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PROVENANCE VARIATION IN *PODOCARPUS TOTARA*

Summary: Variation in seedling growth and form between provenances of *Podocarpus totara* from 42 sites throughout New Zealand was investigated. Seedlings were grown for three years under uniform nursery conditions. There were significant differences between provenances in height growth in the fust three years after sowing. Early growth was highly correlated with germination rate after sowing. In the third year, growth followed a different pattern and was negatively correlated with provenance latitude, i.e., provenances from southern latitudes grew more slowly than those from further north. This suggests that genetic factors correlated with mean summer temperature of the locality of seed source were beginning to predominate. Stem form and branch length also varied between provenances, but foliage colour and leaf size did not. Neither stem form nor branch length were related to any provenance site variable. Since provenance variation is appreciable, it is recommended that *P. totara* plantings for ecological purposes should be of seedlings raised from locally collected seed. However, for growing *P. totara* in plantations to produce special-purpose high value timber, considerable scope exists for an in-depth breeding study that will eventually lead to producing planting stock with both superior height growth and good tree form.

Keywords: *Podocarpus totara; Podocarpus hallii;* provenance; seed; nursery; height growth; stem form; ecotype.

Introduction

Podocarpus totara[1] is widely distributed in lowland forests throughout the country from sea level to 600 m in the North Island and to 500 m in the South Island. In parts of the central North Island it forms a major component of native conifer forests on deep pumice deposits often in mixture with *Prumnopitys taxifolia* (D. Don) Laubenf. but also *Dacrydium cupressinum*, and to a lesser extent *Dacrycarpus dacrydioides* (A. Rich.) Laubenf. and *Prumnopitys ferrugineus* (D. Don) Laubenf. In the South Island *P. totara* is found mainly in scattered small pockets on the most fertile soils (Hinds and Reid, 1957). In farming districts such as Northland, Waikato, and Horowhenua, small stands or isolated trees of short stature and rounded crowns are now a common landscape feature. The species is a pioneer invader of grassland where there is a local seed source and birds to distribute seed. It is relatively unpalatable to grazing stock with trees often growing along fencelines.

P. totara is of considerable cultural value, long prized by Maori for its durable and easily worked timber for carvings and construction of canoes. Until recently it was used extensively for posts, house piles, and exterior joinery. Most forests containing mature *P. totara* have now been protected and other materials have been substituted for previous timber uses. However, with the resurgence in cultural activities and use of indigenous timbers for furniture and wall panelling, there is an increasing demand for long-term supplies of indigenous timber species including *P. totara*.

A recent survey by the Forest Research Institute (F.R.I.; Bergin and Pardy, 1990) indicates that *P. totara* is planted widely in parks and on farmland. Height growth averages 30 cm annually for nursery-raised seedlings planted on upland sites, with faster growth at lower elevations. Trees in two 50-year-old *P. totara* plantations established on good sites are 18 m in height with stem diameters of 35 cm at 1.4 m above ground (Bergin and Pardy, 1987). However, plantations often require pruning of lower branches and thinning to remove trees with multiple leaders.

Tens of thousands of *P. totara* seedlings were raised at the F.R.I. Nursery in the 1970s and early 1980s for planting in selectively logged forest in the central North Island. While in nursery beds, seedlings exhibited considerable phenotypic variation, particularly in habit of branching and stem form, but it was not known whether variation was related to provenance. It was also not known if there were any ecotypic or clinal variation in growth rates and other characteristics such as foliage colour. The potential for selecting straight-growing strains of *P. totara* for plantations is not known. An evaluation of provenances may therefore allow for the selection of genotypes with better form and growth for planting.

P. totara forms hybrids with most, if not all, of the

[1] Nomenclature follows Allan (1961) except where noted.

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closely related *P. acutifolius, P. hallii,* and *P. nivalis* (Allan, 1961; Wardle, 1972; Webby, Markham and Molloy, 1987). A study of the provenance variation of *P. totara* should contribute further understanding of the genetic background of the species and its hybrid complexes. Implications could extend to the selection and management of representative reserves containing *P. totara*. The study could also form the basis of a breeding study that will enable selection of superior progeny of *P. totara* for establishing plantations.

The present nursery-based study was undertaken to investigate the variability between provenances of *P. totara* as reflected in seedlings raised from seed collected from sites throughout the natural range of the species, and to relate any variation in form and growth to geographic or other parameters. An evaluation of differences between seedlots of *P. hallii* and suspected hybrids from a central North Island site was also included in the initial stages of the study.

A further objective was to raise seedlings of a wide range of provenances so that permanent provenance trials of *P. totara* could be established on several sites for long-term monitoring.

Methods

Seed sources

Seed of *P. totara* was collected in 1985 from naturally occurring stands throughout the country. Attempts were made to collect seed from 8-10 seed trees where trees were at least 100m apart, from communities representative of the natural forest of the area, and within a 200 m altitudinal range. In practice, however, these requirements were often difficult to fulfil, and in many districts the only adequate quantities of seed found were on isolated trees or trees in small groves on farmland. In one locality (Kaikoura), seed was collected from low-growing bushy trees on farmland and from beneath tall mature *P. totara* in high forest nearby and evaluated separately.

Seed was also collected from the introgressive hybrid of *P. totara* var. *waihoensis* which has been described by Wardle (1972).

Green seed attached to ripe receptacles was picked off trees or the ground in autumn. Brown seed in the leaf litter was raked off the ground in winter. Seed soundness was tested by cutting a sample of seed in half. Seeds with a full white endosperm were considered sound. Considerable quantities of green seed collected off trees (even with ripe receptacles) were hollow. Seed collected in late spring and summer also had low viability. The aim was to collect sufficient seed to raise at least 100 seedlings of each provenance.

Seed was collected from 42 sites, giving good geographical coverage, particularly in the North Island

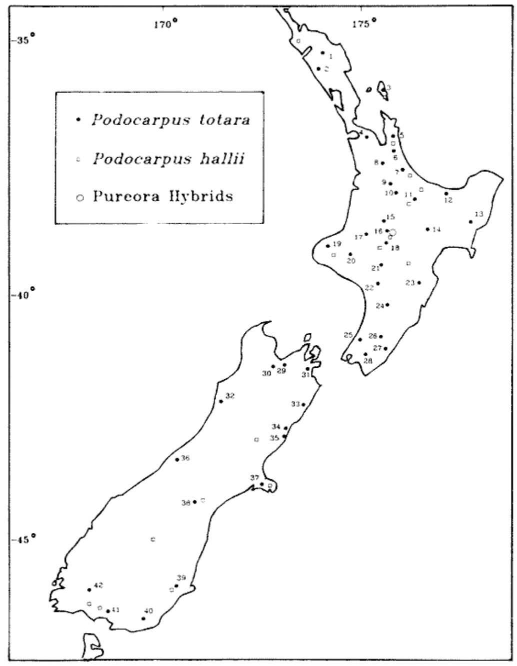

Figure 1: *Seed collection sites. Refer to* Appendix 1 *for details of provenance locations.*

(Fig. 1). Details of *P. totara* seed collections are given in Appendix I. In addition to the *P. totara* seed collections, small quantities of *P. hallii* seed were collected from 18 other sites. At sites where both species are present, foliage and bark characteristics of some trees suggests that hybridisation occurs. Seed was therefore collected from 24 such putative hybrids in a study area in Pureora Forest Park in the central North Island.

Seed measurement

Seed length was measured for a random sample of 50 seeds of most provenances of *P. totara, P. hallii,* and the 24 suspected hybrid trees at Pureora Forest. Differences between provenances and between *P. totara, P. hallii,* and the hybrids were tested by analysis of variance.

Nursery procedure

Depending on when seed was collected for each provenance, seed was kept 3-6 months in moist, cool storage at 2-4 ∞C until sowing. In mid-October 1985 seed was broadcast-sown on to tractor-prepared beds at the Forest Research Institute, Rotorua, at a rate of about 500 seeds per square metre of bed. Seed was sown in a randomised complete block (R.C.B.) design with four blocks or replicates. The quantity of seed collected varied between provenances and unknown quantities of seed were sown. The number of seedlings that germinated for each provenance was variable, and was therefore subjectively assessed into three categories: good, moderate and poor.

One year after sowing, the 10-15 cm high *P. totara* seedlings were transplanted at a spacing of 25 x 25 cm in open nursery beds. The wide spacing allowed seedlings ample room to develop for two further years in the nursery. Wide spacing also minimised plot edge effects.

Seedlings were transplanted again using a R.C.B. design with four blocks. Layout was independent of the sowing design. Each replicate consisted of one plot per provenance with up to 28 seedlings per plot. Of the 40 provenances, 30 had a full complement of 28 seedlings per plot. The other provenances contained from 4 to 26 seedlings per plot.

Assessment of seedlings

Immediately after transplanting and during each of the two winters following, each seedling was assessed for a range of factors including height, stem form, and branch length. Both natural height and pulled-up height were measured; the latter was determined when stem and uppermost branches where pulled gently into a vertical position for measurement.

General seedling habit was assessed using two parameters. Firstly, stem form was determined using three categories: 1 = good - upright, 2 = intermediate, 3 = poor - multi-leadered to recumbent (see Fig. 4). Secondly, branch length of seedlings was assessed with each seedling placed into one of three categories: 1 = light - all branches were less than half of stem length and none exceeded the stem height; 2 = medium - at least one branch was greater than 50% but less than 75% of stem length and did not exceed height of stem; 3 = coarse - at least one branch was greater than 75% of stem length, with branches often extended beyond the top of the stem.

The colour of each provenance was assessed subjectively using several colour choices and combinations. There were also occasional intermediate colours, e.g., red-green or green-yellow. Assessing colour of individual plants proved difficult so the general colour of each replicate was assessed.
Other factors such as mortality, insect damage, and dieback of branches were also noted during assessments.

Analysis

Provenance differences in height, stem form, and branchiness were tested by analysis of variance. As there appeared to be marked fertility trends along the nursery beds, a First Difference nearest neighbour method (Besag and Kempton, 1986) was applied, resulting in a 20 to 30% reduction in residual standard deviation over the standard R.C.B. analysis for seedling height.

Pearson correlation coefficients between provenance height and form means, germination success, and site variables (latitude, altitude, mean summer temperature and mean annual rainfall) were also tested. Mean summer temperature was calculated using the method of Norton (1985).

Results

Seed measurements

Seed shape and length differ between *P. totara* and *P. hallii*. *P. totara* seed is ovoid and *P. hallii* seed is long, narrow, and often pointed. Analysis of variance showed differences in seed length between species ($F_{1,49}$= 256, p<0.01) as well as between provenances ($F_{49,2481}$ = 30.8, p<0.01). There was no significant correlation between seed length and latitude (r=-0.18) or altitude (r=0.25). Seed length averaged about 5 mm for *P. totara* and 8 mm for *P. hallii,* with no overlap between them (Fig. 2). Seed measurements are therefore a convenient check of species identification.

The putative hybrid trees from Pureora Forest Park had seed lengths within the range of both species. However, the distribution appeared to be bimodal, with peaks corresponding to average seed lengths of each species. For a characteristic such as seed length, F1 hybrids usually produce a mean midway between the

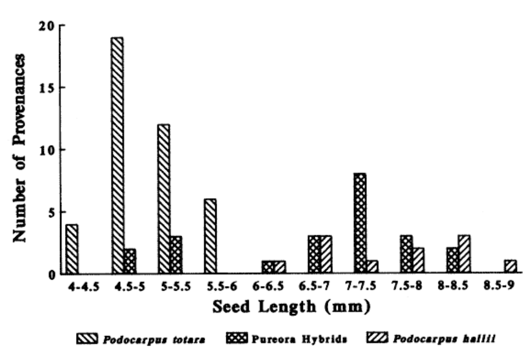

Figure 2: *Seed length distributions.*

two species and with a similar coefficient of variance. Thus, the data suggest either that these trees are not actually hybrids, or that the hybridisation is somewhat complex, e.g., involving backcrossing of F1 or F2 generations.

Seed germination

Six weeks after sowing, half the *P. totara* seedlots had started germinating, and most of the remaining provenances germinated within 10 weeks of sowing. A second flush of germination occurred 6 months after sowing, particularly in provenances where forest litter containing large numbers of seed had been collected. These winter seed collections germinated well. Conversely, some of the early autumn collections of small quantities of freshly fallen green seed picked off the ground had poor germination. Germination of *P. halli;* and suspected Pureora hybrids was very poor for most seedlots, so assessment of seedling differences was not possible. An indication of the overall success of

Table 1: *Provenance .means for important characteristics listed in order of decreasing height for* 1988.
† *Stem form factor* 1 = *good,* 2 = *intermediate,* 3 = *poor*.
‡ *Branch length* 1 = *light branching,* 2 = *medium branching,* 3 = *coarse branching*.
* *Differences between provenances greater than the LSD (Least significant differences) are significant (*p *=0.05)*.

Provenance	Height 1988 (cm)	Height increment 1986-87 (cm)	Height increment 1987-88 (cm)	Stem† form	Branch‡ length
Otaki	104	37	54	1.9	2.7
Pohangina	94	33	52	1.9	2.7
New Plymouth	94	31	50	2.1	2.6
Ngaumu Forest	93	33	48	2.1	2.7
Taumarunui	91	33	49	1.8	2.1
Featherston	89	32	48	2.3	2.8
Kaikoura (good form)	89	31	46	2.2	2.8
Harihari	88	33	47	2.1	2.6
Pureora	87	31	49	2.0	2.4
Kaikohe	87	29	51	2.0	2.4
Opotiki	86	28	49	2.0	2.4
Banks Peninsula	86	29	49	2.1	2.4
Peel Forest	86	30	45	2.3	2.8
Hunterville	85	30	46	2.0	2.5
Waipoua	85	27	51	1.7	2.3
Kauaeranga	85	25	52	2.1	2.5
Masterton	84	28	47	2.3	2.6
Taihape	84	32	42	1.9	2.5
Mamaku	84	28	48	2.1	2.6
Gisbome	84	27	46	2.1	2.5
Kaikoura (poor form)	84	32	41	2.5	3.0
Matamata	84	25	51	2.0	2.4
Whangamomona	83	27	44	2.1	2.6
Nelson	78	25	46	2.0	2.3
Hurakia	78	22	51	1.9	2.3
Pelorus River	78	22	51	1.7	2.3
Waharoa	76	23	48	2.0	2.3
Kaikoura (North)	74	23	44	2.2	2.7
Katikati	71	19	45	2.5	2.7
Auckland	71	18	48	2.2	2.4
Nelson (Wai-iti)	70	17	49	1.8	2.0
Tahuna	70	20	46	2.0	2.4
Coroglen	65	14	48	1.9	2.0
Hawke's Bay	65	16	44	2.2	2.4
Invercargill	61	15	41	2.1	2.2
Dean Forest	57	16	37	1.9	2.2
Mean	81	26	47	2.0	2.5
5% L.S.D. *	7	4	4	0.3	0.2

Table 2: *Correlation matrix between seedling growth and form variables and provenance site factors.*
* *Significant at* $p < 0.05$
** *Significant at* $p < 0.01$
Å*Coded* as: 1 = *poor,* 2 = *moderate,* 3 = *good*

	Final height 1988	Transplanted height 1986	Height increment 1986–87	Height increment 1987–88	Germin-ation†	Branch length	Stem form	Latitude	Altitude
Transplanted height 1986	0.82**								
Height increment 1986–87	0.95**	0.86**							
Height increment 1987–88	0.56**	0.06	0.31						
Germination	0.76**	0.72**	0.81**	0.21					
Branch length	0.55**	0.74**	0.62**	–0.07	0.48**				
Stem form	–0.04	0.27	0.06	–0.42**	0.08	0.66**			
Latitude	–0.16	0.08	0.00	–0.52**	–0.05	0.16	0.20		
Altitude	0.23	0.30	0.31	–0.11	0.35*	0.10	0.01	–0.01	
Mean summer temperature	0.02	-0.23	-0.16	0.49**	-0.13	-0.22	-0.20	-0.86**	-0.44**

germination for each provenance is given in Appendix 1.

Seedling growth

Total pulled-up height and yearly height increments differed significantly between provenances (Table 1). Those provenances classified as having poor germination (Appendix 1) produced less than 20 seedlings from the total but unknown quantity of seed collected, and were omitted from the analysis. Seedling heights three years after germination ranged from 57 cm to 104 cm.

Height at transplantation (1986) and growth during the second year after sowing (1986-1987) were closely related to germination success (Table 2). Growth at this age was not related to any provenance site variable.

The Otaki provenance had the greatest height increment of 54 cm, with Dean Forest having the lowest increment of 37 cm. Other provenances with height increments of 50 cm or more in the 1987-1988 year included New Plymouth, Kauaeranga, Kaikohe, Waipoua, Matamata, Hurakia, Pelorus River, and Pohangina. In contrast to earlier measurements, height increment during 1987-1988 was negatively correlated with provenance latitude (Table 2, Fig. 3), with eight of the fastest growing provenances being from widely scattered North Island localities and one from northern South Island.

Seedling stem form and branch length

Stem form differed significantly between provenances (Table 1), with better stem form tending to be associated with faster growth rates in many provenances. These included Otaki, New Plymouth, Waipoua, Matamata, Hurakia, and Pelorus River. There were two exceptions Ñ Taihape and Dean Forest Ñ which had relatively slow growth but good stem form.

Significant differences also occurred in branch length of seedlings. Neither stem form nor branch length were related to any provenance site variable (Table 2). Extremes of stem form and branch length between two provenances are illustrated in Fig. 4.

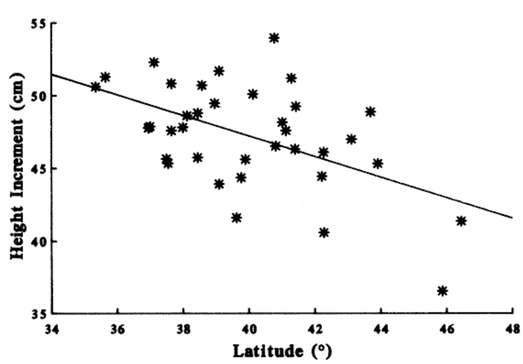

Figure 3: *Relationship between height increment* 1987-88 and *latitude of provenance for* Podocarpus totara.

Figure 4: *Differences in stem form between two provenances of* Podocarpus totara: *— Kaikoura, 126 — New Plymouth.*

Other factors

Nearly all provenances were classed as red-yellow for colour of foliage. The only exceptions were Harihari, which was classed as red, and both the poor and good form Kaikoura provenances, which were classed as yellow. Assessments were not carried out for leaf size and shape and leaf angle to stem as most provenances yielded no visually detectable differences. One exception was the Harihari provenance of hybrid origin (Wardle, 1972) where leaves were smaller and more needle-like.

Discussion

This study has shown some genotypic differences in stem form, height growth and leaf characteristics between widely separated provenances of *P. totara*. The only other New Zealand indigenous tree species of major forestry significance for which a large-scale provenance study has been conducted with a good coverage of provenances from throughout the country are the *Nothofagus* species (Wilcox and Ledgard, 1983). The range in variation of growth between provenances of *P. totara* found in this study was similar to that found in *Nothofagus menziesii,* rather more than in *N.fusca,* but less than that found in *N. solandri*.

There was no significant correlation in height growth of *P. totara* with altitude. Similarly, there was no altitudinal variation with *N. fusca* (Wilcox and Ledgard, 1983). In contrast, there was differentiation in growth rate of *N. menziesii* into altitudinal races, as well as of *N. solandri* var. *cliffortioides* at one site.

Growth of *P. totara* for the first two years after sowing and germination success were highly correlated (Table 2) indicating that vigorous embryos are likely to produce vigorous seedlings. Both parameters were unrelated to climatic and geographic characteristics of the seed source except that slightly better germination was obtained with higher rather than lower altitude provenances. However, germination was more successful for seed collected in winter than early autumn and may be related to the stage of seed maturity.

Height growth during the third year was not related to previous growth but showed a significant negative correlation with provenance latitude and positive correlation with estimated mean summer temperature (Table 2, Fig. 3). This suggests that, although non-genetic factors (e.g., time of seed collection) affected the first two years' growth, genetic factors related to latitude of seed source were beginning to predominate by the third year. A similar result occurred with *N. menziesii* seedlings where the nursery-based study of Wilcox and Ledgard (1983) at first showed no significant correlation of height growth with latitude, whereas, remeasurement two years later found that northern provenances had a longer growing season and grew till later in the autumn than southern provenances (Ledgard and Norton, 1988).

North-south trends in growth rate have been identified in northern temperate conifers such as *Pinus strobus* (Wright, 1970) and *Juniperus virginiana* (Schoenike, 1969; Henderson, Koppe and Schoenike, 1979). Other studies have found seedling growth to be greatly influenced by altitude of seed source, high altitude provenances generally having slower height growth than low altitude provenances, at least when grown in favourable conditions. This was found for *Pseudotsuga menziesii* var. *glauca* (Rehfeldt, 1979, 1983; Herman and Lavender, 1968), *Sequoiadendron giganteum* (Guinon, Larsen and Spethmann, 1982), *Pinus contorta* (Rehfeldt and Wykoff, 1981), *Larix occidentalis* (Rehfeldt, 1982) and *Pinus ponderosa* (Callaham and Liddicoet, 1961). The effects of latitude and altitude identified in these studies suggest that a balance occurs between selection pressure for height growth on mild sites and for cold hardiness on harsh sites. The correlation between latitude/summer temperature and height growth identified in the current study suggests that similar selection pressures have occurred with *P. totara.* Although altitude was found to be not significantly correlated with height growth, a separate study on eight of the provenances (Hawkins *et al.,* 1991) found a strong positive correlation of altitude of seed source with cold hardiness, but no latitude effect. As these provenances covered only a relatively narrow range of latitudes but the extremes of altitudes, these findings are not surprising. It seems therefore, that genetic factors governing both growth and cold hardiness of *P. totara* seedlings are affected by temperature of the locality from which the seed was collected.

There were significant differences in stem form and branch length between provenances (Table 2; Fig. 4). Stem form is significantly correlated with growth in the third year where faster growing provenances had better stem form (Le., straighter stems with greater apical dominance) than slower growing provenances (Table 2). Stem form and branch length of seedlings appeared unrelated to form of parent trees. Tree spacing is known to have a marked effect on tree form (Bergin and Pardy, 1990). Seed collections involved collecting seed from parent trees that occurred in a range of habitats such as open sites or within closed high forest. Therefore, it is highly likely that any genetic differences, in form of the parent trees were masked by the large variation in habitat conditions influencing stem form. However, the Kaikoura provenances did show a significant difference in growth and form between seedlings from parent trees with good and poor form at adjacent localities.

Seedlings from the nursery trial were established in field trials to assess long-term variation among provenances. Additional seedlings from selected provenances were planted in blocks to evaluate growth and form at different spacings as well as with and without pruning. Although these long-term trials should give a more complete picture of provenance variation, the current results do show that considerable variation exists within *P. totara*. It follows that large-scale planting for ecological purposes, such as revegetation of former totara forest areas, should use seed of local origin and similar altitude in order to obtain trees with the same genetic integrity and which are suited to the local climatic conditions. However, for growing *P. totara* in plantations for the long-term objective of producing special-purpose high value timber, these results also indicate considerable scope exists for an in-depth breeding study. By selecting the well formed parent trees of the fastest growing provenances, a breeding study will eventually lead to producing planting stock of *P. totara* with both superior height growth and good tree form for establishing in plantations.

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Appendix 1: *Podocarpus totara provenance seed collections in* 1985.

* *Mean summer temperature calculated using methods of Norton* (1985).

† *Mean annual rainfall from New Zealand Meteorological Service Climatic Map Series Part* 6 (1985).

No	Provenance	Latitude (S)	Longitude (E)	Altitude (m)	Number of seed trees	Seed tree form and/or habitat	When seed collected	Mean summer temperature (ºC)*	Mean annual rainfall (mm)†	Germination
1	Kaikohe	35'21'	173'49'	240	3	Farmland	March	18.3	2000	Good
2	Waipoua	35'39'	173'33'	200	2	Good; forest	March-April	18.2	2000	Good
3	Great Barrier Island	36'09'	175'24'	15	3	Good; Farmland	June-July	18.8	1400	Poor
4	Auckland	37'05'	174'56'	18	20	Poor, groves	May	18.3	1400	Moderate
5	CorogIen	36'57'	175'40'	30	8	Poor, scrub	December	18.4	2000	Moderate
6	Kauaeranga	37'08'	175'37'	30	3	Grove; Farmland	March	18.5	1400	Good
7	Katikati	37'34'	175'53'	18	8	Poor, groves, open	May	18.1	1400	Moderate
8	Tahuna	37'30'	175'15'	40	20	Poor, groves, Farmland	May	18.6	1000	Moderate
9	Waharoa	37'39'	175'39'	55	30	Poor, groves, Farmland	May	18.8	1400	Good
10	Matamata	37'39'	175'39'	60	3	Poor, Farmland	May	18.9	1400	Moderate
11	Mamaku	38'00'	175'54'	270	2	Poor, Farmland	March, May	18.1	2800	Good
12	Opotiki	*38'07*	177'11'	70	10	Good; forest	May	17.7	1400	Good
13	Gisbome	38'27'	177'50'	60	12	Grove; Farmland	April	17.9	2000	Good
14	Whirinaki	38'37'	176'45'	350	12	Poor, Farmland	June	16.8	2000	Poor
15	Pureora	38'27'	175'34'	540	5	Excellent; tall forest	March-May	16.0	2000	Good
16	Waihora	39'27'	175'40'	780	3	Good; forest	May	14.6	2000	Poor
17	Taumarunui	38'58'	175'14'	150	20	Good; pole stand	April	17.0	1400	Good
18	Hurakia	38'35'	175'31'	540	10	Good; forest	April	16.6	2000	Good
19	New Plymouth	39'06'	174'07'	100	15	Poor, groves, open	August	17.4	1400	Good
20	Whangamomona	39'06'	174'46'	210	25	Poor, Farmland	August	17.2	2000	Good
21	Taihape	39'38'	175'46'	490	15	Poor, Farmland	August	15.8	1000	Good
22	Hunterville	39'54'	175'32'	240	20	Poor, Farmland	August	16.6	1000	Good
23	Hawke's Bay	39'46'	176'29'	76	8	Poor, Farmland	July	16.4	700	Moderate
24	Pohangina	40'08'	175'50'	150	20	Good; forest	August	17.0	1000	Good
25	Otaki	40'47'	175'10'	30	30	Poor, Farmland	July	16.9	1000	Good
26	Masterton	40'49'	175'37'	210	30	Poor, Farmland	July	16.4	1000	Good
27	Ngaumu Forest	41'01'	175'58'	372	1	Poor, Farmland	August	151	1400	Good
28	Featherston	41'08'	175'23'	40	30	Poor, groves, Farmland	July	17.1	1000	Good
29	Nelson	41'24'	173'03'	160	2	Good; forest remnant	April	16.0	1000	Good
30	Nelson(Wai-iti)	41'26'	172'59'	180	3	Poor, groves, open	June	15.9	1000	Moderate
31	Pelorus River	41'18'	173'34'	30	3	Poor, forest edge	September	16.7	2000	Moderate
32	Paparoa	42'17'	171'36'	80	3	Poor, Farmland	April	16.1	3600	Poor
33	Kaikoura (North)	42'13'	173'53'	60	10	Poor, low forest	June	16.3	1000	Good
34	Kaikoura	42'16'	173'41'	450	20	Good; forest	July	14.1	1400	Good
35	Kaikoura	42'17'	173'41'	240	20	Poor, Farmland	July	15.1	1000I	Good
36	Harihari	43'07'	170'36'	60	6	Poor, forest, Farmland	April	15.9	4000	Good
37	Banks Peninsula	43'42'	172'54'	60	15	Good; forest	July	15.7	1000	Good
38	Peel Forest	43'54'	111'14'	300	7	Good; forest	May	14.7	1000	Good
39	Dunedin	45'44'	170'36'	30	1	Poor, forest	September	15.1	1400	Poor
40	Catlins	46'29'	169'42'	5	5	Good, small; forest	May	14.8	700	Poor
41	Invercargill	46'21'	168'15'	10	I	Small	August	14.7	1000	Moderate
42	Dean Forest	45'52'	167'38'	350	2	Good; forest	April	14.9	1000	Moderate