PRELIMINARY SELECTION OF SUITABLE PROVENANCES OF EUCALYPTUS REGNANS FOR NEW ZEALAND

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ABSTRACT

Provenance tests of 36 seedlots of **Eucalyptus regnans** F. Muell. were established on two central North Island sites in 1977. Frost resistance recorded in the first winter after planting showed highly significant variation among provenances. At age 3 years there were significant differences in height growth, resistance to Mycosphaerella leaf blotch disease, stem straightness, and branching quality.

The most promising native Australian provenances were from southern Gippsland, Victoria (fast growth, good resistance to Mycosphaerella, but comparatively poor frost tolerance), and from interior southern Tasmania (satisfactory growth, reasonable resistance to Mycosphaerella, and excellent frost tolerance).

A New Zealand exotic provenance from Tokoroa performed well. The seedlot was collected from selected trees in a 9-year-old plantation of southern Tasmanian origin.

INTRODUCTION

A genetic improvement programme in *Eucalyptus regnans* was initiated in New Zealand in 1977 (Wilcox 1980). Detailed results have been reported concerning provenance and family variation in frost tolerance (Rook *et al.* 1980; Wilcox *et al.* 1980). As the field tests progress, important differences among seedlots are becoming apparent in several characteristics other than frost tolerance. Early identification of superior seed sources has become urgent as demand for seed in New Zealand increases.

Results on growth, disease resistance, stem straightness, and branching quality are reported here from 3-year-old provenance trials on two central North Island sites, and correlated with the earlier results on frost tolerance. A preliminary selection is made of the best seed sources.

MATERIALS AND METHODS

Seedlots

A list of 36 provenance seedlots is given in Table 1, and localities are shown in Figs 1 and 2. Provenances 74 (Victoria), 72 and 73 (Tasmania), and 189, 190, 191, 192, 193, and 195 (New Zealand) are composites of open-pollinated seedlots collected from plus-trees selected for breeding programmes. The other seedlots are either commercial collections, or experimental samples from random trees in natural stands (Griffin 1977).

TABLE 1—Provenances of **Eucalyptus regnans** tested in New Zealand

Code No.	N.Z. Lot No.	Origin*	Alt. (m)	Lat. (S)	Long. (E)	Distance from sea (km)
69	S 73/1160	Waitati, N.Z. (C)	40	45°46′	170°34′	2
70	HO 74/815	Franklin, Tas. (C)	330	43°05′	146°58′	5
72	FRI 72/1944A	Uxbridge, Tas. (20)	520	42°49′	146°50′	42
73	FRI 72/1944B	Ellendale, Tas. (18)	500	42°33′	146°40′	60
74	FRI 72/1946	Strzelecki Ranges, Vic. (20)	500	38°27′	146°30′	38
75	HO 68/614	Moogara, Tas. (C)	600	42°47′	146°55′	39
145	FRI 77/2071	Kallista, Vic. (13)	300	37°55′	145°23′	28
146	FRI 77/2072	Narbethong, Vic. (49)	700	37°31′	145°38′	70
147	FRI 77/2073	Rubicon, Vic. (13)	550	37°20′	145°56′	100
148	FRI 77/2074	Mt Toorongo, Vic. (14)	1000	37°48′	146°07′	84
149	FRI 77/2075	Green Hills, Vic. (15)	950	37°41′	146°32′	95
150	FRI 77/2076	Valencia Ck, Vic. (13)	970	37°33′	147°00′	78
151	FRI 77/2077	Quarry Ck, Vic. (50)	780	37°26′	147°39′	66
152	FRI 77/2078	Yalmy River, Vic. (12)	820	37°21′	148°27′	48
153	FRI 77/2079	Narracan, Vic. (14)	300	38°15′	146°13′	46
154	FRI 77/2080	Wilson's Promontory, Vic. (11)	380	39°06′	146°22′	3
155	FRI 77/2081	Traralgon Ck, Vic. (49)	570	38°26′	146°31′	45
156	FRI 77/2082	Carisbrook, Otway Rgs, Vic. (12)	430	38°36′	143°45′	8
158	FRI 77/2084	Ferndene, Tas. (11)	200	41°09′	146°01′	10
159	FRI 77/2085	Christmas Hills, Tas. (11)	330	41°28′	146°36′	34
160	FRI 77/2086	Royal George, Tas. (11)	620	41°56′	147°56′	30
161	FRI 77/2087	Goulds Country, Tas. (13)	150	41°13′	148°09′	11
162	FRI 77/2088	Styx River, Tas. (15)	420	42°49′	146°36′	56
163	FRI 77/2089	Strathblane, Tas. (12)	240	43°22′	146°58′	5
164	FRI 77/2090	Kaoota, Tas. (12)	490	43°01′	147°09′	8
165	FRI 77/2091	Ferntree, Tas. (7)	410	42°55′	147°15′	10
166	FRI 77/2092	Levendale, Tas. (13)	150	42°31′	147°32′	25
167	FRI 77/2093	Nugent, Tas. (13)	370	42°42′	147°49′	11
188	FRI 77/2094	Lisle, Tas. (15)	590	41°15′	147°22′	29
189	FRI 77/2062	Tokoroa, N.Z. (8)	470	38°18′	175°50′	88
190	FRI 77/2063	Rangiwahia, N.Z. (5)	610	39°52′	175°55′	76
191	FRI 77/2064	Ruapuna, N.Z. (6)	275	43°52′	171°22′	40
192	FRI 77/2065	Waitati, N.Z. (6)	40	45°46′	170°34′	2
193	AK/C/77/18	Pureora, N.Z. (2)	610	38°32′	175°34′	87
194	FRI 77/2095	Wyndham, N.Z. (2)	130	46°24′	168°51′	18
195	FRI 77/2066	Mt Erica, Vic. (7)	1000	37°53′	146°21′	95

* Number of individual seed parents in each provenance sample shown in parentheses. (C) = commercial seedlot from unknown number of trees.

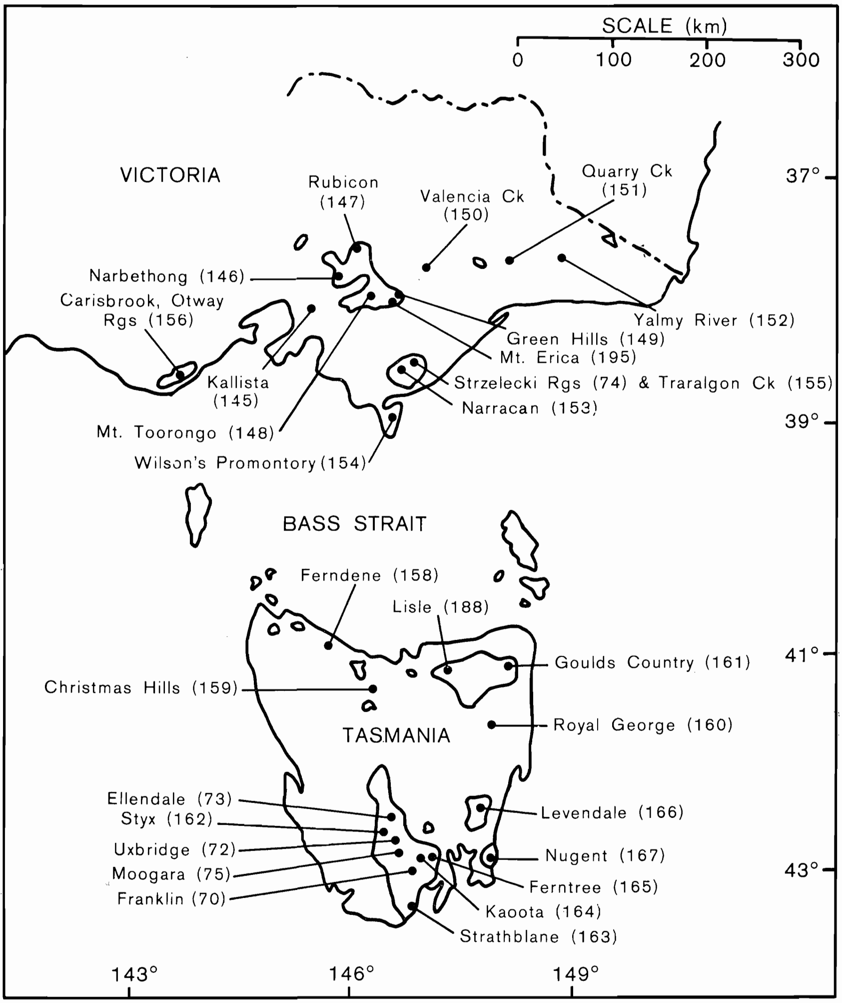

FIG. 1—Natural distribution of **E. regnans**, with origins of provenances tested in New Zealand.

Experimental Design

Four-month-old seedlings in peat pots were planted in November 1977 on two sites. Each test was laid out as a randomised complete block design with 36 replications and one tree per provenance per replication. Tree spacing was 4 × 3 m. Details of the test sites are as follows.

Wiltsdown: Experiment No. R 1906; latitude 38° 10′S; longitude 175° 47′E; altitude 260 m; slope 0–5°; previous crop = pasture; preparation = grazed, sprayed with paraquat, disced, rotary hoed; soil = loam overlying volcanic ash; air drainage = not markedly impeded; location = N.Z. Forest Products Limited, Wiltsdown near Tokoroa.

Kaingaroa: Experiment No. R 1907; latitude 38° 29′S; longitude 176° 36′E; altitude 420 m; slope 15° to north; previous crop = mature first-rotation *Pinus radiata* D. Don

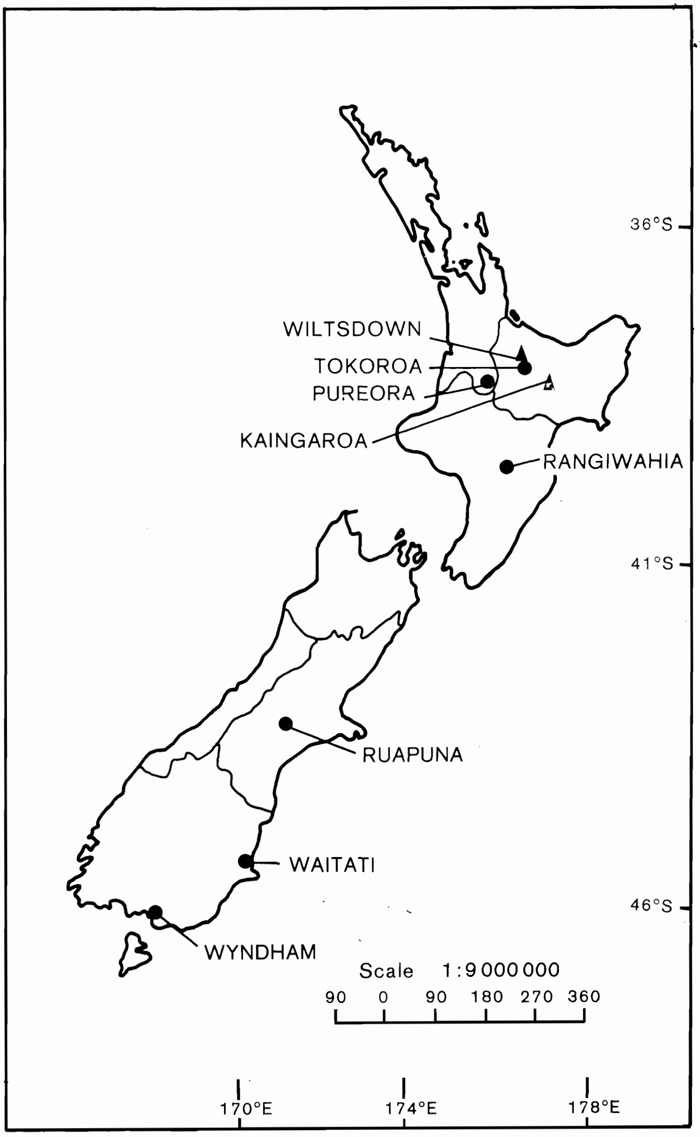

FIG. 2—New Zealand exotic provenances of **E. regnans** tested (●) and location of test sites (▲).

forest; preparation = logged, rootraked, and windrowed; soil = sandy loam topsoil overlying pumice; air drainage = good; location = Cpt 37, Kaingaroa State Forest.

Assessment Method

Frost damage was assessed in June 1978, as described by Rook *et al.* (1980). These results will be referred to later. The tests were assessed in June and July 1980 as follows:

Height; in metres.

Disease susceptibility; scored on a scale of 1 (no visible disease symptoms) to 9 (the whole crown, including the leader, severely infected). The disease was fungal "leaf blotch" attributed mainly to *Mycosphaerella nubilosa* (Cooke) Hansf.* which is particularly prevalent in wet summers.

Branching quality; scored on a scale of 1 (very coarse, steep-angled branching, including multiple forking) to 9 (small-diameter, flat-angled branching, with no forking).

Stem straightness; scored on a scale of 1 (very crooked) to 9 (very straight).

As well as these four quantitative traits, each tree was classified as having flower buds or not, and as having an aggregate plus-tree phenotype (i.e., tree suitable as a candidate for breeding) or not.

Data Analysis

Data from each site were separately analysed. Individual tree data for each trait were analysed and provenance means were estimated by the method of fitting constants (least squares) in a two-way crossed classification model without interaction (Table 2), following the methods of Searle (1971) and Harvey (1960).

Variance components for provenances (σ^2_p), replications (σ^2_r), and error (σ^2_e) were estimated using the model shown in Table 2, and the repeatability of provenance means was calculated at each site from

$$\hat{h}^2_{\bar{P}} = \frac{(N\text{-}b)\ \hat{\sigma}^2_p}{(a\text{-}1)\ M_1}$$

The statistical significance of differences among provenance means was determined from F-tests and least significant differences.

Phenotypic correlations between traits at each site, and between sites for each trait, were calculated from the provenance means.

RESULTS

Individual provenance means, with provenances listed in order of mean height, are shown in Table 3 (Wiltsdown) and Table 4 (Kaingaroa). Means and rankings of the provenances classified into geographic groups are shown in Table 5; variance component estimates, and repeatabilities for both tests are given in Table 6.

TABLE 2—Analysis of variance model for analysis of single-tree plot design of **E. regnans** provenance tests using method of fitting constants

Source	df	SS	MS	E(MS)
Provenance	a-1	$R(\alpha \mid \mu,\beta)$	M_1	$\sigma^2_e + \left[\frac{N-b}{a-1}\right] \sigma^2_p$
Replication	b-1	$R(\beta \mid \mu,\alpha)$	M_2	$\sigma^2_e + \left[\frac{N-a}{b-1}\right] \sigma^2_r$
Error	N-a-b+1	$T_o - R(\mu,a,b)$	M_3	σ^2_e
Total	N-1			

* **See** end of text for note added in proof.

TABLE 3—Assessment of **E. regnans** provenances at Wiltsdown in July 1980 - aged 3 years from sowing

Rank†	Provenance	Height (m)	Disease‡ (1–9)	Frost§ (0–5)	BrQ (1–9)	Str (1–9)	Number of trees‖		
							Total	Buds	Plus
1	74 Strzelecki's, Vic.	7.6	2.7	1.7	5.6	6.2	28	6	0
2	188 Lisle, Tas.	7.2	3.1	1.7	5.7	6.3	23	8	1
3	190 Rangiwahia, N.Z.	7.2	3.5	1.6	5.3	5.2	20	3	0
4	145 Kallista, Vic.	7.1	3.4	1.5	5.6	5.6	25	5	0
5	155 Traralgon Ck, Vic.	7.0	3.1	1.9	5.4	5.7	27	5	0
6	73 Ellendale, Tas.	7.0	3.0	1.3	5.5	5.4	26	6	0
7	75 Moogara, Tas.	6.9	2.5	1.1	6.2	5.9	27	7	0
8	162 Styx River, Tas.	6.9	3.2	1.1	5.8	6.1	31	6	1
9	153 Narracan, Vic.	6.9	3.6	1.7	5.1	5.6	21	3	0
10	154 Wilson's Prom., Vic.	6.9	3.2	1.9	5.0	5.4	25	2	1
11	167 Nugent, Tas.	6.9	3.2	1.5	5.8	5.1	26	1	0
12	189 Tokoroa, N.Z.	6.9	2.2	1.1	6.0	5.9	28	8	3
13	166 Levendale, Tas.	6.9	3.4	1.6	6.1	5.2	24	2	0
14	163 Strathblane, Tas.	6.8	3.1	2.1	5.7	4.6	22	5	0
15	194 Wyndham, N.Z.	6.8	3.6	1.5	5.6	4.5	12	1	0
16	150 Valencia Ck, Vic.	6.8	3.3	1.2	6.6	6.7	33	11	2
17	147 Rubicon, Vic.	6.8	4.3	1.3	6.5	6.5	27	3	1
18	161 Goulds Country, Tas.	6.8	3.3	1.9	5.2	5.7	20	2	0
19	156 Otway Ranges, Vic.	6.7	3.0	2.1	5.9	5.9	19	2	0
20	146 Narbethong, Vic.	6.7	3.8	1.4	6.1	6.1	19	3	0
21	191 Ruapuna, N.Z.	6.6	3.9	1.8	5.2	5.9	25	5	0
22	159 Christmas Hill, Tas.	6.6	4.0	2.0	5.1	5.3	26	2	0
23	151 Quarry Ck, Vic.	6.6	2.9	1.3	5.9	5.6	27	3	0
24	195 Mt Erica, Vic.	6.6	2.6	1.0	5.5	5.8	30	4	0
25	72 Uxbridge, Tas.	6.6	3.5	1.4	6.0	5.4	26	3	2
26	149 Green Hills, Vic.	6.6	3.8	1.2	6.0	5.4	26	3	1
27	160 Royal George, Tas.	6.6	3.2	1.3	5.7	6.5	18	3	0
28	70 Franklin, Tas.	6.5	2.8	1.2	5.1	5.4	32	4	1
29	148 Mt Toorongo, Vic.	6.5	3.1	1.0	5.4	6.1	24	6	0
30	164 Kaoota, Tas.	6.5	3.0	1.8	5.5	5.6	18	3	0
31	192 Waitati, N.Z.	6.4	4.5	2.0	5.2	5.2	15	2	0
32	193 Pureora, N.Z.	6.3	3.4	1.6	5.7	5.9	16	1	0
33	158 Ferndene, Tas.	6.3	4.3	2.2	5.4	5.1	18	1	0
34	152 Yalmy River, Vic.	6.3	3.6	1.7	5.9	5.7	23	2	0
35	69 Waitati, N.Z.	6.1	4.1	2.9	5.8	5.6	13	2	0
36	165 Ferntree, Tas.	5.9	3.5	2.2	4.9	4.6	12	2	0
	Mean	6.7	3.4	1.6	5.6	5.6	23	3.7	0.4
	LSD (0.05)	0.5	1.0	0.3	0.9	0.8			
	F-test, provs.	2.4**	2.1*	10.9**	1.6*	2.7**			

† Ranked in order of mean height.

‡ Infection by **Mycosphaerella nubilosa** (1 = no infection; 9 = very severe damage).

§ Frost damage rated in 1978 (0 = no damage; 5 = killed by frost).

‖ Total = number of crop trees surviving out of 36 planted; Buds = number of trees with flower buds; Plus = number of plus-trees provisionally selected in the provenance.

TABLE 4—Assessment of **E. regnans** provenances at Kaingaroa in June 1980 - aged 3 years from sowing

Rank†	Provenance	Height (m)	Disease‡ (1–9)	Frost§ (0–5)	BrQ (1–9)	Str (1–9)	Number of trees‖ Total	Buds	Plus
1	153 Narracan, Vic.	6.5	2.6	0.8	5.0	4.9	26	10	3
2	190 Rangiwahia, N.Z.	6.5	3.5	0.7	4.9	5.1	32	7	1
3	74 Strzelecki's, Vic.	6.2	3.4	0.9	5.7	5.7	31	5	5
4	154 Wilson's Prom., Vic.	6.2	3.6	0.6	5.2	5.1	33	6	2
5	145 Kallista, Vic.	6.1	3.3	1.1	5.0	5.0	30	6	1
6	158 Ferndene, Tas.	6.1	3.8	1.4	5.0	5.2	32	2	1
7	161 Goulds Country, Tas.	6.1	4.2	1.5	5.0	4.5	32	4	1
8	189 Tokoroa, N.Z.	6.0	3.6	0.1	5.4	5.5	30	9	2
9	159 Christmas Hills, Tas.	6.0	4.0	1.2	4.9	5.1	30	4	1
10	166 Levendale, Tas.	6.0	4.7	0.4	5.1	5.2	32	5	3
11	163 Strathblane, Tas.	5.9	4.3	1.4	4.6	4.5	30	5	0
12	70 Franklin, Tas.	5.9	3.6	0.3	5.5	5.6	35	4	2
13	73 Ellendale, Tas.	5.9	3.5	0.5	4.4	4.5	28	8	0
14	150 Valencia Ck, Vic.	5.9	3.5	0.4	5.1	5.3	34	7	1
15	195 Mt Erica, Vic.	5.9	3.3	0.1	4.8	4.8	33	5	0
16	151 Quarry Ck, Vic.	5.9	3.2	0.3	5.3	5.2	31	10	2
17	152 Yalmy River, Vic.	5.9	3.9	1.1	5.2	5.1	29	0	0
18	75 Moogara, Tas.	5.8	3.7	0.1	5.4	5.5	25	6	4
19	164 Kaoota, Tas.	5.8	3.7	1.1	5.3	5.2	32	8	2
20	146 Narbethong, Vic.	5.8	4.8	0.6	4.6	4.5	32	4	0
21	156 Otway Ranges, Vic.	5.8	3.1	1.3	4.4	4.6	26	3	0
22	188 Lisle, Tas.	5.8	3.4	0.9	5.5	5.5	30	5	2
23	155 Traralgon Ck, Vic.	5.8	3.9	1.0	5.2	5.2	33	4	1
24	165 Ferntree, Tas.	5.8	4.4	1.3	5.0	4.9	27	2	1
25	162 Styx River, Tas.	5.7	4.7	0.1	4.5	5.6	30	4	1
26	191 Ruapuna, N.Z.	5.7	4.6	1.0	4.2	5.1	31	9	0
27	167 Nugent, Tas.	5.7	4.6	0.9	5.2	4.8	31	2	1
28	193 Pureora, N.Z.	5.7	3.3	1.4	5.2	5.3	30	5	1
29	72 Uxbridge, Tas.	5.6	4.4	0.4	5.1	5.1	32	2	0
30	149 Green Hills, Vic.	5.6	4.3	0.4	4.3	4.3	31	2	0
31	148 Mt Toorongo, Vic.	5.4	3.6	0.3	5.1	5.5	28	6	0
32	69 Waitati, N.Z.	5.4	5.6	2.6	3.6	4.9	24	0	0
33	147 Rubicon, Vic.	5.3	4.7	0.5	5.3	5.3	30	3	0
34	194 Wyndham, N.Z.	5.3	5.1	0.5	3.9	4.3	24	2	0
35	160 Royal George, Tas.	5.3	3.6	0.7	4.4	5.4	29	7	0
36	192 Waitati, N.Z.	5.2	7.3	1.3	3.3	3.0	19	1	0
	Mean	5.8	4.0	0.8	4.9	5.0	30	4.8	1.1
	LSD (0.05)	0.5	0.9	0.4	0.9	0.9			
	F-test, provs.	2.9**	6.1**	12.9**	2.6**	2.1*			

† Ranked in order of mean height.

‡ Infection by **Mycosphaerella nubilosa** (1 = no infection; 9 = very severe damage).

§ Frost damage rated in August 1978 (0 = no damage; 5 = killed by frost).

‖ Total = number of crop trees surviving out of 36 planted; Buds = number of trees with flower buds; Plus = number of plus-trees provisionally selected in the provenance.

TABLE 5—Means of provenance groups averaged over the Kaingaroa and Wiltsdown tests

	Provenance group	Height (m)	Disease (1–9)	Frost (0–5)	Branching (1–9)	Straightness (1–9)
I	Interior south Tasmania 420 m+ (72, 73, 75, 162)	6.30 (5)*	3.56 (5)	0.75 (3)	5.36 (3)	5.44 (4)
II	High elevation Victoria 900 m+ (148, 149, 150, 195)	6.16 (8)	3.43 (2)	0.70 (2)	5.34 (4)	5.48 (2)
III	N.Z. stand ex Tasmania (Tokoroa) (189)	6.45 (3)	3.52 (4)	0.60 (1)	5.70 (1)	5.70 (1)
IV	Main central Victorian stands, 500–850 m (145, 146, 147, 151)	6.28 (6)	3.80 (8)	1.00 (4)	5.53 (2)	5.47 (3)
V	Coastal east and south-east Tasmania, 150–330 m (70, 160, 163, 164, 165, 166, 167)	6.18 (7)	3.65 (6)	1.27 (6)	5.27 (6)	5.19 (7)
VI	N.Z. stand ex Victoria (Rangiwahia) (190)	6.85 (1)	3.50 (3)	1.15 (5)	5.10 (8)	5.15 (8)
VII	South Gippsland and Otway Ranges, Victoria (74, 152, 153, 154, 155, 156)	6.48 (2)	3.31 (1)	1.39 (7)	5.30 (5)	5.42 (5)
VIII	Northern Tasmania 150–600 m (158, 159, 161, 188)	6.36 (4)	3.76 (7)	1.60 (8)	5.22 (7)	5.35 (6)
IX	N.Z. stands of unknown origin (69, 191, 192, 193, 194)	5.95 (9)	4.54 (9)	1.66 (9)	4.75 (9)	4.97 (9)

* Rankings in order of superiority are shown in brackets.

Statistically significant differences between provenances were detected for all traits at both sites. Although tree growth was fastest at Wiltsdown, differences between provenances in all traits were generally most pronounced at Kaingaroa. Provenance differences, reflected by the variance components and repeatabilities in Table 6, were most marked in frost tolerance, but were also important in disease resistance, especially at Kaingaroa. The inter-site correlation for branching quality (Table 6) was only 0.11, showing that provenance variation in this trait was slight, or at least difficult to specify using the crude 1–9 subjective grading scale.

The provenance group means and rankings in Table 5 summarise the results of the two tests. The best over-all performer was judged to be Provenance 189 from a stand of Tasmanian origin at Tokoroa, New Zealand. It was among the best in every trait. Another notable New Zealand provenance was 190 from a farm woodlot of Victorian origin at Rangiwahia. It was clearly the fastest growing local provenance, and among the fastest of all 36 provenances averaged over the two sites, but unfortunately displayed a high degree of malformation. The other New Zealand seedlots (Waitati, Pureora, Ruapuna, Wyndham) were very unprepossessing in every way.

None of the native provenance groups were superior in all respects. The high elevation group from Victoria, typified by Provenance 148 from Mt Toorongo, had generally excellent frost tolerance, disease resistance, and stem form, but was among

TABLE 6—Estimates of variance components and their percentage contributions to total variance, within-site repeatabilities, and between-site correlations in provenance tests at Kaingaroa and Wiltsdown

Trait	Provenance ($\hat{\sigma}^2_p$) Kaingaroa	Provenance ($\hat{\sigma}^2_p$) Wiltsdown	Replication ($\hat{\sigma}^2_r$) Kaingaroa	Replication ($\hat{\sigma}^2_r$) Wiltsdown	Error ($\hat{\sigma}^2_e$) Kaingaroa	Error ($\hat{\sigma}^2_e$) Wiltsdown	Repeatability ($\hat{h}^2_p$) Kaingaroa	Repeatability ($\hat{h}^2_p$) Wiltsdown	Inter-site correlation
Height (m)	0.06 (5%)	0.05 (6%)	0.11 (10%)	0.03 (3%)	0.85 (85%)	0.82 (91%)	0.66	0.59	0.42
Disease resistance (1–9)	0.49 (14%)	0.14 (4%)	0.18 (5%)	0.17 (5%)	2.86 (81%)	2.84 (91%)	0.84	0.52	0.59
Frost tolerance (0–5)	0.23 (21%)	0.11 (18%)	0.04 (4%)	0.04 (6%)	0.71 (75%)	0.49 (76%)	0.90	0.84	0.91
Branching quality (1–9)	0.15 (5%)	0.07 (2%)	0.09 (3%)	0.05 (2%)	2.71 (92%)	2.54 (96%)	0.62	0.37	0.11
Stem straightness (1–9)	0.11 (3%)	0.15 (6%)	0.09 (3%)	0.20 (8%)	3.04 (94%)	2.05 (86%)	0.52	0.62	0.47

the slowest in growth. On the other hand, the south Gippsland group (Provenances 74, 155, 153) grew very fast, had good disease resistance, but showed poor frost tolerance and only average stem form. Probably the best all-round native provenance group was from interior south Tasmania (e.g., Moogara, Styx River) in which excellent frost tolerance was combined with very satisfactory growth rate.

The phenotypic correlations between traits are shown in Table 7. Most of the correlations were favourable, and there are indications of strong morphological associations between some traits. For example, provenances with poor frost tolerance also generally had poor branching quality (possibly, in some as a result of frost damage) and poor survival and disease resistance. A large unfavourable correlation (0.83) between height and frost tolerance was evident at Kaingaroa, but not at Wiltsdown; otherwise, correlations were reasonably similar at both sites.

TABLE 7—Phenotypic correlations among provenance means at Wiltsdown and Kaingaroa

Correlation	Wiltsdown	Kaingaroa
Height × disease	-0.37*	-0.57*
Height × frost	-0.06	0.83†
Height × branching	0.05	0.44*
Height × straightness	0.22*	0.19*
Disease × frost	0.41*	0.24*
Disease × branching	-0.06	-0.63*
Disease × straightness	-0.21*	-0.55*
Frost × branching	-0.37*	-0.32*
Frost × straightness	-0.37*	-0.35*
Branching × straightness	0.47*	0.71*
Survival × frost	-0.62*	-0.31*

* Correlations favourable for selection

† Correlation unfavourable for selection

The numbers of trees of plus-tree standard and with flower buds are shown in Tables 3 and 4. These records were not analysed, but do indicate that flowering begins at an early age on these sites and that trees of high phenotypic quality occurred in a surprisingly large number of different provenances, though at higher frequency in the better provenances.

DISCUSSION

The results show that seed source is important in *E. regnans*. Many provenances proved to be ill-adapted to the climates of the test sites, with respect to both frost tolerance (Rook *et al.* 1980) and disease resistance. Although these components of adaptability are crucial only in the first 1–3 years after planting, they are vital on some sites to the success of planting programmes, and must be given high priority when seed sources are being chosen.

The leaf blotch disease caused by *Mycosphaerella nubilosa* inflicted rather severe damage on some provenances, causing heavy defoliation and leader die-back, though for the most part damage was not as severe as it is on *Eucalyptus delegatensis* R.T.Bak. in the central North Island. Fortunately, fast-growing and/or frost-hardy provenances of *E. regnans* appear to be not unduly troubled by the disease. Provenances such as Waitati that had been severely damaged by frost in 1978 were the most susceptible. Observations in the field indicated that badly frosted trees sometimes resprouted from the base and thus may have had greater disease susceptibility because of the high proportion of juvenile foliage in the crown.

The native provenances most susceptible to Mycosphaerella were 147 from Rubicon and 146 from Narbethong in central Victoria. The Rubicon provenance was from a site north of the main divide in Victoria and adjacent to stands of *E. delegatensis*. The poor disease resistance of this provenance may possibly have been inherited via some degree of hybridisation with the highly susceptible mainland *E. delegatensis,* though there was no morphological evidence of this. Certainly at Wiltsdown it was observed that obvious *E. regnans* × *E. delegatensis* hybrid individuals that occasionally occurred in Provenance 193 from Pureora were invariably more heavily diseased than pure *E. regnans* individuals.

Provenance 189 from Tokoroa grew faster, had better stem form, and showed better resistance to frost and disease than nearly all native provenances. Inclusion of local provenances in testing programmes of exotic species has often been rewarding in New Zealand, and with *E. regnans* has conveniently identified a very promising seed source. The seedlot was collected from eight selected trees in a 9-year-old plantation at Tokoroa of southern Tasmanian origin (exact locality not recorded, but suspected to be in the Styx or Florentine Valleys). Consequent on these test results, commercial seed collection has been undertaken in Tokoroa plantations, and a clonal seed orchard is being developed based heavily on trees selected at Tokoroa.

Several of the provenances in the test were composites of progenies from plus-trees selected for good stem straightness, light branching, and fast growth. The performance of Provenance 74 from the Strzelecki Ranges and of Provenance 189 suggests that such selection was probably effective, though it should be noted that the progeny of the finest quality plus-trees selected in New Zealand (from Waitati) were very substandard (Wilcox *et al.* 1980).

Seed of exotic species is frequently imported from the wrong place through lack of information about provenance variation, or because seed was not obtainable from the desired localities. The test results reported here are admittedly very preliminary, but they do indicate that interior south Tasmania is a good source of frost-tolerant seedlots. The more productive southern Victorian provenances may be preferable on milder sites. In any case, seedlots should be chosen for sowing with the environment of the planting site in mind. A good all-round provenance with wide adaptability, like the "Tokoroa" strain, is a better solution, however, than the difficult exercise of trying to precisely match provenance to planting site.

CONCLUSIONS

From these early assessments of *E. regnans* provenance tests in New Zealand it can be concluded that *E. regnans* shows considerable genetic variation (associated with geographic origin) in frost tolerance, resistance to Mycosphaerella leaf blotch disease, growth rate, and, to a lesser extent, branching quality and stem straightness.

The fastest-growing native provenances in the tests were from south Gippsland, Victoria, and northern Tasmania. These provenances also showed the poorest frost tolerance. Provenances from interior south Tasmania seemed best adapted to New Zealand sites in terms of frost tolerance and disease resistance, and had acceptable stem form and growth rate.

Exotic provenances from New Zealand were very variable in their performance. A Tokoroa provenance (ex Tasmania) proved to be a good performer in every way and, of local seed sources so far tested, is the most satisfactory one for general use.

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Note added in proof: Recent studies in Victoria (Park & Keane 1982a, 1982b) indicate that the correct identity of the pathogen responsible for the common leaf blotch disease on **E. regnans** and **E. delegatensis** in New Zealand is **Mycosphaerella cryptica** (Cke) Hansf. **Mycosphaerella nubilosa** also occurs in New Zealand, but only on eucalypts of the subgenus **Symphyomyrtus** (e.g., **E. nitens** and **E. globulus**).

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