

# **Early growth and form of coastal provenances and progenies of Douglas-fir at three sites in New Zealand**

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**NZ Douglas-fir Cooperative**

**Report No. 28, February 2002**

# **NEW ZEALAND DOUGLAS-FIR COOPERATIVE**

## **EARLY GROWTH AND FORM OF COASTAL PROVENANCES AND PROGENIES OF DOUGLAS-FIR AT THREE SITES IN NEW ZEALAND**

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### **SUMMARY**

A Douglas-fir provenance and progeny trial, planted in 1996, consists of 222 open-pollinated families from 21 coastal and one inland provenance from Pacific Northwest U.S.A., as well as eight New Zealand (NZ) land-race seedlots, as controls. The latitude of the provenances in California ranges from 35° 07'N to latitude 44° 10'N in Oregon. The trial layout was a sets-in-replications design of seven sets of progenies with 30 replicates of single-tree plots, planted on three sites in the central North Island, Nelson and Southland regions. Average tree height, assessed at age four years from planting, was 2.5 metres in the central North Island, and 2.2 metres at Nelson and Southland, with the tallest trees reaching 4.9 metres in the central North Island.

Best-grown provenances (and families) at this age are those from Mendocino county in California, especially the Fort Ross and Navarro river provenances. The tallest provenances were those from between latitudes 38° and 39°N; height of provenances from locations going north and south of this latitude were generally reduced, although individual provenances can vary unpredictably. The New Zealand control seedlots all grew well on these sites. The originally-Californian Fort Bragg seedlots, were the most vigorous, followed by seedlots from Beaumont, Ashley and a Kaingaroa seedlot, originally from Washington. Best performing seedlots for growth were three controlled-pollinated seedlots involving inter-provenance crossing, planted in Southland only.

Height, bole straightness and needle retention at age four years had high narrow-sense heritabilities (0.2 – 0.35). Tree form in these trials was highly variable with most of the variation in growth at the provenance level and somewhat less variation at the level of families within provenances. Some interaction variance for height growth was found between families and sites and also between provenances and sites, but there are stable families that rank well across all sites. Family means show moderate correlation ( $r=0.6$ ) between height growth in the nursery and height at each site at age four. The trees in these trials form a very valuable resource for future breeding work.

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## INTRODUCTION

Coastal Douglas-fir (*Pseudotsuga menziesii* var. *menziesii* (MIRB.) FRANCO) has been grown in plantations in New Zealand since about 1870 (Miller and Knowles, 1994). Research into Douglas-fir genetics started in New Zealand in 1955 and the first provenance trial was planted in 1957 from seed supplied by commercial seed companies (Sweet G.B., unpubl. data; Wilcox M.D., unpubl. data). The provenances in this trial were collected from areas in Washington and Oregon, where large timber industries were based around Douglas-fir. The second trial was planted in 1959 from seed collected by a New Zealand Forest Research Institute scientist, Egon Larsen. These collections were generally from areas not represented in the first trial, particularly the coastal fog-belt of California and Oregon (G.B. Sweet, unpubl. data; M.D. Wilcox, unpubl. data). Further trials of local New Zealand seed sources and selected provenances were planted in 1971 and 1974 (C. J. A. Shelbourne, unpubl. data; M. D. Wilcox, unpubl. data).

In the past, Douglas-fir has represented up to ten per cent of the area of the New Zealand forest estate, but currently represents only five per cent. However present production of Douglas-fir tree stocks over the last 3 years has varied from 16-19% of total tree stocks produced (R. Dorey, unpubl. data). The arrival of Swiss needlecast (*Phaeocryptopus guaemannii*) in 1959 had caused the growth rate of many stands (of Washington origin) to decline by 1970 (Beekhuis, 1978). Plus-tree selection was initiated in 1969 in Kaingaroa Forest stands of Washington origin, and open-pollinated progeny tests of these were planted in 1972. However, results from the 1959 provenance trials, obtained in 1974 (M. D. Wilcox, unpubl. data), showed clearly that Washington provenances grew up to 30 percent slower than provenances from the fog-belt on the coast of California. This news, as well as a general decline of industry interest in the species, effectively halted the breeding programme for the next 13 years.

By 1987, the timber industry had started to show greater appreciation of Douglas-fir, as high prices were being obtained for exported Douglas-fir logs. A decision was taken to select a new breeding population from trees of the best-performing provenances that were growing in the 1957 and 1959 trials (C.J.A. Shelbourne, unpubl. data). Under the sponsorship of PROSEED NZ Ltd., 185 trees were selected and scions from these were grafted to plant a clonal archive at Waikuku in Canterbury.

The limited genetic base of ten seed parents of most of the seedlots in the 1959 provenance trial made it necessary to impose a limit on selections from these. The need to broaden the genetic base resulted, in 1993, in selection and open-pollinated seed collection from a further 200 trees from coastal fog-belt populations in California and Oregon. The first assessment of the trials planted from this seed are reported here.

## MATERIAL AND METHODS

### Seed Collection

A team consisting of Charlie Low and Mark Miller from Forest Research (New Zealand) in 1993 selected trees and collected cones in coastal California, where, that year, there was an adequate seed crop. Seed from selected parents under test in tree improvement programmes in Oregon and California, was also provided by the USDA Forest Service, Bureau of Land Management and by Louisiana-Pacific. The California Department of Forestry provided equipment, extracted seed from the collected cones and shipped it back to New Zealand.

22 provenances (populations) were located for seed collection and seed of from three to 23 parent trees per stand was collected (Table 1, Fig. 1). Parent trees were selected at a minimum distance of 50 metres apart. Selection criteria were good growth, bole straightness, crown form and health. The altitude of all populations was below 500 metres, and altitude for individual trees within a population often varied from 200 to 500 metres due to the hilly terrain. For various reasons, only 95% of these seedlots were eventually raised in the nursery and planted in field trials.

**Table 1** – Provenance location and number of families in 1993 seed collection

Provenance	State	Seed Zone	Latitude	Number of families planted
Los Padres	California	130	35° 49'	6
Swanton	California	97	37° 06'	3
Cascade Ranch	California	97	37° 08'	13
SF water reserve	California	97	37° 27'	19
SP Taylor Forest Park	California	96	38° 02'	10
Point Reyes	California	96	38° 04'	10
Russian river	California	96	38° 21'	10
Fort Ross	California	96	38° 25'	10
Gualala	California	95	38° 47'	9
Navarro river	California	95	39° 11'	13
Noyo river	California	94	39° 25'	20
Rockport	California	94	39° 47'	5
Usal road	California	93	39° 49'	1
Arcata	California	92	39° 59'	15
Brookings	Oregon	82	42° 06'	7
Ophir	Oregon	81	42° 36'	3
Myrtle Point	Oregon	72	43° 06'	5
Coos Bay	Oregon	71	43° 20'	11
Coquille	Oregon	71	43° 13'	1
Umpqua river	Oregon	71	43° 36'	22
Siuslaw forest	Oregon	61	44° 10'	19
Willamette forest	Oregon	262	43° 50'	10

In 1994, as there was a good seed crop in New Zealand, seed was collected from various New Zealand stands as “control” seedlots (shown in Table 2). Seed from a seed stand of Fort Bragg, California, provenance at Rotoehu Forest was used for surround and filler trees. Up to four families from each of three seed orchards, owned by Weyerhaeuser in Oregon and Washington, were included in the Kaingaroa and Golden Downs tests. Four control-pollinated crosses between the 1987 provenance trial selections, grafted in PROSEED’s Waikuku seed orchard were planted only at Gowan Hills.

**Table 2** – Origin of control seedlots

Code	Provenance	Origin
900	Fort Bragg, CA	Seed Stand, Compartment 55, Rotoehu forest
901	Fort Bragg, CA	Compartment 1132, Kaingaroa forest (2 <sup>nd</sup> generation ex Rotoehu)
902	Washington	Compartment 1061, Kaingaroa (3 <sup>rd</sup> generation in New Zealand)
903	Fort Bragg, CA	Seed Stand, Compartment 115, Golden Downs forest
904	Oregon	Seed Stand, Eyrewell forest (2 <sup>nd</sup> generation ex Ashley)
905	Oregon	Seed Stand, Mount Thomas forest (2 <sup>nd</sup> generation ex Ashley)
906	Washington	Seed stand, Beaumont forest
907	Arcata, CA	Louisiana-Pacific Seed Orchard, Humboldt County, California

### Nursery sowing and raising of plants

Seed from Washington and Oregon provenances and seed orchards was stratified for four weeks but open-pollinated seed from Californian provenances was stratified for two weeks. The seed was sown in early December 1994, to provide one-and-a-half year-old bare-rooted plants for planting in winter (August) 1996. The nursery layout was in randomised complete blocks with three replicates, which helped minimise effects of growth differences along nursery beds.

### Field sites, layout and planting

Progeny trials were planted at three sites in August 1996. At each site the trial layout was sets in replications, with seven sets of 36 seedlots, planted as 30 replicates of single-tree plots. Each set was composed of 34 families, composed of from one to three families from each provenance, and two control seedlots. There were shortfalls of families in some sets, so some seedlots that had surplus plants supplied as a second entry, instead of using fillers. Fillers were used to replace missing plants of those families with less than 30 plants per site. Spacing was 3.0 metres by 3.0 metres, or a stocking of 1111 stems/ha. This stocking was chosen to delay the onset of competition and is rather less than the 1600 stems/ha normally used for commercial plantings.

The sites are located at Kaingaroa Forest in the North Island, Golden Downs and Gowan Hills forests in the South Island (Fig. 2, Table 3). The progeny trial sites are “better-than-average” sites in each area, with adequate rainfall (1200mm to 1900mm) occurring throughout the year, mild climate and good growth potential.

Establishment was excellent at all progeny trial sites and good weed control resulted in good early growth. Some lower-lying rep/set blocks suffered damage from late spring frosts at Kaingaroa and Gowan Hills. The Golden Downs trial suffered two land-slides affecting about 240 trees, but this only removed one or at the most two trees per family. The number of available families did not quite fit the planting layout, so some families with surplus plants were repeated on all sites.

**Table 3 – Site description**

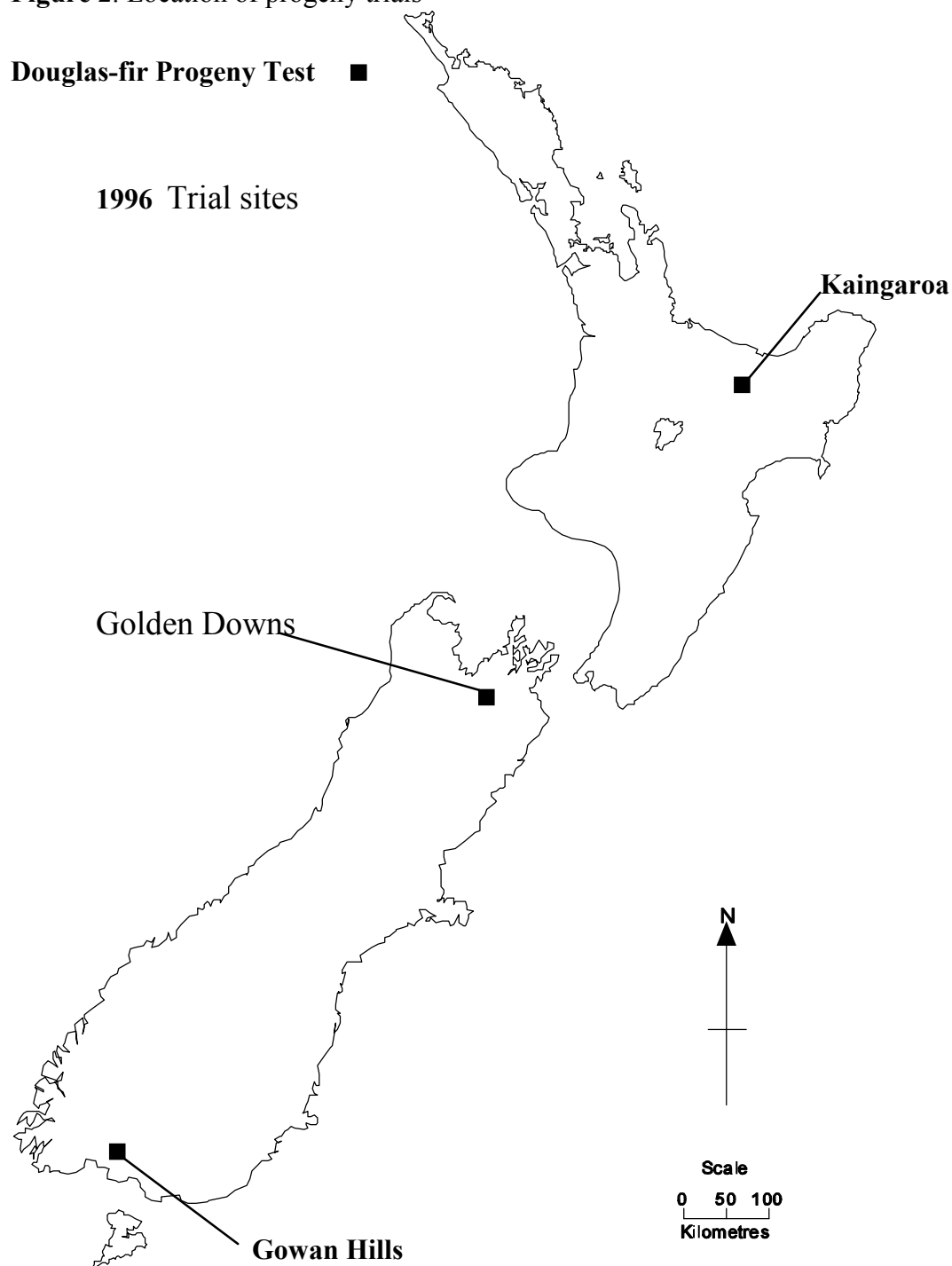
Site	Soil type	Owner	Previous use	Land preparation	Altitude metres	Rainfall mm	Mean monthly temperature, Celsius
Kaingaroa Cpt 1322	Tarawera scoria over Taupo ash	Fletcher Challenge Forests	Radiata pine plantation	Herbicide application to kill weeds	300	1855	6.6° July to 17.6° February
Golden Downs Cpt 114	Moutere gravel	Weyerhaeuser	Douglas-fir plantation	Herbicide application, fertilised at age 3	350	1304	6.1° July to 17.1° February
Gowan Hills Cpt 740	Pourakino yellow-brown earth	Ernslaw One Ltd.	sheep pasture	Deep ripped, mounded, herbicide application	300	987	4.3° July to 14.3° January

Figure 1

Pacific Coast of North America, Douglas fir provenances



**Figure 2.** Location of progeny trials



### **Traits and their assessment**

100-seeds weight was estimated for each family when the seed was extracted.

Families were scored for the timing of the spring flush in the nursery on 1<sup>st</sup> November 1995, nearly 1 year from sowing. Heights of the tallest 30 trees per family were measured by ruler to the nearest centimetre in the nursery in June 1996, one and half years from sowing. These nursery data were used for correlations with family and provenance means.

The following characteristics were measured, scored or counted in October to December 2000:

- Tree height, by height pole to the base of the terminal bud or any new growth (Trees <1.4 metres tall, were not assessed at Kaingaroa and Gowan Hills, but were assessed at Golden Downs).
- Ramicorn branches and forks for any year of growth (count), up to a maximum of three occurrences.
- Bole straightness score, 1-9 scale, omitting the score of five (scores 1-4, from extremely sinuous to marginally unacceptable; score 6-9, acceptable to perfectly straight).

Bole straightness score was assessed for the whole tree at Kaingaroa, but only for the first three years' growth at Gowan Hills, where exposure to strong winds often resulted in completely different scores for stem and the leading shoot, so these were scored separately.

- Leader straightness: same scale as bole straightness except 1 = leading shoot with some, or all of the shoot at 90° from vertical (trees with broken or missing tops, not scored).
- Branch-type: Gowan Hills, 1= one whorl per year, and few intermediate branches, 2 = two whorls per year, but few other branches, 3=many intermediate branches.

However, many trees were found with intermediate branches on half of the annual shoot extension at Gowan Hills, so at Kaingaroa, this was scored as 3 and a score of 4 was used for trees with intermediate branches over the whole annual extension.

- Needle retention: 1-6 score, at Kaingaroa only in late November and early December. In hindsight it would have been better to score needlecast later in the season as there is some confounding of needle loss with the new flush, and many trees had not begun to flush at the time of assessment. The scoring system uses two points for each full year of foliage, the extremes marked by trees with six months foliage or less, which scored 1 on the scale, while trees with three years foliage scored 6.

Gowan Hills was assessed in late October, Golden Downs in early November and Kaingaroa in late November to early December. Numbers of trees assessed are shown in Table 4. There may appear to be discrepancies in this table due to filler trees that were planted to make up shortfalls in some families and were assessed, but not used in the analysis.

**Table 4** – Number of trees measured at each site

Site	Dead	Too small*	Identity problem	Alive	Mean number of trees assessed per seedlot
Kaingaroa	1071	348	15	6126	24.92
Gowan Hills	921	691		5948	21.65
Golden Downs	1327	949*		5284	21.64

\* Trees less than 1.4 metres in height were included in the analysis of Golden Downs, and these are shown separately here.

## Analysis

The field design is a set-within-replications (Schutz and Cockerham, 1966) but as the provenances are shared evenly across sets, for simplicity, the trial was analysed as a randomised complete block design. The equation for the model of analysis of variance of such a design on a single site is as follows:

$$Y_{ijk} = \mu + P_i + R_j + F_k : P_i + E_{ijk}$$



Where :

$Y_{ijk}$  = the observation on the tree of the  $k^{\text{th}}$  family in the  $j^{\text{th}}$  provenance in the  $i^{\text{th}}$  replicate

$\mu$  = the overall mean

$R_i$  = the effect of the  $i^{\text{th}}$  replicate

$P_j$  = the effect of the  $j^{\text{th}}$  provenance

$F_k : P_j$  = the effect of the  $k^{\text{th}}$  family within the  $j^{\text{th}}$  provenance

$E_{ijk}$  = the random error associated with each tree of the  $k^{\text{th}}$  family in the  $j^{\text{th}}$  provenance in the  $i^{\text{th}}$  replicate

The equation for the analysis of variance model on several sites contains a term for sites and terms for the interaction of provenance and family-within-provenance with site:-

$$Y_{ijkl} = \mu + S_i + R_j + P_k * S_i + F_l : P_k + F_l : P_k * S_i + E_{ijkl}$$

Where :

$Y_{ijkl}$  = the observation on the tree of the  $l^{\text{th}}$  family in the  $k^{\text{th}}$  provenance in the  $j^{\text{th}}$  replicate of the  $i^{\text{th}}$  site

$\mu$  = the overall mean

$S_i$  = the effect of the  $i^{\text{th}}$  Site

$R_j : S_i$  = the effect of the  $j^{\text{th}}$  replicate within the  $i^{\text{th}}$  site

$P_k$  = the effect of the  $k^{\text{th}}$  provenance

$P_k * S_i$  = the interaction effect of the  $k^{\text{th}}$  provenance with the  $i^{\text{th}}$  site

$F_l : P_k$  = the effect of the  $l^{\text{th}}$  family within the  $k^{\text{th}}$  provenance

$F_l : P_k * S_i$  = the interaction effect of the  $l^{\text{th}}$  family within the  $k^{\text{th}}$  provenance with the  $i^{\text{th}}$  site

$E_{ijkl}$  = the random error associated with each tree of the  $l^{\text{th}}$  family in the  $k^{\text{th}}$  provenance in the  $j^{\text{th}}$  replicate of the  $i^{\text{th}}$  site

The first analysis of this trial examined the data from the three sites separately. Analysis of variance was carried out by PROC GLM of the SAS<sup>®</sup> statistical package (SAS Institute inc. 1989) and provenance means were compared by Tukey's multiple range test. As each provenance is represented by about 10 families, the terms of the analysis model were replicates, provenances, families nested within provenances and error. Control seedlots, Weyerhaeuser seedlots, CP seedlots and repeated families were omitted from the analysis. Golden Downs data were analysed with trees of less than 1.4 metres and without them, but as there was little difference in the analysis results, the analysis with all trees is shown here.

An overall analysis of variance for all three sites was also carried out for height and forks only. This analysis contained the same terms as the single site models, but also included site and its interaction with provenances and families. Analyses were also carried out for pairs of sites to check the source of any interactions.

Variance components were estimated using the SAS<sup>®</sup> procedure PROC VARCOMP and the same model as the analysis of variance. The coefficient of relationship between families was assumed to be 0.25, as most families are open-pollinated from natural populations. Heritabilities were derived from the variance components using the following formulae:

$$\text{Narrow sense heritability } h_i^2 \text{ per site : } \frac{4*\sigma^2_f}{\sigma^2_f + \sigma^2_e}$$

$$h_i^2 \text{ over all sites: } \frac{4*\sigma^2_f}{\sigma^2_f + \sigma^2_{f*s} + \sigma^2_e}$$

$$\text{Family mean heritability } h_F^2 \text{ per site : } \frac{\sigma^2_f}{\sigma^2_f + \frac{\sigma^2_e}{x}}$$

$$h_F^2 \text{ over all sites: } \frac{\sigma^2_f}{\sigma^2_f + \frac{\sigma^2_{f*s}}{3} + \frac{\sigma^2_e}{x}}$$

where:

$\sigma^2_f$  is the family mean variance,

$\sigma^2_s$  is the site mean variance;

$\sigma^2_{f*s}$  is the family by site interaction variance;

$\sigma^2_e$  is the error variance and;

$x$  is the mean number of trees per family.

Standard errors of heritability were calculated according to the method of Becker (Becker, 1992).

Family means were calculated using the SAS<sup>®</sup> procedure PROC MEANS (SAS Institute inc. 1990) and these means were used to estimate family mean correlations using the SAS<sup>®</sup> procedure PROC CORR. Both within-site and between-site family mean correlation coefficients were calculated. The family means were also correlated with family means from the 1996 nursery assessments and other data such as seed weight and latitude of provenance origin.

## RESULTS AND DISCUSSION

### Provenance Means

The best-grown provenances were from the central Californian coast in Sonoma and Mendocino counties at around latitudes 38-39°N, including the control seedlots from seed stands of Fort Bragg origin. Provenance means for 3 sites, (with (p<0.05) Tukey's multiple range test letters) are ranked from the southernmost, Los Padres to the northernmost, Siuslaw National Forest in Tables 5, 6 and 7. Height growth is less for provenances from central Oregon, northwards and

there is a tendency for the more southern populations to grow slower at this stage, possibly influenced by frost damage. However, much provenance variation in height growth appears to be random within the latitudinal trends. The slowest-grown seedlots are the southernmost Los Padres and northernmost Weyerhaeuser orchard progenies from Washington. The NZ seed stand seedlots of Fort Bragg origin have grown particularly well at all 3 sites, equalling or exceeding the height growth of the tallest native populations.

**Table 5 - Provenance means at Kaingaroa**

Provenance	Latitude °N	No. Trees	Height dm	Straightness 1-9	Forks 0-3	Branching 1-3	Needle retention. 1-6
Los Padres	35° 49'	108	20.67 j	7.50 ab	0.57	3.23 bcdef	2.49 i
Swanton	37° 06'	69	28.06 abc	6.38 ef	0.39	3.12 cdef	2.91 cdefgh
Cascade Ranch	37° 08'	311	25.71 bcdefg	6.82 cdef	0.42	3.39 abcd	2.64 hi
SF water reserve	37° 27'	375	22.27 hij	7.13 bcd	0.38	3.48 abc	2.60 hi
SP Taylor FP	38° 02'	248	24.07 fghi	6.95 bcde	0.52	3.31 bcdef	2.62 hi
Pt Reyes	38° 04'	232	23.87 ghi	6.91 bcde	0.55	3.42 abcd	2.80 efghi
Russian river	38° 21'	198	25.57 defg	6.75 cdef	0.51	3.36 abcde	2.76 fghi
Fort Ross	38° 25'	225	29.60 a	6.22 f	0.53	2.96 f	2.92 cdefgh
Gualala	38° 47'	173	26.38 bcdef	6.70 def	0.42	3.33 bcdef	2.72 ghi
Navarro river	39° 11'	315	28.16 ab	6.84 cde	0.51	3.11 def	2.97 bcdefgh
Noyo river	39° 25'	470	25.55 defg	7.19 abcd	0.50	3.23 bcdef	3.12 abcdef
Rockport	39° 47'	93	25.16 defg	6.95 bcde	0.60	3.19 bcdef	2.84 defghi
Usal road	39° 49'	25	22.32 hij	7.76 a	0.38	3.72 a	3.28 abc
Arcata	39° 59'	376	26.81 bcde	7.36 abc	0.40	3.08 def	3.13 abcdef
Brookings	42° 06'	144	26.88 bcd	7.25 abcd	0.48	3.01 ef	3.03 abcdefg
Ophir	42° 36'	46	24.41 efgh	7.26 abcd	0.54	3.52 ab	2.76 fghi
Myrtle Point	43° 06'	108	25.10 defg	7.05 bcd	0.53	3.42 abcd	3.06 abcdefg
Coos Bay	43° 20'	167	24.05 fghi	7.18 abcd	0.49	3.11 def	3.15 abcde
Coquille	43° 13'	25	25.64 cdefg	6.96 bcde	0.64	3.12 cdef	3.36 a
Umpqua river	43° 36'	412	22.57 hij	7.22 abcd	0.46	3.37 abcde	3.08 abcdefg
Siuslaw forest	44° 10'	495	23.81 ghi	7.26 abcd	0.45	3.31 bcdef	3.30 ab
Willamette forest	43° 50'	242	21.63 ij	7.35 abc	0.46	3.32 bcdef	3.19 abcd
Weyco 602 Coos	43° 25'	27	26.5	7.30	0.44	3.37	3.30
Weyco 605 LV	46° 30'	17	24.2	7.82	0.47	3.06	2.76
Weyco 606 LV	46° 30'	16	21.1	7.13	0.56	3.38	3.13
Weyco 608 LV	46° 30'	24	20.2	6.79	0.54	3.46	3.21
Weyco 610 TH	48° 05'	21	21.4	7.38	0.38	3.00	3.19
Weyco 612 TH	48° 05'	7	20.6	7.86	0.86	3.86	3.14
900 Ft Bragg	39° 15'	177	29.8	6.94	0.41	3.02	3.25
901 Ft Bragg	39° 15'	25	29.2	7.08	0.44	3.08	3.63
902 Kaingaroa		26	24.8	7.54	0.31	3.00	3.35
903 Ft Bragg	39° 15'	23	28.4	6.91	0.57	3.17	2.91
904 Ashley (Eyre)		24	22.9	7.29	0.67	3.21	3.42
905 Ashley (MT)		27	24.0	7.22	0.30	3.26	3.19
906 Beaumont		26	24.6	7.54	0.38	3.00	3.35
907 Arcata	39° 59'	24	26.8	7.21	0.63	2.71	3.04

Provenances not sharing a letter are considered to be significantly different (Tukey's test)

**Table 6 – Provenance means at Gowan Hills**

Provenance	Latitude °N	No. trees	Height dm	Straightness 1-9	Forks 0-3	Branching 1-3	Leader straightness
Los Padres	35° 49'	63	17.22 f	6.84 ab	0.62 b	2.48 ab	6.67 a
Swanton	37° 06'	74	22.61 abc	6.50 abcd	0.49 ab	2.74 a	4.49 h
Cascade Ranch	37° 08'	290	22.10 abcde	6.66 abcd	0.42 ab	2.42 abc	5.54 bcdefg
SF water reserve	37° 27'	397	20.28 de	6.84 ab	0.43 ab	2.14 bcdef	6.51 ab
SP Taylor FP	38° 02'	239	21.27 bcde	6.73 abcd	0.46 ab	2.43 abc	6.08 abcd
Pt Reyes	38° 04'	205	21.80 abcde	6.69 abcd	0.45 ab	2.37 abcd	5.80 abcdef
Russian river	38° 21'	228	22.24 abcd	6.56 abcd	0.51 ab	2.35 abcd	5.71 abcdef
Fort Ross	38° 25'	229	22.50 abc	6.31 cd	0.43 ab	2.44 abc	4.53 gh
Gualala	38° 47'	199	22.03 abcde	6.29 d	0.39 ab	2.33 bcdef	4.96 fgh
Navarro river	39° 11'	332	23.58 a	6.55 abcd	0.39 ab	2.30 abcde	5.01 fgh
Noyo river	39° 25'	510	21.03 cde	6.64 abcd	0.39 ab	2.18 bcdef	5.36 defgh
Rockport	39° 47'	112	21.36 bcde	6.41 bcd	0.52 ab	2.47 ab	5.14 efgh
Usal road	39° 49'	24	21.92 abcde	6.88 a	0.25 a	1.95 def	6.45 abc
Arcata	39° 59'	398	22.01 abcde	6.76 abc	0.27 a	2.02 cdef	5.45 cdefgh
Brookings	42° 06'	178	22.03 abcde	6.57 abcd	0.43 ab	2.22 bcdef	5.83 abcdef
Ophir	42° 36'	77	23.32 ab	6.69 abcd	0.32 a	2.24 bcdef	5.03 fgh
Myrtle Point	43° 06'	119	21.98 abcde	6.44 abcd	0.39 ab	2.02 cdef	5.18 efgh
Coos Bay	43° 20'	242	21.59 abcde	6.70 abcd	0.31 a	1.83 f	5.44 cdefgh
Coquille	43° 13'	20	21.30 bcde	6.50 abcd	0.30 a	2.07 bcdef	5.56 bcdefg
Umpqua river	43° 36'	471	20.18 de	6.66 abcd	0.31 a	2.05 bcdef	5.86 abcdef
Siuslaw forest	44° 10'	503	21.90 abcde	6.56 abcd	0.31 a	1.86 ef	5.63 bcdef
Willamette forest	43° 50'	236	20.11 e	6.58 abcd	0.25 a	1.89 ef	6.23 abcd
721 Ashley x Cal		25	25.5	6.64	0.56	2.42	5.71
722 Cal x Cal		28	26.5	6.32	0.43	2.63	2.96
723 Oregon x Cal		26	25.8	6.88	0.42	2.36	5.52
724 Wash x Cal		10	21.5	6.60	0.40	2.00	5.33
900 Ft Bragg	39° 15'	196	24.3	6.48	0.48	2.13	4.77
901 Ft Bragg	39° 15'	26	22.5	6.77	0.35	2.36	5.73
902 Kaingaroa		28	21.8	6.71	0.43	1.73	5.88
903 Ft Bragg	39° 15'	27	21.9	6.48	0.56	2.26	4.58
904 Ashley (Eyre)		28	23.7	6.57	0.32	1.96	5.71
905 Ashley (MT)		26	21.6	6.50	0.46	2.17	5.35
906 Beaumont		26	21.0	6.38	0.50	2.36	5.67
907 Arcata	39° 59'	27	22.2	6.74	0.41	1.90	5.42

**Table 7 – Provenance means at Golden Downs**

Provenance	Latitude °N	No. trees	Height dm	Forks 0-3
Los Padres	35° 49'	122	14.15 h	1.07 f
Swanton	37° 06'	77	21.35 abcd	0.82 abcdef
Cascade Ranch	37° 08'	305	19.55 defg	0.80 abcdef
SF water reserve	37° 27'	436	17.39 g	0.91 cdef
SP Taylor FP	38° 02'	255	19.89 cdefg	0.94 def
Pt Reyes	38° 04'	240	18.38 efg	0.97 ef
Russian river	38° 21'	242	21.06 abcd	0.90 cdef
Fort Ross	38° 25'	265	22.70 ab	0.69 abcde
Gualala	38° 47'	211	22.41 abc	0.73 abcdef
Navarro river	39° 11'	336	23.23 a	0.69 abcde
Noyo river	39° 25'	501	21.49 abcd	0.67 abcde
Rockport	39° 47'	113	21.78 abcd	0.86 bcdef
Usal road	39° 49'	26	21.08 abcd	0.50 ab
Arcata	39° 59'	384	21.63 abcd	0.54 abc
Brookings	42° 06'	175	21.09 abcd	0.65 abcde
Ophir	42° 36'	51	19.35 defg	0.78 abcdef
Myrtle Point	43° 06'	128	20.13 bcdef	0.76 abcdef
Coos Bay	43° 20'	185	20.32 bcde	0.58 abcd
Coquille	43° 13'	25	21.04 abcd	0.48 a
Umpqua river	43° 36'	440	17.65 fg	0.73 abcdef
Siuslaw forest	44° 10'	471	19.36 defg	0.64 abcde
Willamette forest	43° 50'	254	17.39 g	0.73 abcdef
Weyco 601 Coos	43° 25'	28	22.9	0.54
Weyco 602 Coos	43° 25'	16	20.8	0.44
Weyco 603 Coos	43° 25'	20	21.8	1.05
Weyco 604 Coos	43° 25'	20	20.0	1.00
Weyco 605 LV	46° 30'	21	16.4	0.67
Weyco 606 LV	46° 30'	24	14.8	0.54
Weyco 607 LV	46° 30'	17	15.1	0.65
Weyco 608 LV	46° 30'	22	17.7	1.05
Weyco 609 TH	48° 05'	22	16.9	0.45
Weyco 610 TH	48° 05'	28	17.3	0.71
Weyco 611 TH	48° 05'	23	14.3	1.09
Weyco 612 TH	48° 05'	21	16.6	0.81
900 Ft Bragg	39° 15'	170	23.8	0.68
901 Ft Bragg	39° 15'	24	23.6	0.67
902 Kaingaroa		23	17.4	0.52
903 Ft Bragg	39° 15'	28	22.3	0.57
904 Ashley (Eyre)		26	18.5	1.08
905 Ashley (MT)		24	19.0	0.75
906 Beaumont		28	20.7	0.46
907 Arcata	39° 59'	23	19.4	0.48

Bole straightness tended to be a little better in the provenances from Rockport (39°47'N) northwards, and the fastest-grown provenances from Fort Ross, Gualala and Navarro River were slightly more crooked at Kaingaroa and Gowan hills. Leader straightness at Gowan Hills showed the same thing, more clearly, with lowest scores from Swanton, Fort Ross and Gualala and higher scores in provenances from further north. There were, however, plenty of exceptions to these trends.

Branch-type scores showed little in the way of provenance trends at Kaingaroa, but at Gowan Hills trees were more uni-nodal, with less scattered branches from the northernmost provenances in Oregon. There was a strong site influence on branching type, as many trees at Kaingaroa showed a very clear bi-nodal pattern that was much less marked at Gowan Hills.

At Kaingaroa, needle retention of the northernmost provenances tended to be better, yet all the New Zealand control lots, including those of Fort Bragg origin, showed individually higher scores, implying that outcrossing combined with some local selection had resulted in better needle retention than in the native populations.

The leader straightness score followed similar patterns to stem straightness, even though many of worst examples had been caused by wind damage. Heritability was also comparable with stem straightness. The amount of damage sustained at Gowan Hills would serve as an ideal screening to identify families that maintain good form in exposed locations. A separate “breed” for exposed sites could in future be selected as recommended by Talbert (1990).

The Los Padres provenance at Gowan Hills and Golden Downs showed the highest forking percent and the Oregon provenances and seed orchard progenies from Arcata showed least. Forking showed less genetic variation than that found by Stonecypher *et al.* (1996). The most likely reason is that these trees are too young for this trait to be expressed properly.

The Los Padres population appears to be behaving as an outlier for most traits. It comes from isolated southernmost stands of Douglas-fir on the Californian coast. It is located well to the south of any other populations, at latitude 35°49'N; Swanton is the next most southerly, at 37°06'N. Los Padres had the smallest height, the most forking, and the worst needle retention.

### Analysis of variance and variance components

Variation between populations or provenances, which were all from coastal locations, represents a substantial proportion of the total (genetic) variation among all open-pollinated families for all traits (Tables 8, 9, 10, 11, 12).

**Table 8 – Variance components: Kaingaroa**

Source	Df	Height	Straightness	Forks	Branching	Needle ret.
Rep	29	1.481***	0.0914***	0.00353***	0.0146***	0.0312***
Prov	21	4.714***	0.0698***	0.00082*	0.0182***	0.0527***
Family (Prov)	183	2.398***	0.1428***	0.00700***	0.0159***	0.0374***
Error	4623	25.035	1.6010	0.39043	0.5658	0.5854
Total	4856					
Narrow sense H <sup>2</sup>		0.35	0.33	0.07	0.11	0.24
Family mean H <sup>2</sup> F		0.69	0.68	0.30	0.40	0.60
Standard error		0.10	0.09	0.03	0.04	0.07

**Table 9 – Variance components: Gowan Hills**

Source	Df	Height	Straightness	Forks	Branching	Leader str.
Rep	29	2.519***	0.0152***	0.00310***	0.0209***	0.2999***
Prov	21	1.157***	0.0120***	0.00537***	0.0458***	0.2320***
Family (Prov)	200	0.960***	0.0441***	-0.00056	0.0168***	0.3028***
Error	4894	17.999	0.8746	0.31245	0.6509	4.0548
Total	5144					
Narrow sense H <sup>2</sup>		0.20	0.19	-	0.10	0.28
Family mean H <sup>2</sup> F		0.55	0.54	-	0.33	0.63
Standard error		0.06	0.06		0.04	0.08

**Table 10 – Variance components: Golden Downs**

Source	df	height	forks
Rep	29	1.913***	0.0360***
Prov	21	4.170***	0.0145***
Family (Prov)	190	1.546***	0.0096***
Error	5001	30.401	0.5891
Total	5241		
Narrow sense H <sup>2</sup>		0.19	0.06
Family mean H <sup>2</sup> F		0.56	0.29
Standard error		0.06	0.02

**Table 11 – Variance components: over all sites analysis**

Source	Df	Height	Forks
Site	2	5.963***	0.0368***
Rep(Site)	87	1.980***	0.0146***
Prov	21	2.707***	0.0038***
Site*Prov	42	0.623***	0.0033***
Family(Prov)	200	1.130***	0.0039***
Site*Family(Prov)	373	0.481***	0.0013
Error	14519	24.511	0.4326
Total	15244		
Narrow sense H <sup>2</sup>		0.17	0.04
Family mean H <sup>2</sup> F		0.69	0.38
Standard error		0.03	0.02

**Table 12 – Variance components over Kaingaroa and Gowan Hills**

Source	Df	Height	Straightness	Forks	Branching
Site	1	5.4352***	0.0930***	0.0041***	0.6018***
Rep(Site)	58	2.0158***	0.0523***	0.0033***	0.0176***
Prov	21	1.9577***	0.0209*	0.0019**	-0.0037
Prov*Site	21	0.9309***	0.0195*	0.0013***	0.0348***
Family(Prov)	200	0.9812***	0.0589	0.0013***	-0.0009
Site*Family(Prov)	183	0.6710***	0.0327	0.0018***	0.0174***
Error	9518	21.4165	1.2274	0.3503	0.6055
Total	10002				
Narrow sense H <sup>2</sup>		0.17	0.18	0.01	-
Family mean H <sup>2</sup> F		0.55	0.58	0.13	-
Standard error		0.03	0.03	0.02	-

Differences among provenances were highly significant at each of the three sites for all traits. For height growth at all three sites, provenance variance was larger than family in provenance variance. At Gowan Hills the provenance variance was 55% of total families variance, at Kaingaroa, 66% and at Golden Downs, 73% of total families variance. For bole straightness, measured only at

Kaingaroo and Gowan Hills, the provenance variance was relatively small, only 21-33% of the size of total families variance. For forking, the genetic signal was generally weaker, and provenance effects were minor at Kaingaroo but constituted 60% of total families variance at Golden Downs. There was substantial provenance variance for branch-type at Kaingaroo and Gowan Hills and for needle retention at Kaingaroo. In these open-pollinated family seedlots from almost entirely coastal provenances, early height growth was strongly controlled by provenance and provenance selection would provide a substantial part of gain from early selection.

Site x provenance interaction variance for height in the “across-sites” analysis only represented 23% of the provenance component, though it was highly significant. There were some provenance rank changes across the 3 sites, but the range of provenance mean heights was smaller at Gowan Hills and Golden Downs than it was at Kaingaroo, and is probably the main cause of the significant provenance x site interaction. The best-grown provenances at Kaingaroo eg. Fort Ross, 29.6m dm, contrast with the worst, Los Padres, 20.7 dm, while at Gowan Hills, the tallest provenance of Navarro River was 23.6 dm versus 17.2 dm for Los Padres. The ratio of site x provenance interaction variance to provenance variance for forking was as high as for height, though there were no significant provenances differences at Kaingaroo.

### **Narrow sense and family mean heritabilities**

Family-within-provenance variance and the associated narrow-sense heritabilities, express the proportion of additive genetic variance to phenotypic variance within provenances. Family-within-provenance effects were highly significant for all traits at all sites, except for forking at Gowan Hills. Family-within-provenance variance for height was very much less than provenance variance at Kaingaroo and Golden Downs, but at Gowan Hills, this was nearly equal.

Narrow-sense heritabilities at Kaingaroo were moderate for height, bole straightness and needle retention (0.24-0.35) but low for forking and branch-type (0.07 and 0.11). At Gowan Hills heritabilities were somewhat lower, 0.20 for height and 0.19 for bole straightness, 0 for forks and 0.10 for branch-type. At Golden Downs, narrow-sense heritability was 0.19 for height and very low for forking

Family mean (within provenance) heritabilities followed the same trends by sites for the different traits. They were acceptably high at all three sites for height growth (0.69-0.55) and also for bole straightness and leader straightness at Gowan Hills and Kaingaroo (0.54-0.68). This promises well for ranking families at all sites, as well as for forwards selection in future. Therefore, indications at this age are that for forwards selection, Kaingaroo would be the site at which to get highest gain, as both family mean and individual-tree heritabilities are highest there. These family mean heritabilities are “within-provenance”. If calculated across provenances, they would be much higher and the phenotypic variance of family means, greater, resulting in more gain from family selection across provenances. Heritability of family means across all three sites, ignoring provenances, for height is 0.84 (versus 0.69 within provenance) and for forking is 0.49 (versus 0.38). Selecting families across provenances would be an acceptable strategy for selecting seed orchard parents, but not for selecting the breeding population parents, as it would reduce effective population size (status number) too much. However at this age, it is not intended to use these data for selection.



The range and standard deviations of family means are shown at each site in Table 13. The range is somewhat wider for family means than for provenance means. For instance, at Kaingaroa, provenance mean heights varied from 20.7 dm for Los Padres to 29.6 dm for Fort Ross, whereas family means varied from 18.3 dm to 32.6 dm. For bole straightness, where provenance effects were not so large, at Kaingaroa, provenance means varied from 6.22 to 7.76 and family means from 5.29 to 8.13. Family means for each trait at each site are tabulated in Appendices 1, 2 and 3. The consistently slower performance of “repeated” seedlots points to a need for large plants from the nursery. Many of the repeated seedlots were from good families that had a large surplus of plants, yet the growth rate of this material was invariably inferior.

**Table 13** – Basic statistics for family means

Trait	Description	N	Mean	Standard Deviation	Minimum	Maximum
krsurv	Kaingaroa survival %	205	81.43	8.39	60.00	100.00
kr_ht	Kaingaroa height (decimetres)	205	24.82	2.84	18.32	32.57
kr_fr	Kaingaroa forks	205	0.47	0.16	0.13	1.05
kr_str	Kaingaroa straightness	205	7.06	0.53	5.29	8.13
kr_brt	Kaingaroa branch type	205	3.27	0.24	2.43	3.83
kr_nra	Kaingaroa needle retention	205	2.94	0.34	1.95	3.68
gdsurv	Golden Downs survival %	213	83.39	8.09	50.00	100.00
gd_ht	Golden Downs height	213	19.89	2.66	12.00	27.14
gd_fr	Golden Downs forks	213	0.75	0.22	0.17	1.32
gwsurv	Gowan Hills survival %	222	78.53	13.00	20.00	100.00
gw_ht	Gowan Hills height	222	21.38	1.80	13.00	25.36
gw_fr	Gowan Hills forks	222	0.39	0.14	0.04	1.00
gw_str	Gowan Hills straightness	222	6.62	0.31	5.27	7.26
gw_brt	Gowan Hills branch type	221	2.17	0.31	1.33	3.00
gw_tst	Gowan Hills leader straightness	221	5.62	0.86	3.50	7.65
latitude	latitude of origin in degrees	222	40.29	2.60	35.82	44.17
seedwt	weight of 100 seeds	222	1.13	0.18	0.70	1.72
nurs_ht	nursery height	222	43.48	5.75	25.50	61.95
flush	nursery flushing score	222	5.54	0.92	3.67	7.00

### Correlations between traits and between sites

Correlations between all traits at all sites were calculated for provenance means (Appendix 4) and family means (Appendix 5). Many of the correlations are not significant so subsets of these correlations for both provenance and family means are presented in smaller tables. Table 14 shows correlations between the same trait at pairs of sites, Table 15 shows correlations of selected pairs of traits within sites and Table 16 shows correlations with nursery traits and latitude of seed origin.

Correlation between provenance means for the same trait at pairs of sites provides an indication of the consistency of provenance performance between those sites and thus the strength of provenance x site interaction. Practically all of the correlations examined are stronger at the provenance level than the family mean level, where there is extra variation from family differences within provenances.

Height growth shows high provenance mean correlations of Kaingaroa with Gowan Hills, (0.73), of Kaingaroa with Golden Downs (0.85), and between Gowan Hills and Golden Downs, (0.81). This reflects the fairly low level of provenance x site or family-within-provenance x site interaction and stable performance of the different provenances. Nursery height was moderately

correlated with 4-year height at Kaingaroa (0.60), Golden Downs (0.65) and Gowan Hills (0.46). The correlation between height growth and needle retention at Kaingaroa was extremely low, which was expected as no needlecast was observed at all until only six months before the assessment.

There is a moderate negative correlation of height with bole straightness and with branch-type at Kaingaroa, -0.51 and -0.54, but not at Gowan Hills. There, there was a correlation of -0.59 between leader straightness and height. This means that taller families at Gowan Hills tend to be more crooked and have more intermediate branches between annual nodes. There was a moderate positive correlation of bole straightness at Kaingaroa with bole straightness and leader straightness at Gowan Hills (0.54 and 0.46).

Forking was poorly inter-correlated at the different sites, but had a significant negative correlation with latitude of origin at both Golden Downs and Gowan Hills, yet no correlation at Kaingaroa. This implies that the families from lower latitudes in USA forked more on the South Island sites than at the milder North Island site. It is likely that greater windspeeds or harder frosts are a factor along with the extended growing season of families from lower latitudes.

There were moderate to weak but significant correlations for various traits with latitude of origin, but not for height. Kaingaroa needle retention (0.59) and Gowan Hills forking and branch-type (-0.40 and -0.55) showed moderate correlation with latitude of origin. No traits showed significant correlation with seed weight. Flushing time in the nursery showed a high correlation with latitude (0.70) but very low correlation with height at each site. There is a high negative correlation at Kaingaroa between needle retention and flushing time (-0.84). Part of this will be a real effect as the southernmost Los Padres families were hardest hit but some of the correlation would be caused by the assessment being too early for the late flushing families.

**Table 14** – Provenance and progeny mean correlations between the same trait at pairs of sites

Site 1	Site 2	Trait	Provenance correlation	Progeny correlation
Kaingaroa	Golden Downs	Survival	0.51*	0.16*
		Height	0.85***	0.76***
		Forking	0.19	0.25***
Kaingaroa	Gowan Hills	Survival	0.60**	0.38***
		Height	0.73***	0.61***
		Forking	0.34	0.16*
		Straightness	0.70***	0.50***
		Branch type	-0.19	-0.08
Golden Downs	Gowan Hills	Survival	0.77***	0.35***
		Height	0.81***	0.63***
		Forking	0.81***	0.36***

**Table 15** – Provenance and progeny mean correlations between selected pairs of traits within a site

Site	Trait 1	Trait 2	Provenance correlation	Progeny correlation
Kaingaroa	Height	Straightness	-0.75***	-0.51***
	Height	Branching	-0.63**	-0.54***
	Height	Needle retention	0.09	0.14*
Golden Downs	Survival	Height	0.14	0.34***
	Height	Forking	-0.17	-0.30***
Gowan Hills	Survival	Height	0.76***	0.41***
	Height	Straightness	-0.39	-0.26***
	Height	Leader straightness	-0.70***	-0.59***
	Forking	Branching	0.77***	0.40***
	Straightness	Leader straightness	0.73***	0.48***

**Table 16** – Selected provenance and progeny mean correlations with nursery traits

Trait 1	Trait 2	Provenance correlation	Progeny correlation
Nursery height	Height at Kaingaroa	0.79***	0.60***
	Height at Golden Downs	0.76***	0.68***
	Height at Gowan Hills	0.60**	0.54***
Nursery flushing	Needle retention at Kaingaroa	-0.84***	-0.63***
	Forking at Kaingaroa	-0.03	0.05
	Forking at Golden Downs	0.84***	0.51***
	Forking at Gowan Hills	0.75***	0.47***
	Latitude	-0.82***	-0.72***
Latitude	Needle retention at Kaingaroa	0.59***	0.75***
	Forking at Kaingaroa	-0.02	0.12
	Forking at Golden Downs	-0.38***	-0.62***
	Forking at Gowan Hills	-0.48***	-0.70***
	Branch type at Gowan Hills	-0.60***	-0.77***

## CONCLUSIONS

Although there were some trends with latitude of origin for all traits, the best grown provenances (and control seedlots) needed to be identified empirically on performance, but were located in California from Fort Ross (38° 21'N) to Arcata (39° 59'). In general, the faster-grown provenances had poorer bole straightness and leader straightness scores but differences between best and worst provenances in this respect were only about one score point out of 9. The Weyerhaeuser orchard progenies from Washington provenances grew particularly slowly. The Los Padres provenance appears to be an outlier in location, at the southern extremity of the range of coast Douglas fir, and it performed poorly for growth, forking and needle retention.

The NZ seed-stand seedlots of Fort Bragg origin grew as well as the best two native populations and much better than the other NZ seed stand lots, especially at Kaingaroa and at Golden Downs. These results provide some preliminary confirmation that, as found in the 1959 provenance trials, these Californian populations are still performing as well or better than any other, even in Southland, well south of their native latitudes.

The control-pollinated seedlots of California x California, California x Oregon and California x Ashley seed stand origin, whose parents were selected in the 1959 provenance trials, were 10% taller than the best native populations at Gowan Hills, the only site where they were planted. The good prospects of inter-provenance hybrids between Californian and southern Oregon provenances are tantalisingly suggested by the results of the crosses at Gowan Hills.

Provenance rankings for height are quite stable across the three sites but there is diminished provenance variation at Gowan Hills. This contributes to significant provenance x site interaction variance, which amounts to 23% of the provenance variance in the across-sites analysis. Family x site variance for height amounted to 42% of the families within-provenances variance, indicating that this would be sufficient to cause some reduction in gain from family selection across sites but which can be accommodated by selecting families that perform well at all sites. Considering the wide range in latitude (38-45°), and in climatic and site conditions at the three test sites this was not unexpected.

These broadly-based and well-established trials of over 200 families from 22 coastal Californian and Oregon provenances form an extremely valuable genetic resource for future breeding. They also form one of the two “superlines” of the Douglas fir breeding population, the other being based on clones selected in 1988 from the 1957 and 1959 provenance trials and from land race populations already established in NZ. This breeding population is therefore very well endowed with more-than-sufficient, well-adapted genetic material to effect large gains in growth rate and other economically important characters in future.

## ACKNOWLEDGMENTS

We are very grateful for the tremendous help in the collection and processing of seed, provided by the California Department of Forestry, Bureau of Land Management, USDA Forest Service and by the Louisiana Pacific Company. The authors would also like to acknowledge the financial support of the New Zealand Douglas-fir Co-operative for seed collection and planting of the trials and the Foundation of Research and Science Technology who funded the assessment. We are particularly grateful to Ernslaw One Ltd., Fletcher Challenge Forests and Weyerhaeuser New Zealand for help in the establishment, tending and measurement of the trials.

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## APPENDIX 1 – FAMILY MEANS AT KAINGAROA

Code	Family	Provenance	No.	Height	Straight -ness	Forks	Branch type	Needle retent.
52	52	Fort Ross	21	32.6	6.48	0.20	2.43	2.76
55	55	Fort Ross	20	31.7	7.00	0.75	2.95	2.70
727	55	Fort Ross	14	27.4	7.00	0.43	2.64	2.50
130	130	Navarro River	21	31.5	6.71	0.43	2.95	3.14
56	56	Fort Ross	21	31.4	5.29	0.76	2.62	3.14
60	60	Fort Ross	26	31.2	5.31	0.46	3.08	3.23
308	308	Brookings	13	30.6	5.85	0.62	2.85	2.92
121	121	Navarro River	26	30.4	6.88	0.38	3.08	3.04
53	53	Fort Ross	22	30.4	6.00	0.32	2.95	2.82
162	162	Cascade Ranch	25	30.3	5.80	0.52	3.08	2.60
609	162	Cascade Ranch	27	24.1	7.00	0.56	3.44	2.96
125	125	Navarro River	26	30.2	6.85	0.36	3.00	3.27
760	125	Navarro River	25	27.5	7.20	0.40	3.04	3.36
133	133	Navarro River	24	29.8	6.33	0.63	3.08	3.04
900		NZ Fort Bragg	177	29.8	6.94	0.41	3.02	3.25
143	143	Swanton	24	29.8	6.75	0.25	2.67	2.83
127	127	Navarro River	28	29.7	6.18	0.68	2.93	2.52
200	200	Arcata	24	29.4	7.75	0.29	2.83	3.13
201	201	Arcata	26	29.2	7.35	0.38	3.27	3.23
901		NZ Fort Bragg	25	29.2	7.08	0.44	3.08	3.63
128	128	Navarro River	24	29.1	7.33	0.46	3.04	3.08
193	193	Arcata	26	29.0	6.96	0.42	2.85	3.12
728	193	Arcata	24	23.3	7.08	0.46	2.96	2.79
141	141	Swanton	24	28.8	5.88	0.63	3.29	2.96
44	44	Gualala	27	28.8	7.07	0.30	3.07	2.93
152	152	Cascade Ranch	27	28.8	6.52	0.22	3.07	3.11
132	132	Navarro River	23	28.7	6.26	0.43	3.09	2.74
123	123	Navarro River	21	28.7	6.57	0.71	2.95	3.05
194	194	Arcata	24	28.7	6.83	0.29	3.00	3.17
51	51	Fort Ross	26	28.7	6.15	0.38	3.12	3.08
601	51	Fort Ross	22	26.0	6.59	0.55	3.05	2.82
903		NZ Fort Bragg	23	28.4	6.91	0.57	3.17	2.91
57	57	Fort Ross	24	28.3	6.58	0.71	2.88	2.83
69	69	Noyo River	26	28.2	6.58	0.31	3.23	3.08
35	35	Russian River	26	28.1	6.96	0.73	3.35	2.85
63	63	Noyo River	25	28.0	6.88	0.64	3.24	3.20
54	54	Fort Ross	21	27.9	6.24	0.62	3.38	2.67
58	58	Fort Ross	22	27.6	6.91	0.41	2.95	2.95
199	199	Arcata	28	27.6	7.43	0.50	3.18	2.82
192	192	Arcata	24	27.5	7.42	0.29	3.29	3.38
205	205	Arcata	24	27.4	7.29	0.63	3.04	3.50
197	197	Arcata	22	27.3	7.64	0.27	3.05	3.14
45	45	Gualala	23	27.3	7.00	0.39	3.17	2.65
70	70	Noyo River	24	27.3	6.96	0.46	2.83	3.29
42	42	Gualala	24	27.1	6.08	0.46	3.46	3.04

# APPENDIX 1 – FAMILY MEANS AT KAINGAROA (CONTINUED)

Code	Family	Provenance	No.	Height	Straight -ness	Forks	Branch Type	Needle retent.
305	305	Brookings	27	27.0	6.59	0.85	2.74	3.11
368	368	Siuslaw Forest	23	26.9	7.22	0.59	3.22	3.17
21	21	S. P. Taylor	24	26.9	7.13	0.71	3.29	3.17
129	129	Navarro River	23	26.8	6.87	0.39	3.17	2.78
59	59	Fort Ross	22	26.8	6.50	0.76	3.23	2.86
735	59	Fort Ross	22	24.4	6.82	0.77	3.27	3.00
61	61	Noyo River	26	26.8	7.50	0.46	3.12	2.85
307	307	Brookings	30	26.8	7.53	0.50	3.33	2.70
33	33	Russian River	25	26.8	7.08	0.56	3.16	3.00
326	326	Myrtle Pt.	16	26.8	6.19	0.75	3.25	2.94
907		USA L.P. S.O.	24	26.8	7.21	0.63	2.71	3.04
66	66	Noyo River	18	26.7	7.11	0.61	3.00	3.28
109	109	Rockport	25	26.7	6.92	1.04	3.08	2.92
304	304	Brookings	25	26.7	7.64	0.24	2.84	3.00
20	20	Pt. Reyes	27	26.7	6.70	0.81	3.30	2.78
742	20	Pt. Reyes	24	22.5	6.67	0.67	3.25	2.88
202	202	Arcata	24	26.6	7.38	0.17	2.63	2.92
154	154	Cascade Ranch	25	26.6	6.80	0.28	3.24	2.44
37	37	Russian River	22	26.6	7.05	0.50	3.50	2.73
602	602	Coos Bay clone	27	26.5	7.30	0.44	3.37	3.30
381	381	Siuslaw Forest	28	26.5	7.57	0.46	3.11	3.68
195	195	Arcata	27	26.4	6.37	0.52	3.22	2.74
62	62	Noyo River	25	26.4	6.88	0.48	3.16	2.84
168	168	Cascade Ranch	21	26.3	6.67	0.52	3.24	3.29
334	334	Myrtle Point	28	26.3	6.25	0.43	3.54	3.07
41	41	Gualala	24	26.3	6.46	0.58	3.25	2.67
165	165	Cascade Ranch	30	26.2	7.37	0.53	3.23	2.27
131	131	Navarro River	26	26.2	7.69	0.35	3.42	3.23
372	372	Siuslaw Forest	28	26.1	6.75	0.25	3.25	3.39
310	310	Brookings	23	26.1	7.83	0.26	2.87	3.09
330	330	Myrtle Point	28	26.1	7.32	0.54	3.36	3.14
161	161	Cascade Ranch	20	26.0	7.00	0.25	3.40	2.70
191	191	Arcata	26	25.9	7.15	0.42	2.85	2.96
182	182	SF Water Reserve	20	25.8	6.75	0.55	3.45	2.60
163	163	Cascade Ranch	24	25.8	6.29	0.42	3.46	2.63
733	163	Cascade Ranch	18	25.9	6.83	0.61	3.33	3.06
309	309	Brookings	26	25.8	7.42	0.42	3.31	3.35
108	108	Rockport	15	25.7	7.27	0.53	3.33	3.07
196	196	Arcata	28	25.7	7.57	0.29	3.14	3.04
167	167	Cascade Ranch	23	25.7	6.65	0.48	3.30	2.78
78	78	Noyo River	25	25.7	7.24	0.48	3.40	2.60
312	312	Coquille	25	25.6	6.96	0.64	3.12	3.36
25	25	S. P. Taylor	29	25.6	7.14	0.31	3.41	2.86
758	25	S. P. Taylor	18	24.5	6.61	0.44	3.44	2.78
72	72	Noyo River	23	25.6	7.13	0.39	3.26	3.09

# APPENDIX 1 – FAMILY MEANS AT KAINGAROA (CONTINUED)

Code	Family	Provenance	No.	Height	Straight -ness	Forks	Branch Type	Needle retent.
607	72	Noyo River	24	26.0	7.25	0.46	3.21	3.13
30	30	S. P. Taylor	23	25.5	6.74	0.27	3.22	2.39
39	39	Russian River	22	25.5	5.86	0.59	3.09	2.73
47	47	Gualala	26	25.5	6.64	0.23	3.42	3.00
75	75	Noyo River	26	25.5	6.88	0.62	3.23	3.46
324	324	Coos Bay	30	25.4	6.83	0.37	3.20	3.23
361	361	Siuslaw Forest	26	25.4	7.15	0.60	2.81	3.46
34	34	Russian River	23	25.4	5.65	0.26	3.39	2.61
323	323	Coos Bay	27	25.4	6.67	0.59	3.26	3.15
342	342	Umpqua River	27	25.4	7.37	0.37	3.48	3.07
124	124	Navarro River	26	25.3	6.46	0.73	3.38	2.85
80	80	Noyo River	21	25.3	7.29	0.43	3.33	3.19
164	164	Cascade Ranch	25	25.3	6.96	0.52	3.68	2.80
79	79	Noyo River	19	25.3	6.63	0.63	3.32	3.26
198	198	Arcata	20	25.3	7.70	0.50	3.20	3.20
142	142	Swanton	21	25.2	6.52	0.29	3.43	2.95
759	142	Swanton	22	21.8	6.91	0.68	3.59	2.77
71	71	Noyo River	26	25.2	7.38	0.46	3.38	3.08
151	151	Cascade Ranch	23	25.2	6.96	0.48	3.61	2.65
43	43	Gualala	25	25.2	6.68	0.56	3.12	2.56
68	68	Noyo River	20	25.2	7.45	0.45	3.20	3.15
74	74	Noyo River	20	25.2	6.70	1.05	3.20	3.25
732	74	Noyo River	23	23.7	7.35	0.52	3.09	3.22
369	369	Siuslaw Forest	27	25.0	7.07	0.46	3.33	3.30
386	386	Willamette Forest	27	25.0	7.07	0.48	3.52	3.07
603	386	Willamette Forest	21	23.0	7.33	0.48	3.48	3.19
379	379	Siuslaw Forest	27	25.0	6.96	0.52	3.22	3.33
27	27	S. P. Taylor	24	25.0	7.17	0.54	3.38	2.33
325	325	Myrtle Point	13	24.9	7.46	0.38	3.23	2.92
64	64	Noyo River	24	24.9	7.21	0.50	3.17	3.39
126	126	Navarro River	24	24.9	7.54	0.75	3.21	3.08
73	73	Noyo River	25	24.9	7.64	0.32	3.32	3.12
370	370	Siuslaw Forest	23	24.9	7.48	0.65	3.13	3.30
729	370	Siuslaw Forest	23	24.2	7.42	0.38	3.04	2.88
365	365	Siuslaw Forest	29	24.9	6.83	0.59	3.48	3.31
31	31	Russian River	13	24.8	7.00	0.38	3.31	2.85
170	170	Cascade Ranch	25	24.8	6.76	0.33	3.52	2.60
354	354	Umpqua River	25	24.8	6.84	0.44	3.08	3.28
32	32	Russian River	22	24.8	6.91	0.36	3.50	2.95
22	22	S. P. Taylor	26	24.8	6.69	0.46	3.12	2.81
65	65	Noyo River	26	24.8	7.85	0.35	3.00	3.27
902		NZ Kaingaroa	26	24.8	7.54	0.31	3.00	3.35
122	122	Navarro river	23	24.7	7.30	0.35	3.09	2.83
335	335	Umpqua River	26	24.7	7.31	0.31	3.08	3.31
906		NZ Beamont	26	24.6	7.54	0.38	3.00	3.35



# APPENDIX 1 – FAMILY MEANS AT KAINGAROA (CONTINUED)

Code	Family	Provenance	No.	Height	Straight -ness	Forks	Branch Type	Needle retent.
24	24	S. P. Taylor	27	24.6	6.63	0.56	3.07	2.22
107	107	Rockport	26	24.5	6.65	0.46	3.27	2.69
14	14	Point Reyes	26	24.5	6.96	0.54	3.27	2.58
301	301	Ophir	22	24.5	7.27	0.36	3.36	2.91
19	19	Point Reyes	27	24.4	6.89	0.67	3.81	2.70
314	314	Coos Bay	23	24.4	7.35	0.43	3.13	3.04
353	353	Umpqua River	25	24.4	7.08	0.48	3.36	3.24
49	49	Gualala	24	24.3	6.92	0.42	3.83	2.13
303	303	Ophir	24	24.3	7.25	0.71	3.67	2.63
313	313	Coos Bay	19	24.3	7.11	0.37	3.00	2.95
18	18	Point Reyes	23	24.3	7.48	0.39	3.17	3.17
748	18	Point Reyes	22	23.6	7.41	0.45	3.36	2.91
605	605	Long View clone	17	24.2	7.82	0.47	3.06	2.76
378	378	Siuslaw Forest	30	24.1	6.30	0.13	3.30	3.40
110	110	Rockport	27	24.0	7.07	0.35	3.15	2.78
905		NZ Ashley	27	24.0	7.22	0.30	3.26	3.19
36	36	Russian River	23	24.0	7.74	0.48	3.43	2.39
17	17	Point Reyes	21	24.0	6.33	0.43	3.76	2.38
351	351	Umpqua River	27	23.9	7.41	0.56	3.52	3.11
366	366	Siuslaw Forest	24	23.9	7.58	0.58	3.38	3.33
185	185	SF Water Reserve	20	23.7	7.35	0.35	3.60	2.50
391	391	Willamette Forest	23	23.6	6.74	0.39	3.04	3.04
204	204	Arcata	26	23.6	8.00	0.50	3.35	3.46
362	362	Siuslaw Forest	26	23.6	6.92	0.46	3.65	3.35
367	367	Siuslaw Forest	25	23.6	7.64	0.48	3.24	2.96
188	188	SF Water Reserve	24	23.5	7.08	0.46	3.39	2.17
67	67	Noyo River	23	23.5	7.43	0.22	3.52	3.09
12	12	Point Reyes	26	23.4	6.00	0.58	3.46	2.69
412	412	Los Padres	22	23.4	7.18	0.50	3.36	2.41
187	187	SF Water Reserve	25	23.4	6.96	0.52	3.52	2.12
38	38	Russian River	22	23.4	6.50	0.64	3.50	2.77
77	77	Noyo River	24	23.3	7.42	0.75	3.33	3.00
13	13	Point Reyes	24	23.2	7.38	0.54	3.33	2.92
15	15	Point Reyes	22	23.2	7.14	0.45	3.32	3.41
16	16	Point Reyes	15	23.1	6.87	0.33	3.40	2.67
364	364	Siuslaw Forest	26	23.1	7.92	0.31	3.35	3.19
731	364	Siuslaw Forest	20	22.7	8.05	0.40	3.20	2.65
171	171	SF Water Reserve	20	23.1	7.25	0.30	3.75	2.85
751	171	SF Water Reserve	22	19.7	7.00	0.36	3.36	2.91
317	317	Coos Bay	23	23.0	6.87	0.39	3.00	3.17
382	382	Willamette Forest	27	23.0	7.56	0.41	3.48	3.67
752	382	Willamette Forest	24	21.5	7.75	0.33	3.25	3.25
337	337	Umpqua River	24	23.0	7.08	0.50	3.25	3.00
730	337	Umpqua River	18	19.9	6.94	0.94	3.44	2.89
350	350	Umpqua River	25	22.9	7.76	0.48	3.36	3.44

# APPENDIX 1 – FAMILY MEANS AT KAINGAROA (CONTINUED)

Code	Family	Provenance	No.	Height	Straight -ness	Forks	Branch Type	Needle retent.
904		NZ Ashley	24	22.9	7.29	0.67	3.21	3.42
81	81	Noyo River	24	22.9	7.46	0.50	3.29	3.04
203	203	Arcata	27	22.9	7.70	0.56	3.30	3.26
320	320	Coos Bay	20	22.9	8.10	0.70	2.90	3.50
23	23	S. P. Taylor	24	22.8	6.17	0.79	3.38	2.63
371	371	Siuslaw Forest	25	22.7	7.21	0.28	3.16	3.04
184	184	SF Water Reserve	28	22.7	6.89	0.39	3.43	2.79
604	184	SF Water Reserve	22	22.3	6.77	0.57	3.50	3.36
166	166	Cascade Ranch	24	22.7	7.46	0.54	3.63	2.50
726	166	Cascade Ranch	22	20.1	7.73	0.27	3.82	2.55
189	189	SF Water Reserve	20	22.7	6.70	0.20	3.70	3.50
738	189	SF Water Reserve	14	23.1	7.00	0.57	3.64	2.71
28	28	S. P. Taylor	24	22.6	7.13	0.67	3.29	2.75
176	176	SF Water Reserve	23	22.6	7.13	0.35	3.52	3.00
339	339	Umpqua River	25	22.6	7.16	0.44	3.32	2.88
343	343	Umpqua River	25	22.5	6.40	0.32	3.56	3.08
316	316	Coos Bay	25	22.4	7.60	0.60	3.16	3.00
91	91	Usal Road	25	22.3	7.76	0.38	3.72	3.28
173	173	SF Water Reserve	27	22.3	7.11	0.48	3.30	2.33
190	190	SF Water Reserve	21	22.3	6.86	0.24	3.24	3.05
383	383	Willamette Forest	26	22.1	7.19	0.31	3.12	3.23
384	384	Willamette Forest	28	22.1	7.61	0.43	3.46	3.07
357	357	Umpqua River	26	22.0	7.42	0.31	3.35	2.77
172	172	SF Water Reserve	23	21.8	6.52	0.39	3.61	2.35
375	375	Siuslaw Forest	28	21.8	7.46	0.43	3.39	3.36
753	375	Siuslaw Forest	20	21.0	7.70	0.50	2.65	3.60
380	380	Siuslaw Forest	25	21.7	7.00	0.36	3.60	3.32
178	178	SF Water Reserve	15	21.7	7.60	0.60	3.67	2.47
374	374	Siuslaw Forest	23	21.7	7.67	0.42	3.58	3.42
734	374	Siuslaw Forest	24	19.7	7.83	0.50	3.63	3.08
340	340	Umpqua River	25	21.6	7.40	0.44	3.52	3.16
1	1	Los Padres	22	21.5	7.18	0.64	3.09	2.95
610	610	Twin Harbour	21	21.4	7.38	0.38	3.00	3.19
29	29	S. P. Taylor	23	21.3	7.74	0.32	3.65	2.43
329	329	Myrtle Point	23	21.3	8.04	0.57	3.57	3.13
181	181	SF Water Reserve	22	21.3	7.05	0.32	3.05	2.05
338	338	Umpqua River	13	21.3	7.62	0.31	3.42	2.77
345	345	Umpqua River	26	21.2	7.54	0.58	3.42	3.08
175	175	SF Water Reserve	21	21.1	7.48	0.29	3.62	2.43
26	26	S. P. Taylor	24	21.1	7.04	0.63	3.29	2.54
606	606	Long View clone	16	21.1	7.13	0.56	3.38	3.13
336	336	Umpqua River	29	21.1	6.90	0.39	3.34	2.93
355	355	Umpqua River	20	21.0	6.43	0.57	3.33	3.10
373	373	Siuslaw Forest	23	20.9	8.09	0.43	3.30	3.26
11	11	Point Reyes	21	20.8	7.50	0.59	3.36	2.68

# APPENDIX 1 – FAMILY MEANS AT KAINGAROA (CONTINUED)

Code	Family	Provenance	No.	Height	Straight -ness	Forks	Branch Type	Needle retent.
390	390	Willamette Forest	26	20.8	6.81	0.54	3.15	2.85
611	390	Willamette Forest	23	18.8	7.43	0.70	3.43	3.00
612	612	Twin Harbour	7	20.6	7.86	0.86	3.86	3.14
183	183	SF Water Reserve	22	20.5	7.41	0.45	3.59	3.23
363	363	Siuslaw Forest	29	20.4	7.41	0.55	3.38	3.10
348	348	Umpqua River	23	20.3	7.09	0.78	3.57	3.17
180	180	SF Water Reserve	23	20.2	7.57	0.22	3.43	2.48
608	608	Long View clone	24	20.2	6.79	0.54	3.46	3.21
186	186	SF Water Reserve	21	19.8	7.76	0.33	3.52	2.48
2	2	Los Padres	10	19.8	7.50	0.60	3.50	2.00
389	389	Willamette Forest	21	19.8	7.62	0.33	3.52	3.10
761	389	Willamette Forest	24	17.8	7.46	0.42	3.58	2.96
3	3	Los Padres	18	19.7	7.56	0.78	2.72	2.56
387	387	Willamette Forest	22	19.5	7.68	0.64	3.45	3.36
388	388	Willamette Forest	19	19.5	7.68	0.58	3.42	3.16
5	5	Los Padres	21	19.5	7.67	0.33	3.52	2.00
749	5	Los Padres	19	20.8	7.63	0.42	3.26	2.68
346	346	Umpqua River	21	19.5	8.05	0.52	3.33	2.71
385	385	Willamette Forest	23	19.3	7.70	0.52	3.00	3.30
4	4	Los Padres	15	18.7	8.13	0.67	3.27	2.87
169	169	Cascade Ranch	19	18.3	7.58	0.37	3.74	1.95

## APPENDIX 2 – FAMILY MEANS AT GOLDEN DOWNS

Code	Family	Provenance	No.	Height	Forks
133	133	Navarro River	22	27.1	0.86
56	56	Fort Ross	25	26.4	0.68
123	123	Navarro River	26	25.3	0.77
49	49	Gualala	29	25.0	0.62
53	53	Fort Ross	27	25.0	0.59
121	121	Navarro River	30	24.8	0.87
205	205	Arcata	28	24.8	0.36
194	194	Arcata	26	24.5	0.62
44	44	Gualala	28	24.4	0.75
72	72	Noyo River	24	24.2	0.71
128	128	Navarro River	27	24.0	0.63
130	130	Navarro River	27	24.0	0.48
193	193	Arcata	26	23.9	0.35
728	193	Arcata	24	20.5	0.63
900		NZ Fort Bragg	170	23.8	0.68
127	127	Navarro River	25	23.8	0.76
60	60	Fort Ross	27	23.7	0.74
901		NZ Fort Bragg	24	23.6	0.67
48	48	Gualala	26	23.4	0.77
125	125	Navarro River	22	23.4	0.45
57	57	Fort Ross	25	23.3	0.48
381	381	Siuslaw Forest	23	23.3	0.52
37	37	Russian River	25	23.2	0.72
162	162	Cascade Ranch	23	23.1	1.13
80	80	Noyo River	25	23.1	0.56
66	66	Noyo River	28	23.0	0.96
35	35	Russian River	25	23.0	1.20
42	42	Gualala	29	23.0	0.90
199	199	Arcata	28	23.0	0.43
109	109	Rockport	26	22.9	1.04
601	601	Coos Bay clone	28	22.9	0.54
63	63	Noyo River	28	22.9	0.75
65	65	Noyo River	26	22.8	0.69
132	132	Navarro River	26	22.6	0.69
334	334	Myrtle Point	26	22.6	0.58
372	372	Siuslaw Forest	22	22.5	0.18
324	324	Coos Bay	25	22.5	0.56
58	58	Fort Ross	29	22.5	0.66
31	31	Russian River	32	22.5	0.91
21	21	S. P. Taylor	28	22.5	1.04
110	110	Rockport	25	22.4	0.52
108	108	Rockport	25	22.4	0.92
51	51	Fort Ross	29	22.3	0.38
903		NZ Fort Bragg	28	22.3	0.57
122	122	Navarro River	27	22.3	0.56

## APPENDIX 2 – FAMILY MEANS AT GOLDEN DOWNS (CONTINUED)

Code	Family	Provenance	No.	Height	Forks
201	201	Arcata	26	22.3	0.69
141	141	Swanton	28	22.2	0.75
308	308	Brookings	24	22.1	0.42
77	77	Noyo River	23	22.1	0.65
151	151	Cascade Ranch	29	22.0	0.79
725	151	Cascade Ranch	26	19.3	0.77
304	304	Brookings	29	22.0	0.62
323	323	Coos Bay	27	22.0	0.70
195	195	Arcata	21	21.9	0.62
306	306	Brookings	19	21.9	0.74
126	126	Navarro River	28	21.9	0.89
36	36	Russian River	27	21.9	1.07
70	70	Noyo River	21	21.8	0.67
603	603	Coos Bay clone	20	21.8	1.05
202	202	Arcata	25	21.8	0.52
124	124	Navarro River	25	21.6	0.80
129	129	Navarro River	25	21.6	0.56
305	305	Brookings	25	21.6	1.16
43	43	Gualala	20	21.6	0.65
75	75	Noyo River	28	21.5	0.68
81	81	Noyo River	22	21.5	0.55
73	73	Noyo River	25	21.5	0.64
325	325	Myrtle Point	27	21.4	0.74
79	79	Noyo River	27	21.4	0.63
61	61	Noyo River	26	21.3	0.54
204	204	Arcata	28	21.3	0.50
74	74	Noyo River	25	21.2	0.68
55	55	Fort Ross	26	21.2	0.92
727	55	Fort Ross	25	22.3	0.80
71	71	Noyo River	26	21.2	0.42
22	22	S. P. Taylor	26	21.2	0.50
47	47	Gualala	26	21.2	0.88
52	52	Fort Ross	26	21.2	0.58
143	143	Swanton	23	21.1	0.83
23	23	S. P. Taylor	26	21.1	0.85
91	91	Usal Road	26	21.1	0.50
326	326	Myrtle Point	26	21.1	1.04
312	312	Coquille	25	21.0	0.48
59	59	Fort Ross	27	21.0	0.74
735	59	Fort Ross	20	17.3	1.30
200	200	Arcata	23	21.0	0.74
78	78	Noyo River	24	20.9	0.50
365	365	Siuslaw Forest	29	20.9	0.69
62	62	Noyo River	25	20.8	0.84
310	310	Brookings	23	20.8	0.17

## APPENDIX 2 – FAMILY MEANS AT GOLDEN DOWNS (CONTINUED)

Code	Family	Provenance	No.	Height	Forks
602	602	Coos Bay clone	16	20.8	0.44
64	64	Noyo River	19	20.7	0.53
906		NZ Beamont	28	20.7	0.46
142	142	Swanton	26	20.6	0.88
196	196	Arcata	28	20.6	0.50
301	301	Ophir	27	20.6	0.70
313	313	Coos Bay	27	20.6	0.22
105	105	Rockport	14	20.6	1.21
314	314	Coos Bay	24	20.5	0.63
192	192	Arcata	28	20.5	0.82
152	152	Cascade Ranch	21	20.5	0.24
380	380	Siuslaw Forest	23	20.5	0.52
378	378	Siuslaw Forest	25	20.5	0.68
307	307	Brookings	28	20.5	0.61
20	20	Point Reyes	25	20.5	0.88
54	54	Fort Ross	24	20.4	1.21
320	320	Coos Bay	25	20.4	0.72
33	33	Russian River	25	20.4	0.96
163	163	Cascade Ranch	25	20.4	0.84
733	163	Cascade Ranch	24	15.9	0.67
45	45	Gualala	26	20.3	0.62
68	68	Noyo River	27	20.3	0.78
366	366	Siuslaw Forest	24	20.3	0.71
69	69	Noyo River	26	20.3	0.92
198	198	Arcata	24	20.3	0.46
371	371	Siuslaw Forest	27	20.2	0.59
32	32	Russian River	26	20.2	0.73
318	318	Coos Bay	11	20.2	0.45
382	382	Willamette Forest	26	20.2	0.50
19	19	Point Reyes	27	20.1	0.93
28	28	S. P. Taylor	28	20.1	0.93
190	190	SF Water Reserve	20	20.1	0.70
131	131	Navarro River	26	20.0	0.58
39	39	Russian River	29	20.0	0.76
184	184	SF Water Reserve	23	20.0	0.87
604	604	Coos Bay clone	23	20.0	1.00
30	30	S. P. Taylor	25	20.0	1.32
197	197	Arcata	24	19.9	0.25
170	170	Cascade Ranch	25	19.9	0.52
191	191	Arcata	24	19.9	0.67
107	107	Rockport	23	19.9	0.74
339	339	Umpqua River	21	19.9	0.86
391	391	Willamette Forest	28	19.8	0.89
41	41	Gualala	27	19.8	0.63
168	168	Cascade Ranch	22	19.8	0.91

## APPENDIX 2 – FAMILY MEANS AT GOLDEN DOWNS (CONTINUED)

Code	Family	Provenance	No.	Height	Forks
363	363	Siuslaw Forest	27	19.6	0.78
370	370	Siuslaw Forest	25	19.5	0.80
729	370	Siuslaw Forest	20	19.3	0.55
25	25	S. P. Taylor	28	19.4	0.93
335	335	Umpqua River	26	19.4	0.62
907		USA L.P. S.O.	23	19.4	0.48
12	12	Point Reyes	24	19.4	0.92
353	353	Umpqua River	27	19.4	0.59
330	330	Myrtle Point	23	19.3	0.78
368	368	Siuslaw Forest	21	19.3	0.62
154	154	Cascade Ranch	24	19.3	0.71
34	34	Russian River	27	19.2	1.04
38	38	Russian River	26	19.2	0.73
18	18	Point Reyes	25	19.2	0.84
748	18	Point Reyes	25	16.1	0.92
27	27	S. P. Taylor	25	19.1	0.88
352	352	Umpqua River	25	19.1	0.84
176	176	SF Water Reserve	24	19.0	0.75
905		NZ Ashley	24	19.0	0.75
309	309	Brookings	27	19.0	0.78
17	17	Point Reyes	22	19.0	0.82
379	379	Siuslaw Forest	24	19.0	0.71
351	351	Umpqua River	28	18.9	0.86
24	24	S. P. Taylor	25	18.8	0.96
342	342	Umpqua River	25	18.8	0.92
361	361	Siuslaw Forest	28	18.8	0.93
386	386	Willamette Forest	25	18.8	0.80
317	317	Coos Bay	23	18.8	0.74
15	15	Point Reyes	25	18.8	1.24
164	164	Cascade Ranch	21	18.7	1.05
354	354	Umpqua River	24	18.7	0.54
367	367	Siuslaw Forest	27	18.7	0.67
14	14	Point Reyes	22	18.6	1.00
178	178	SF Water Reserve	23	18.6	0.65
904		NZ Ashley	26	18.5	1.08
383	383	Willamette Forest	27	18.4	0.63
337	337	Umpqua River	27	18.4	0.93
730	337	Umpqua River	21	13.3	0.81
167	167	Cascade Ranch	21	18.3	1.19
165	165	Cascade Ranch	26	18.3	0.96
203	203	Arcata	25	18.3	0.68
29	29	S. P. Taylor	21	18.2	0.86
166	166	Cascade Ranch	22	18.1	0.45
161	161	Cascade Ranch	23	18.1	0.96
303	303	Ophir	24	18.0	0.88

## APPENDIX 2 – FAMILY MEANS AT GOLDEN DOWNS (CONTINUED)

Code	Family	Provenance	No.	Height	Forks
338	338	Umpqua River	24	18.0	0.54
374	374	Siuslaw Forest	24	17.9	0.42
734	374	Siuslaw Forest	25	13.8	0.96
175	175	SF Water Reserve	22	17.9	0.82
186	186	SF Water Reserve	28	17.8	1.21
183	183	SF Water Reserve	23	17.8	0.91
608	608	Long View clone	22	17.7	1.05
26	26	S. P. Taylor	23	17.7	1.13
177	177	SF Water Reserve	19	17.7	0.95
350	350	Umpqua River	22	17.6	0.27
375	375	Siuslaw Forest	24	17.6	0.63
346	346	Umpqua River	21	17.5	0.62
369	369	Siuslaw Forest	25	17.5	0.56
739	369	Siuslaw Forest	22	16.1	0.95
384	384	Willamette Forest	24	17.5	0.67
179	179	SF Water Reserve	15	17.5	1.00
364	364	Siuslaw Forest	25	17.4	0.60
902		NZ Kaingaroa	23	17.4	0.52
172	172	SF Water Reserve	22	17.4	0.86
348	348	Umpqua River	24	17.4	0.83
362	362	Siuslaw Forest	23	17.3	0.96
187	187	SF Water Reserve	25	17.3	0.92
385	385	Willamette Forest	19	17.3	0.63
610	610	Twin Harbour	28	17.3	0.71
67	67	Noyo River	26	17.2	0.62
373	373	Siuslaw Forest	25	17.2	0.56
169	169	Cascade Ranch	23	17.1	0.65
731	731	Siuslaw Forest	19	17.1	0.95
180	180	SF Water Reserve	24	17.1	0.71
13	13	Point Reyes	25	17.1	1.04
345	345	Umpqua River	23	17.0	1.09
316	316	Coos Bay	23	17.0	0.57
388	388	Willamette Forest	26	16.9	0.85
609	609	Twin Harbour	22	16.9	0.45
722	722	California CP	20	16.8	0.50
612	612	Twin Harbour	21	16.6	0.81
732	732	Noyo River	18	16.6	0.72
355	355	Umpqua River	26	16.5	0.81
171	171	SF Water Reserve	20	16.5	1.05
605	605	Long View clone	21	16.4	0.67
181	181	SF Water Reserve	24	16.3	0.96
173	173	SF Water Reserve	25	16.2	1.08
188	188	SF Water Reserve	25	16.2	0.80
189	189	SF Water Reserve	25	16.1	0.84
185	185	SF Water Reserve	25	16.1	0.92



## APPENDIX 2 – FAMILY MEANS AT GOLDEN DOWNS (CONTINUED)

Code	Family	Provenance	No.	Height	Forks
329	329	Myrtle Point	26	16.1	0.65
11	11	Point Reyes	25	15.8	0.92
182	182	SF Water Reserve	24	15.7	1.17
343	343	Umpqua River	26	15.5	0.96
357	357	Umpqua River	20	15.5	0.55
390	390	Willamette Forest	29	15.4	0.76
607	607	Long View clone	17	15.1	0.65
336	336	Umpqua River	26	15.0	0.50
340	340	Umpqua River	25	14.9	0.72
389	389	Willamette Forest	24	14.9	0.88
4	4	Los Padres	15	14.9	1.00
3	3	Los Padres	24	14.8	1.29
606	606	Long View clone	24	14.8	0.54
16	16	Point Reyes	20	14.8	1.10
2	2	Los Padres	21	14.7	0.95
387	387	Willamette Forest	26	14.7	0.65
611	611	Twin Harbour	23	14.3	1.09
412	412	Los Padres	19	14.0	0.84
5	5	Los Padres	20	13.9	1.20
749	5	Los Padres	22	12.3	0.86
1	1	Los Padres	23	12.8	1.04

### APPENDIX 3 – FAMILY MEANS AT GOWAN HILLS

Code	Family	Provenance	No.	Height	Straight	Forks	Leader str	Br type
722	722	Cal x Cal C.P.	28	26.5	6.32	0.43	2.96	2.63
723	723	Oregon x Cal C.P.	26	25.8	6.88	0.42	5.52	2.36
721	721	Ashley x Cal C.P.	25	25.5	6.64	0.56	5.71	2.42
133	133	Navarro River	28	25.4	6.61	0.54	4.29	2.57
127	127	Navarro River	25	25.0	6.08	0.24	5.04	2.67
125	125	Navarro River	24	24.8	6.54	0.33	5.30	2.39
122	122	Navarro River	27	24.7	6.48	0.44	5.04	2.24
205	205	Arcata	29	24.6	6.55	0.21	5.07	2.14
123	123	Navarro River	26	24.6	6.58	0.46	5.12	2.50
165	165	Cascade Ranch	26	24.5	6.62	0.46	5.56	2.31
900		NZ Fort Bragg	196	24.3	6.48	0.48	4.77	2.13
129	129	Navarro River	25	24.2	6.00	0.44	4.56	2.13
53	53	Fort Ross	22	24.2	6.23	0.50	3.89	2.41
303	303	Ophir	23	24.1	6.70	0.43	5.36	2.26
55	55	Fort Ross	24	24.1	6.58	0.46	3.91	2.30
727	55	Fort Ross	19	20.6	6.58	0.37	5.21	2.29
52	52	Fort Ross	23	24.1	5.91	0.39	3.50	2.30
31	31	Russian River	20	24.1	6.35	0.65	6.44	2.37
326	326	Myrtle Point	23	24.0	6.39	0.35	4.05	2.30
309	309	Brookings	24	23.9	6.50	0.42	4.70	1.95
20	20	Point Reyes	28	23.7	6.64	0.50	5.65	2.36
904		NZ Ashley	28	23.7	6.57	0.32	5.71	1.96
302	302	Ophir	26	23.7	6.65	0.27	4.64	2.58
372	372	Siuslaw Forest	27	23.6	6.22	0.37	5.26	1.78
132	132	Navarro River	23	23.6	6.22	0.35	4.96	2.29
154	154	Cascade Ranch	20	23.5	6.75	0.65	5.53	2.50
200	200	Arcata	29	23.4	6.93	0.34	6.19	2.04
49	49	Gualala	22	23.4	5.73	0.32	3.55	2.10
35	35	Russian River	27	23.4	6.37	0.41	4.93	2.46
72	72	Noyo River	28	23.3	6.75	0.29	5.04	2.31
321	321	Coos Bay	9	23.2	6.67	0.56	3.57	1.63
161	161	Cascade Ranch	20	23.2	7.05	0.25	5.16	2.21
168	168	Cascade Ranch	16	23.2	6.88	0.38	6.25	2.53
143	143	Swanton	22	23.1	6.64	0.41	4.45	2.50
105	105	Rockport	22	23.0	6.45	0.59	4.63	2.52
15	15	Point Reyes	24	23.0	7.08	0.54	5.75	2.40
196	196	Arcata	25	23.0	6.80	0.20	4.54	1.86
51	51	Fort Ross	21	23.0	6.52	0.43	3.95	2.28
48	48	Gualala	21	22.9	6.76	0.33	5.62	2.22
81	81	Noyo River	28	22.9	6.71	0.54	4.54	2.54
306	306	Brookings	26	22.9	6.38	0.42	5.20	2.35
308	308	Brookings	25	22.9	6.48	0.52	6.16	1.95
44	44	Gualala	22	22.9	5.95	0.59	3.86	2.35
322	322	Coos Bay	20	22.9	6.50	0.50	5.06	2.11
130	130	Navarro River	29	22.8	6.55	0.34	4.68	1.96

### APPENDIX 3 – FAMILY MEANS AT GOWAN HILLS (CONTINUED)

Code	Family	Provenance	No.	Height	Straight	Forks	Leader str	Br type
367	367	Siuslaw Forest	29	22.8	6.55	0.24	5.64	1.69
41	41	Gualala	22	22.8	6.45	0.09	5.09	2.50
128	128	Navarro River	24	22.8	7.00	0.29	5.52	2.45
363	363	Siuslaw Forest	26	22.8	6.23	0.46	6.35	1.88
324	324	Coos Bay	28	22.7	6.61	0.36	4.70	1.58
19	19	Point Reyes	24	22.7	6.54	0.42	4.27	2.18
344	344	Umpqua River	12	22.7	6.25	0.58	4.50	2.40
381	381	Siuslaw Forest	30	22.7	6.50	0.07	4.70	1.96
21	21	S. P. Taylor	26	22.7	6.73	0.65	5.73	2.45
63	63	Noyo River	22	22.6	6.73	0.27	5.00	1.95
162	162	Cascade Ranch	27	22.6	6.33	0.41	4.43	2.62
370	370	Siuslaw Forest	26	22.6	6.73	0.38	5.42	1.92
729	370	Siuslaw Forest	21	21.0	6.52	0.38	6.10	2.00
194	194	Arcata	28	22.6	7.00	0.25	5.85	2.22
142	142	Swanton	25	22.6	6.68	0.56	4.42	2.88
198	198	Arcata	25	22.6	6.76	0.24	5.52	1.83
164	164	Cascade Ranch	22	22.6	6.64	0.41	4.86	2.43
391	391	Willamette Forest	24	22.6	6.13	0.38	4.29	1.91
33	33	Russian River	25	22.6	6.64	0.68	6.21	2.42
64	64	Noyo River	24	22.5	6.83	0.42	5.16	2.45
371	371	Siuslaw Forest	26	22.5	6.31	0.31	5.60	2.22
901		NZ Fort Bragg	26	22.5	6.77	0.35	5.73	2.36
34	34	Russian River	23	22.5	5.83	0.52	5.05	2.00
152	152	Cascade Ranch	24	22.5	6.46	0.46	4.74	2.48
70	70	Noyo River	25	22.4	6.68	0.36	4.96	2.15
378	378	Siuslaw Forest	26	22.4	6.46	0.35	5.00	1.61
195	195	Arcata	28	22.4	6.32	0.21	4.52	2.13
121	121	Navarro River	28	22.4	6.79	0.43	5.21	2.54
301	301	Ophir	28	22.4	6.71	0.29	5.11	1.88
316	316	Coos Bay	17	22.4	6.82	0.29	6.41	2.00
193	193	Arcata	25	22.3	6.60	0.32	5.04	1.67
728	193	Arcata	23	21.7	6.48	0.13	5.17	2.05
323	323	Coos Bay	25	22.3	6.32	0.48	4.36	1.91
305	305	Brookings	25	22.3	6.16	0.44	4.88	2.41
77	77	Noyo River	26	22.3	6.54	0.58	5.36	2.22
50	50	Gualala	15	22.3	5.87	0.53	5.40	2.15
32	32	Russian River	20	22.3	6.75	0.30	5.05	2.67
54	54	Fort Ross	24	22.3	6.58	0.54	5.82	2.64
330	330	Myrtle Point	25	22.2	6.52	0.52	5.45	2.19
361	361	Siuslaw Forest	24	22.2	6.67	0.25	4.79	2.24
38	38	Russian River	26	22.2	6.73	0.58	6.15	2.30
141	141	Swanton	27	22.2	6.22	0.48	4.60	2.79
907		USA L.P. S.O.	27	22.2	6.74	0.41	5.42	1.90
65	65	Noyo River	28	22.2	6.61	0.36	6.13	1.75

### APPENDIX 3 – FAMILY MEANS AT GOWAN HILLS (CONTINUED)

Code	Family	Provenance	No.	Height	Straight	Forks	Leader Str	Br type
131	131	Navarro River	27	22.1	6.78	0.37	5.54	1.84
339	339	Umpqua River	23	22.1	6.61	0.39	5.43	2.26
37	37	Russian River	26	22.1	6.81	0.46	6.08	2.45
12	12	Point Reyes	22	22.1	6.64	0.45	6.43	2.52
57	57	Fort Ross	22	22.1	6.55	0.32	4.43	2.38
383	383	Willamette Forest	22	22.1	6.82	0.14	5.77	1.90
42	42	Gualala	23	22.1	5.74	0.48	4.45	2.25
124	124	Navarro River	23	22.1	6.61	0.48	5.18	2.06
304	304	Brookings	25	22.1	6.44	0.40	5.87	2.62
365	365	Siuslaw Forest	29	22.1	6.52	0.28	4.64	1.77
110	110	Rockport	20	22.1	5.95	0.60	6.00	2.20
13	13	Point Reyes	22	22.0	6.82	0.27	6.68	2.47
126	126	Navarro River	23	22.0	6.83	0.35	4.82	2.19
108	108	Rockport	24	22.0	6.21	0.29	4.57	2.52
59	59	Fort Ross	26	22.0	6.62	0.50	6.17	2.41
735	59	Fort Ross	14	19.5	6.50	0.50	6.36	2.38
375	375	Siuslaw Forest	26	22.0	6.69	0.31	6.31	1.76
17	17	Point Reyes	15	21.9	6.33	0.20	6.40	2.23
368	368	Siuslaw Forest	29	21.9	6.45	0.45	5.74	2.07
24	24	S. P. Taylor	25	21.9	6.28	0.32	5.25	2.14
91	91	Usal Road	24	21.9	6.88	0.25	6.45	1.95
903	903	NZ Fort Bragg	27	21.9	6.48	0.56	4.58	2.26
902	902	NZ Kaingaroa	28	21.8	6.71	0.43	5.88	1.73
374	374	Siuslaw Forest	25	21.8	6.72	0.36	6.20	2.09
734	374	Siuslaw Forest	25	18.5	7.04	0.28	6.83	1.53
25	25	S. P. Taylor	26	21.8	6.46	0.31	5.64	2.38
30	30	S. P. Taylor	24	21.8	6.58	0.46	6.14	2.70
307	307	Brookings	27	21.7	7.15	0.44	6.72	2.10
151	151	Cascade Ranch	26	21.7	6.88	0.35	6.04	2.48
725	151	Cascade Ranch	14	19.9	6.71	0.64	6.57	2.50
334	334	Myrtle Point	25	21.7	5.52	0.52	4.75	1.67
22	22	S. P. Taylor	24	21.7	7.00	0.58	4.64	2.41
318	318	Coos Bay	27	21.7	6.52	0.37	5.40	1.83
342	342	Umpqua River	28	21.7	6.57	0.21	6.26	2.21
177	177	SF Water Reserve	18	21.7	6.72	0.22	6.22	2.41
337	337	Umpqua River	28	21.6	6.71	0.32	4.96	2.42
730	337	Umpqua River	19	18.1	6.95	0.58	6.17	2.46
191	191	Arcata	25	21.6	7.12	0.16	6.08	2.00
79	79	Noyo River	27	21.6	6.52	0.37	5.04	2.54
201	201	Arcata	27	21.6	6.30	0.30	5.35	2.00
170	170	Cascade Ranch	25	21.6	6.12	0.60	5.58	2.52
47	47	Gualala	27	21.6	6.41	0.44	4.83	2.14
192	192	Arcata	29	21.6	7.14	0.34	6.25	2.15
163	163	Cascade Ranch	24	21.6	6.75	0.54	5.26	2.53

### APPENDIX 3 – FAMILY MEANS AT GOWAN HILLS (CONTINUED)

Code	Family	Provenance	No.	Height	Straight	Forks	Leader Str	Br type
733	163	Cascade Ranch	22	18.9	6.86	0.23	6.29	2.33
905		NZ Ashley	26	21.6	6.50	0.46	5.35	2.17
184	184	SF Water Reserve	23	21.6	6.57	0.35	5.55	2.32
314	314	Coos Bay	23	21.6	6.48	0.39	6.70	1.80
384	384	Willamette Forest	27	21.5	6.85	0.15	6.26	2.13
345	345	Umpqua River	26	21.5	6.65	0.27	5.85	2.14
724	724	WA x CA C.P.	10	21.5	6.60	0.40	5.33	2.00
23	23	S. P. Taylor	23	21.5	6.61	0.35	6.32	2.39
386	386	Willamette Forest	29	21.4	6.00	0.45	6.33	1.75
40	40	Russian River	22	21.4	6.86	0.45	6.41	1.85
366	366	Siuslaw Forest	27	21.4	6.74	0.41	5.30	2.05
325	325	Myrtle Point	25	21.4	6.88	0.16	5.58	2.00
60	60	Fort Ross	22	21.4	5.27	0.32	4.67	2.67
364	364	Siuslaw Forest	25	21.4	7.00	0.28	6.13	1.70
731	364	Siuslaw Forest	18	20.2	7.11	0.06	6.56	1.50
351	351	Umpqua River	23	21.3	6.91	0.35	5.25	2.05
312	312	Coquille	20	21.3	6.50	0.30	5.56	2.07
202	202	Arcata	28	21.3	6.61	0.18	5.48	1.73
315	315	Coos Bay	26	21.3	6.81	0.12	5.12	2.00
185	185	SF Water Reserve	23	21.3	6.83	0.52	6.39	2.25
189	189	SF Water Reserve	21	21.2	6.95	0.19	6.67	1.68
379	379	Siuslaw Forest	26	21.2	6.46	0.27	5.76	1.86
199	199	Arcata	25	21.2	6.80	0.28	5.91	2.41
109	109	Rockport	23	21.2	6.74	0.65	5.48	2.47
18	18	Point Reyes	25	21.2	6.76	0.48	5.60	2.43
62	62	Noyo River	29	21.1	6.24	0.45	4.81	1.96
317	317	Coos Bay	23	21.1	6.91	0.35	4.83	1.67
29	29	S. P. Taylor	22	21.0	6.91	0.36	6.71	2.28
39	39	Russian River	22	21.0	6.50	0.55	4.67	2.75
56	56	Fort Ross	23	21.0	6.17	0.39	4.50	2.61
906		NZ Beamont	26	21.0	6.38	0.50	5.67	2.36
373	373	Siuslaw Forest	29	21.0	6.79	0.24	6.62	1.60
369	369	Siuslaw Forest	22	20.9	6.64	0.18	5.81	1.83
167	167	Cascade Ranch	18	20.9	6.83	0.33	5.11	2.50
75	75	Noyo River	26	20.9	6.35	0.35	3.76	2.05
197	197	Arcata	23	20.9	7.04	0.35	4.95	1.95
58	58	Fort Ross	22	20.9	6.55	0.45	4.14	2.41
183	183	SF Water Reserve	26	20.8	6.96	0.62	6.04	2.17
171	171	SF Water Reserve	20	20.8	6.85	0.50	5.70	2.33
26	26	S. P. Taylor	21	20.8	6.76	0.67	6.61	2.53
68	68	Noyo River	29	20.8	6.59	0.48	5.63	2.30
382	382	Willamette Forest	23	20.7	7.00	0.09	6.39	2.11
61	61	Noyo River	27	20.7	6.70	0.30	6.30	1.91
173	173	SF Water Reserve	22	20.6	6.77	0.36	7.29	1.95
204	204	Arcata	26	20.6	6.92	0.23	5.65	2.00

### APPENDIX 3 – FAMILY MEANS AT GOWAN HILLS (CONTINUED)

Code	Family	Provenance	No.	Height	Straight	Forks	Leader Str	Br type
350	350	Umpqua River	23	20.6	6.83	0.41	5.22	2.05
175	175	SF Water Reserve	21	20.5	6.90	0.38	6.70	1.82
329	329	Myrtle Point	21	20.5	6.95	0.43	6.10	1.93
353	353	Umpqua River	28	20.5	7.00	0.39	6.19	1.59
73	73	Noyo River	22	20.5	6.14	0.36	5.50	2.33
45	45	Gualala	25	20.4	6.84	0.48	6.67	2.00
36	36	Russian River	17	20.4	6.76	0.47	6.33	2.15
737	36	Russian River	14	18.4	7.07	0.50	6.86	2.33
354	354	Umpqua River	25	20.4	6.76	0.16	5.40	2.19
362	362	Siuslaw Forest	27	20.4	6.56	0.37	5.81	1.60
188	188	SF Water Reserve	19	20.4	7.05	0.47	6.37	2.00
66	66	Noyo River	22	20.3	6.77	0.36	6.00	2.44
335	335	Umpqua River	29	20.3	6.66	0.21	6.25	2.00
43	43	Gualala	22	20.3	6.64	0.23	5.14	2.40
736	43	Gualala	17	18.5	7.00	0.47	4.88	2.45
166	166	Cascade Ranch	23	20.3	6.78	0.26	6.70	2.19
726	166	Cascade Ranch	20	19.7	6.95	0.20	6.50	1.88
187	187	SF Water Reserve	23	20.3	7.26	0.57	7.32	2.06
14	14	Point Reyes	20	20.3	6.40	0.45	5.20	2.50
28	28	S. P. Taylor	26	20.2	6.88	0.50	6.81	2.50
190	190	SF Water Reserve	19	20.2	6.37	0.47	6.22	2.33
390	390	Willamette Forest	24	20.2	6.25	0.29	6.39	1.90
176	176	SF Water Reserve	20	20.2	6.55	0.25	6.32	2.20
186	186	SF Water Reserve	23	20.1	7.00	0.52	6.87	2.44
348	348	Umpqua River	22	20.0	6.55	0.36	6.19	2.00
320	320	Coos Bay	20	20.0	7.10	0.10	7.00	1.59
356	356	Umpqua River	10	20.0	6.40	0.40	5.89	3.00
380	380	Siuslaw Forest	24	20.0	6.42	0.38	6.16	1.56
203	203	Arcata	26	19.9	6.50	0.38	5.28	2.13
338	338	Umpqua River	25	19.9	6.80	0.36	5.92	2.05
182	182	SF Water Reserve	25	19.8	6.84	0.36	5.88	1.94
336	336	Umpqua River	23	19.7	6.48	0.04	5.70	1.47
180	180	SF Water Reserve	13	19.7	6.85	0.54	6.55	2.33
78	78	Noyo River	25	19.7	7.00	0.40	6.38	2.32
357	357	Umpqua River	23	19.6	6.83	0.17	6.39	1.68
178	178	SF Water Reserve	20	19.6	6.95	0.45	6.95	2.33
67	67	Noyo River	26	19.5	6.77	0.23	5.80	1.95
11	11	Point Reyes	9	19.4	7.11	0.33	5.44	2.17
69	69	Noyo River	23	19.4	6.30	0.52	4.62	2.31
313	313	Coos Bay	24	19.4	7.08	0.08	6.08	1.95
172	172	SF Water Reserve	23	19.4	6.61	0.48	7.00	1.88
80	80	Noyo River	22	19.3	6.91	0.32	5.95	1.57
71	71	Noyo River	24	19.2	7.00	0.54	5.65	2.25
343	343	Umpqua River	21	19.2	6.62	0.43	5.00	2.29
181	181	SF Water Reserve	18	19.2	6.89	0.39	6.76	1.67

### APPENDIX 3 – FAMILY MEANS AT GOWAN HILLS (CONTINUED)

Code	Family	Provenance	No.	Height	Straight	Forks	Leader Str	Br type
385	385	Willamette Forest	22	19.1	6.41	0.32	6.29	1.75
352	352	Umpqua River	22	19.0	6.59	0.27	5.45	2.20
4	4	Los Padres	12	19.0	6.50	0.83	5.91	2.90
27	27	S. P. Taylor	22	19.0	7.14	0.45	7.18	2.63
340	340	Umpqua River	18	18.8	6.50	0.33	6.94	2.00
16	16	Point Reyes	16	18.8	6.63	0.75	6.93	2.25
347	347	Umpqua River	16	18.8	6.94	0.38	7.06	1.70
74	74	Noyo River	27	18.7	6.70	0.30	5.72	2.16
732	74	Noyo River	23	17.3	6.61	0.30	6.27	2.33
355	355	Umpqua River	23	18.7	6.26	0.48	6.09	2.06
169	169	Cascade Ranch	19	18.6	6.68	0.32	7.12	2.15
310	310	Brookings	26	18.6	6.81	0.35	7.12	2.12
107	107	Rockport	23	18.6	6.65	0.48	5.10	2.62
3	3	Los Padres	11	18.5	6.91	0.73	7.09	2.00
387	387	Willamette Forest	20	18.5	6.95	0.20	6.55	1.33
5	5	Los Padres	12	17.5	7.08	0.33	6.50	2.56
179	179	SF Water Reserve	20	17.5	6.90	0.40	7.06	2.44
388	388	Willamette Forest	19	17.5	6.53	0.32	7.65	2.08
346	346	Umpqua River	22	17.0	6.59	0.23	7.05	1.45
389	389	Willamette Forest	26	16.7	7.04	0.19	6.80	1.86
412	412	Los Padres	6	16.3	7.00	0.83	6.60	2.67
2	2	Los Padres	10	16.2	6.40	0.50	6.20	2.00
1	1	Los Padres	12	15.3	7.17	0.58	7.64	2.43

#### APPENDIX 4 – PROVENANCE MEAN CORRELATIONS

	kr_surv	kr_ht	kr_frk	kr_str	kr_brt	kr_nra	gdsurv	gd_ht	gd_frk	gwsurv	gw_ht	gw_frk	gw_str	gw_brt	gw_tst	latitude	seedwt	nurs_ht
kr_ht	0.11	1																
kr_frk	-0.10	0.02	1															
kr_str	0.18	-0.75***	-0.10	1														
kr_brt	0.04	-0.63**	-0.31	0.44*	1													
kr_nra	0.56**	0.09	-0.04	0.28	-0.17	1												
gdsurv	<b>0.51*</b>	0.59**	-0.19	-0.31	-0.09	0.41	1											
gd_ht	0.40	<b>0.85***</b>	-0.06	-0.50*	-0.38	0.33	0.14	1										
gd_frk	-0.51*	-0.29	<b>0.19</b>	-0.20	0.22	-0.86***	-0.17	-0.59**	1									
gwsurv	<b>0.60**</b>	0.48*	-0.40	-0.13	-0.08	0.52*	<b>0.77***</b>	0.65***	-0.56**	1								
gw_ht	0.35	<b>0.73***</b>	-0.17	-0.46*	-0.11	0.23	0.77***	<b>0.81***</b>	-0.38	0.76***	1							
gw_frk	-0.47*	0.04	<b>0.34</b>	-0.36	-0.17	-0.76***	-0.41	-0.22	0.81***	-0.62**	-0.32	1						
gw_str	-0.19	-0.64**	-0.26	<b>0.70***</b>	0.44*	-0.11	-0.49*	-0.57**	0.12	-0.24	-0.39	-0.09	1					
gw_brt	-0.44*	0.40	0.17	-0.65**	<b>-0.19</b>	-0.68***	-0.05	0.13	0.63**	-0.29	0.10	0.77***	-0.22	1				
gw_tst	-0.01	-0.83***	-0.10	<b>0.72***</b>	0.48*	-0.11	-0.50*	-0.71**	0.21	-0.46*	-0.70***	0.00	0.73***	-0.34	1			
latitude	0.56**	-0.12	0.12	0.36	-0.06	0.75***	0.28	0.04	-0.62**	0.48*	0.14	-0.70***	-0.15	-0.77***	-0.05	1		
seedwt	-0.28	-0.32	-0.09	0.30	0.26	-0.43*	-0.26	-0.40	0.42	-0.39	-0.39	0.26	0.49*	0.17	0.57**	-0.45*	1	
nurs_ht	0.01	<b>0.79***</b>	0.01	-0.68***	-0.29	-0.03	0.52*	<b>0.76***</b>	-0.15	0.33	<b>0.60**</b>	0.03	-0.47*	0.46*	-0.57**	-0.36	-0.07	1
flush	-0.53**	-0.04	-0.03	-0.43*	0.14	-0.84***	-0.37	-0.30	0.84***	-0.47*	-0.17	0.75***	0.15	0.74***	0.12	-0.82***	0.42*	0.12



**APPENDIX 5 – CORRELATIONS OF FAMILY MEANS ACROSS ALL SITES (LOWER TRIANGLE) AND GENETIC CORRELATIONS (UPPER TRIANGLE)**

	kr_surv	kr_ht	kr_frk	kr_str	kr_brt	kr_nra	gdsurv	gd_ht	gd_frk	gwsurv	gw_ht	gw_frk	gw_str	gw_brt	gw_tst	latitude	seedwt	nurs_ht
kr_ht	0.16*	1.00	0.02	-0.56	-0.63	0.21												
kr_frk	-0.07	0.02	1.00	-0.10	0.26	0.01												
kr_str	-0.08	-0.51***	-0.13	1.00	-0.05	-0.02												
kr_brt	-0.01	-0.54***	-0.06	0.17*	1.00	-0.20												
kr_nra	0.12	0.14*	0.01	0.14*	-0.21**	1.00												
gdsurv	<b>0.16*</b>	0.30***	0.03	-0.15*	-0.11	0.16*	1.00											
gd_ht	0.17*	<b>0.76***</b>	0.08	-0.37***	-0.41***	0.23***	0.34***	1.00	-0.03									
gd_frk	-0.18*	-0.16*	<b>0.25***</b>	-0.14*	0.20**	-0.37***	-0.04	-0.30***	1.00									
gwsurv	<b>0.38***</b>	0.39***	-0.04	-0.06	-0.13	0.41***	<b>0.35***</b>	0.48***	-0.30***	1.00								
gw_ht	0.26***	<b>0.61***</b>	0.00	-0.31***	-0.25***	0.17*	0.31***	<b>0.63***</b>	-0.10	0.41***	1.00	.	-0.37	0.32	-0.54			
gw_frk	-0.17*	0.03	<b>0.16*</b>	-0.19**	0.05	-0.31***	-0.11	-0.02	<b>0.36***</b>	-0.20**	-0.09	1.00	.	.	.			
gw_str	-0.23***	-0.31***	0.00	<b>0.50***</b>	0.13	-0.02	-0.15*	-0.36***	0.04	-0.17**	-0.26***	-0.16*	1.00	0.09	0.60			
gw_brt	-0.16*	0.31***	0.18**	-0.34***	<b>-0.08</b>	-0.30***	-0.03	0.23***	0.36***	-0.17*	0.17*	0.40***	-0.10	1.00	-0.26			
gw_tst	-0.19**	-0.60***	-0.03	0.46***	0.31***	-0.20**	-0.27***	-0.57***	0.12	-0.29***	-0.59***	-0.02	0.48***	-0.20**	1.00			
latitude	0.33***	-0.16*	-0.02	0.26***	-0.06	0.59***	0.13	-0.05	-0.38***	0.38***	-0.01	-0.40***	-0.08	-0.55***	-0.03	1.00		
seedwt	-0.12	0.01	0.02	-0.12	-0.02	-0.16*	0.06	-0.06	0.06	-0.11	-0.06	0.12*	0.08	0.08	0.12	-0.21**	1.00	
nurs_ht	0.06	0.60***	0.08	-0.38***	-0.23***	-0.02	0.29***	0.65***	0.07	0.33***	0.46***	0.09	-0.24***	0.28***	-0.40***	-0.34***	0.15*	1.00
flush	-0.32***	-0.11	0.05	-0.28***	0.22**	-0.63***	-0.20**	-0.27***	0.51***	-0.46***	-0.09	0.40***	0.07	0.48***	0.16*	-0.70***	0.16*	0.01