limiting growth in these *N. solandri* trees. It would therefore seem that these chronologies offer much potential for palaeoclimatic reconstruction, especially palaeotemperatures.

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Table 1. Sampling site details for sixteen *Nothofagus solandri* chronologies.

Site	Code	Lat.	Long.	Alt.	Aspect	Slope	No. Trees	Date
Ashton Creek	AST630	43°08'S	171°39'E	1300m	SW	35°	13	15.12.1980
Craigieburn Valley	CGB625	43°07'S	171°42'E	1250m	NE	35°	12	11.12.1980
Camp Stream	CMP614	43°08'S	171°42'E	1350m	SE	30°	19	11.12.1980
Doubtful Creek	DBT629	43°06'S	171°37'E	1400m	NE	30°	13	17.12.1980
Entwood	ENT615	43°06'S	171°41'E	1250m	NE	5°	12	23.12.1980
Hidden Creek	HDC632	43°08'S	171°36'E	1350m	W	30°	12	16.12.1980
Lower Cass Valley	LCV631	43°05'S	171°43'E	1350m	N	20°	11	12.2.1981
Logos Hill	LGH618	43°05'S	171°42'E	1300m	E	30°	11	10.12.1980
Lagoon Saddle	LGS624	43°03'S	171°36'E	1300m	SW	15°	15	12.1.1981
Mirkwood	MKW626	43°03'S	171°41'E	1275m	NW	30°	12	4.12.1980
Mount Bruce	MTB613	43°03'S	171°38'E	1300m	SE	35°	15	12.1.1981
Ribbonwood Creek	RBW628	43°06'S	171°44'E	1350m	SE	20°	14	11.1.1981
Snowslide Stream	SSS627	43°03'S	171°43'E	1250m	SE	25°	15	15.1.1981
Takahe Valley	TKV633	45°18'S	167°41'E	1100m	N	20°	15	2.2.1981
Takahe Stream	TST634	45°17'S	167°39'E	1000m	NE	15°	15	1.2.1981
Windy Creek	WDC616	43°05'S	171°35'E	1350m	NW	30°	14	17.12.1980

Table 2. *Nothofagus solandri* chronology statistics. Notes; 1, autocorrelation; 2, mean sensitivity; 3, standard deviation; 4, percent missing rings; 5, mean ring width in mm.

Code	No. trees	No. radii	Period A.D.	AC ¹	MS ²	SD ³	%Abs ⁴	MRW ⁵
AST630	13	26	1720-1979	0.43	0.38	0.42	1.98	0.56
CGB625	12	24	1740-1979	0.45	0.37	0.41	1.43	1.22
CMP614	16	35	1759-1979	0.47	0.31	0.34	0.50	0.79
DBT629	13	26	1780-1979	0.46	0.35	0.37	1.23	1.03
ENT615	12	23	1744-1979	0.54	0.38	0.40	1.96	1.01
HDC632	12	21	1730-1979	0.49	0.34	0.36	1.37	0.58
LCV631	11	20	1730-1979	0.42	0.35	0.36	0.70	0.79
LGH618	11	20	1740-1979	0.50	0.40	0.42	2.30	0.66
LGS624	15	28	1760-1979	0.46	0.33	0.35	1.43	0.75
MKW626	12	24	1730-1979	0.56	0.34	0.38	2.24	0.95
MTB613	14	36	1758-1979	0.57	0.39	0.41	1.15	0.95
RBW628	14	28	1760-1979	0.44	0.31	0.34	0.76	1.03
SSS627	13	26	1760-1979	0.55	0.30	0.36	0.96	1.14
TKV633	11	19	1630-1979	0.43	0.30	0.33	1.37	0.85
TST634	11	19	1840-1979	0.56	0.36	0.39	1.24	1.35
WDC616	11	22	1747-1979	0.59	0.30	0.35	1.01	1.13
Combined data (16 chronologies)			mean	0.50	0.34	0.37	1.35	0.92
			standard deviation	0.06	0.03	0.03	0.54	0.23

Table 3. *Nothofagus solandri* chronology statistics continued. Notes; 1, subset of main chronology with two cores per tree for the common period given in the next column; 2, percent common variance; 3, percent variance due to differences between trees; 4, mean correlation coefficients.

Code	No. trees ¹	Period (A.D.)	%Y ²	ANOVA %YXT/G ³	% other	Correlation Analysis ⁴			
						r all series	r within trees	r among trees	r among trees
AST630	10	1860-1979	33.04	7.74	59.22	0.35	0.42	0.34	0.42
CGB625	9	1869-1979	44.49	14.37	41.14	0.47	0.58	0.46	0.58
CMP614	14	1869-1979	39.73	11.87	48.40	0.42	0.54	0.42	0.54
DBT629	11	1880-1979	43.46	17.29	39.25	0.47	0.65	0.46	0.65
ENT615	10	1850-1965	50.45	19.89	29.27	0.57	0.73	0.56	0.73
HDC632	8	1850-1979	38.50	19.98	41.52	0.42	0.58	0.41	0.58
LCV631	8	1840-1979	44.78	14.18	41.04	0.46	0.60	0.46	0.60
LGH618	9	1890-1979	41.30	22.21	36.49	0.51	0.66	0.50	0.66
LGS624	9	1850-1979	35.65	13.91	50.44	0.40	0.56	0.39	0.56
MKW626	12	1880-1979	36.05	10.08	53.87	0.40	0.52	0.39	0.52
MTB613	12	1890-1976	46.60	21.34	32.06	0.49	0.66	0.49	0.66
RBW628	14	1860-1979	38.66	13.01	48.33	0.41	0.53	0.40	0.53
SSS627	10	1840-1979	45.98	15.78	38.24	0.49	0.64	0.48	0.64
TKV633	6	1840-1979	37.93	22.17	39.90	0.41	0.62	0.39	0.62
TST634	7	1850-1979	52.47	11.41	36.12	0.55	0.67	0.55	0.67
WDC616	8	1870-1979	39.13	11.41	49.46	0.42	0.55	0.41	0.55
Combined data (16 chronologies)		mean standard deviation	41.76 5.42	16.08 5.31	42.17 8.33	0.45 0.06	0.59 0.08	0.44 0.06	0.59 0.08