

DOUGLAS-FIR

Cooperative

**DOUGLAS-FIR CLONES
IN WAIKUKU SEED ORCHARD**

**PART 1: FLUSHING ORDER
PART 2: HEALTH ASSESSMENT**

C.B. Low, T.G. Vincent & S. van Ballekom

Report No. 8

June 1994



**NZ FORESTRY INDUSTRY
RESEARCH
COOPERATIVES**

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EXECUTIVE SUMMARY

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PART 1: FLUSHING ORDER

The timing of vegetative bud burst is crucial to gibberellin application in seed orchards. In this study 2,513 ramets of 186 clones at Waikuku Douglas fir seed orchard were scored for flushing on the 1st of November 1993.

There was a wide variation between clones in timing of bud burst, as reflected by the scoring of length of the new shoot. Generally this was related to the latitude of the provenance of the clones, but individual clones varied widely within provenances. Ramet age appeared to have a small effect, but it is impossible to evaluate this as clones are not represented evenly across ages.

PART 2: HEALTH ASSESSMENT

Tree health was scored subjectively on a one-to-three scale on the Douglas-fir grafts, aged two to four years, in Proseed's Waikuku seed orchard. Over 80% of the trees, and 30% of the clones assessed showed no signs of ill health. Ranked mean health scores are provided for each clone assessed.

A number of the clones in this orchard were grafted onto plants raised from "compatible rootstock" seed supplied by the Pacific Northwest Research Station, Corvallis, Oregon. Overall means health scores for compatible and routine rootstocks were similar. Rootstock families were ranked so that the best performers could be used if seed was reordered by family numbers.

PART 1: FLUSHING ORDER OF DOUGLAS FIR CLONES IN WAIKUKU SEED ORCHARD

Summary

The timing of vegetative bud burst is crucial to gibberellin application in seed orchards. In this study 2,513 ramets of 186 clones at Waikuku Douglas fir seed orchard were scored for flushing on the 1st of November 1993.

There was a wide variation between clones in timing of bud burst, as reflected by the scoring of length of the new shoot. Generally this was related to the latitude of the provenance of the clones, but individual clones varied widely within provenances. Ramet age appeared to have a small effect, but it is impossible to evaluate this as clones are not represented evenly across ages.

Introduction

In 1957 and 1959 the Genetics and Tree Improvement group of NZFRI established provenance trials of Douglas fir throughout New Zealand. These trials contained seedlots from latitudes ranging from 48° North in Washington, through Oregon, to 37° in California. In 1988 plus trees were selected mainly from these trials from the better provenances which are all from low elevation sites within 20 kilometres of the sea.

The trees were climbed to collect grafting scions and the resulting grafts were planted in Proseed's Waikuku seed orchard between 1989 and 1992. 186 clones from 22 American and three New Zealand provenances were successfully grafted. The selection, scion collection, and grafting of this material was funded by Proseed NZ.

The clones in Proseed's Waikuku seed orchard originate from a number of different provenances and they have a wide range of flushing times. Correct timing of gibberellin application is important to enhance female flower production and it is usually applied at the time of vegetative bud burst. The purpose of this study was to record flushing time for each clone and thus allow a better chance of correct timing of gibberellin application in future years.

This information will also provide some estimate of mean flushing date of each provenance and also estimate the range of flushing time between clones within each provenance.

Method

On 1 November 1993 the upper half of each tree was assessed using the categories pictured in Figure 1 (from the 1974 study of Wilcox and Vincent). Category 1 are the late flushers; category 7 describes trees that had flushed and on which extension growth was well advanced.

The actual dates and the number of days between each flushing state category were not recorded but the largest difference between trees in flushing time is around six weeks (Bollman 1966). Trees that were dying, dead, or damaged by rabbits were excluded from the assessment. A total of 2,513 trees from 186 clones in the 1989 to 1992 plantings were assessed, an average of just over 13 ramets per clone.

The assessment data was recorded by tree position in the orchard, matched with the clone numbers on the orchard maps, then sorted by clone number. Provenance information, including latitude was then added to this data-set.

Clone mean flushing scores were estimated and are tabulated in Table 1. Scatter plots were done for the southernmost and a mid-range Oregon provenance, both having more than 10 clones, as shown in Figure 2.

Provenance means were also estimated, and listed in Table 2. They are also graphed as a scatter plot against latitude, using the New Zealand provenance means as benchmarks (Figure 3).

Results and Discussion

The data were analysed by an analysis of variance, with the effects being graft age, provenance and clone within provenance. All effects appeared to be significant, but the significance of age cannot be determined from this data as virtually no clones were represented across all age groups, and age groups occupied different orchard blocks.

ANOVA table

Source	DF	Mean square	F	Probability	Variance
AGE	2	11.474	23.95	0.0001	0.027
PROV	22	70.049	146.19	0.0001	1.076
CLONE(PROV)	154	8.896	18.57	0.0001	0.666
ERROR	2168	0.479			0.479

The means of age groups are listed to show the extent of the apparent variation :-

AGE	Number	Mean Flush Score
1	112	3.38
2	1607	3.57
3	1132	3.27

Correlation coefficients were computed between clone mean and latitude ($r=-0.53$) and between provenance means and latitude ($r=-0.89$). Both coefficients are negative and highly significant, as illustrated graphically in Figure 3. The provenances from the northern latitudes of Washington and Oregon thus flush later in the season than those from southern latitudes in California.

Individual clones had a wide range of flushing times within provenances (Figure 2). Some clones from the earliest flushing provenance (Santa Cruz) flushed at almost the same time as the earliest clones from mid-Oregon provenances.

Repeatability of provenance means was 0.99 and repeatability of clone means was 0.97. These values are extremely high, and indicate that the variation within a clone (ramet to ramet variation) is extremely low compared to variation between clones.

Average flushing scores for provenances (Table 2, Fig. 3) generally agreed with expectations of flushing time, with southernmost provenances flushing first, northernmost flushing last. One important exception was the Fort Bragg provenance, whose flushing time was much later than would be predicted, and was more in line with Oregon provenances than Californian.

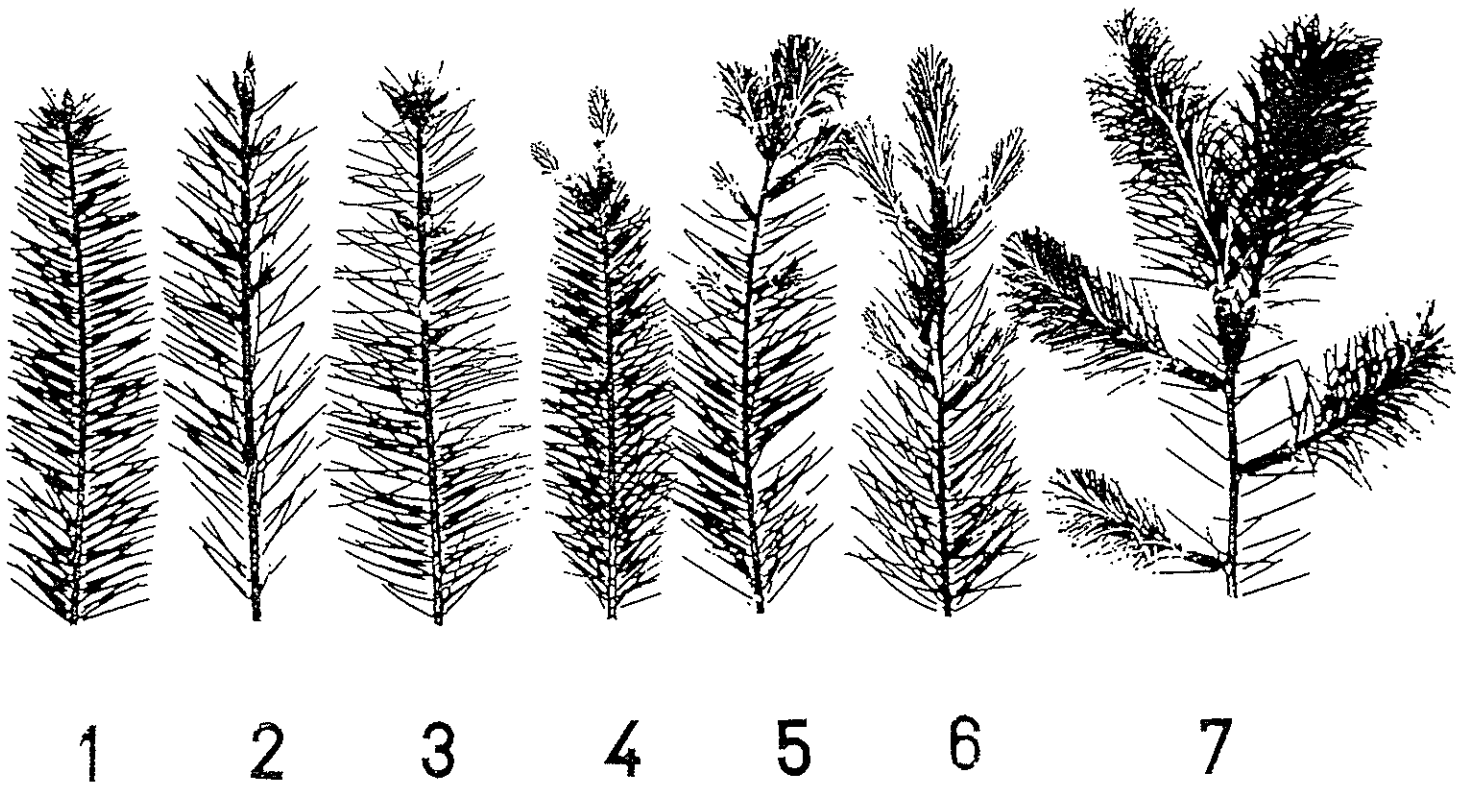
Another provenance of interest is Berteleda, whose seed came from a planted, rather than a natural stand, but flushes at exactly the predicted time. These results are essentially the same as those shown by Bollman, but the trends are shown more clearly, as there are no confounding effects of southern latitude, interior, high elevation provenances.

The mean flushing scores of the three New Zealand populations (Table 2) show that the Ashley population, whose mean is quite well estimated, shows the same flushing score as the southern Oregon provenances. The Kaingaroa and Dusky populations are only sampled by two and four clones respectively and their origin cannot be confirmed by this study.

Acknowledgment

Proseed NZ did the field assessment as an in-kind contribution to the cooperative.

Figure 1. Flushing categories

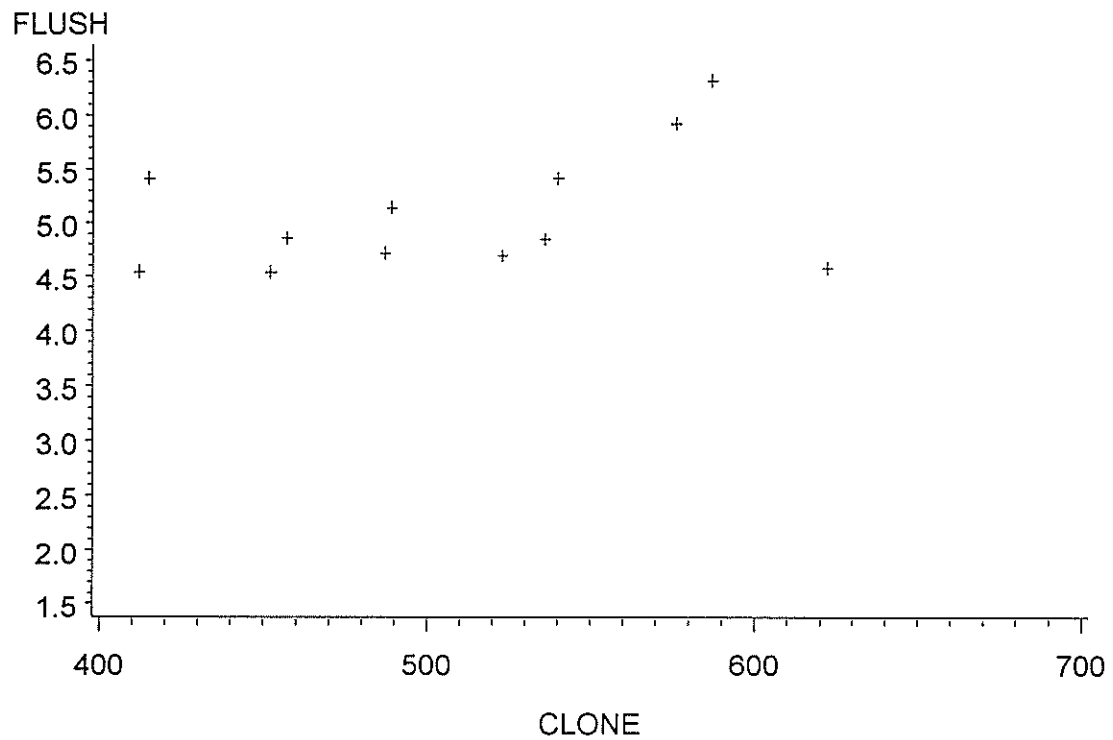


References :

Bollman M.P. 1966 1965 bud burst of Douglas fir at "Long Mile", FRI Internal report number 3.

Wilcox M.D., Vincent T. G. 1974 Third year results of a Douglas fir seed source test. FRI Internal Report number 58

Figure 2.
Flushing times for Santa Cruz D. fir clones at Waikuku



Flushing times for Deadwood, Oregon clones at Waikuku

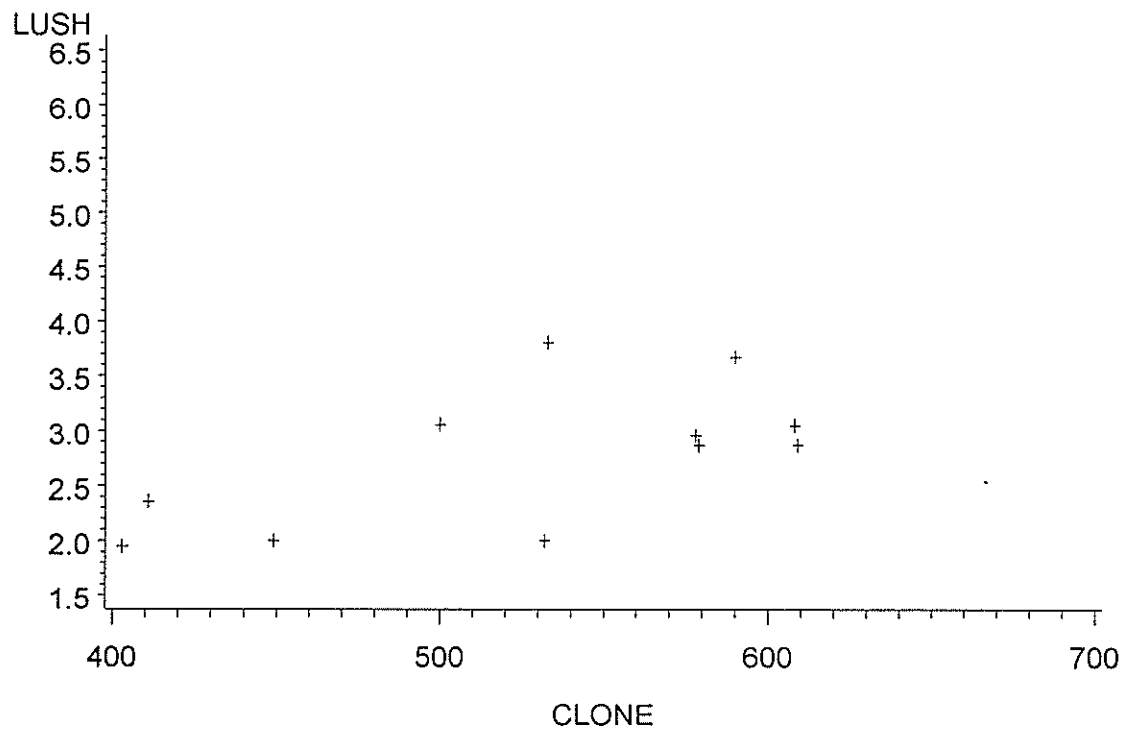


Figure 3.

Flushing times versus latitude, Waikuku Douglas fir clones

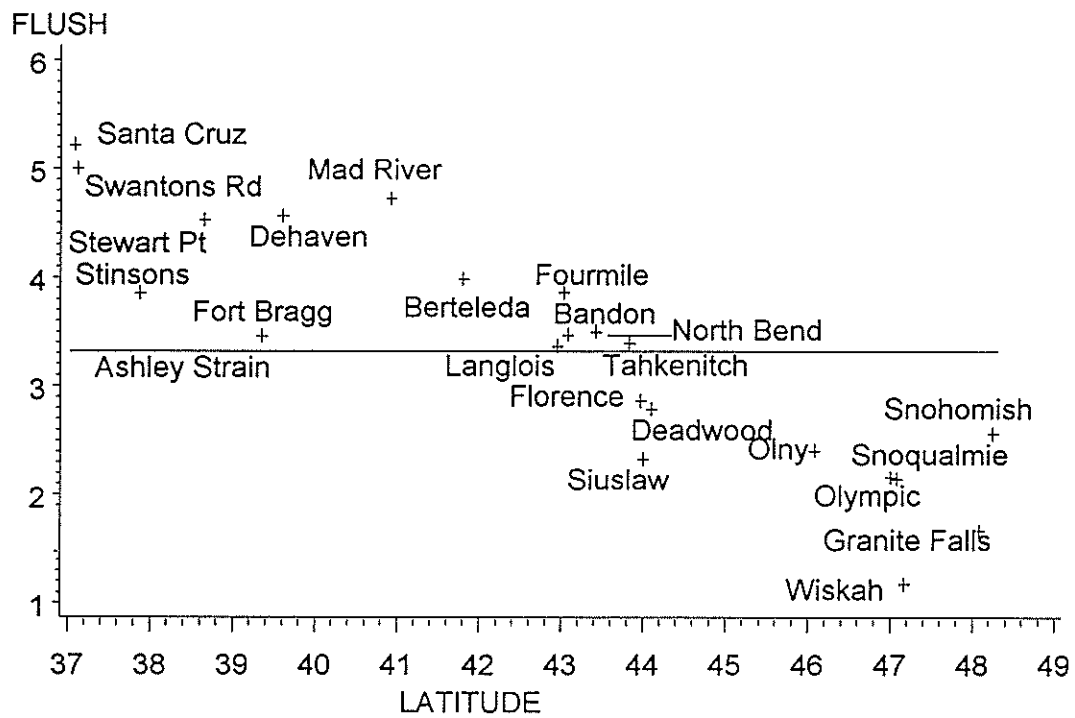


TABLE 1.

Mean flush score per clone, sorted by clone number

series	clone	seedlot	provenance	n. trees	flush
888	401	647	Ca. Mad River	2	4.00
888	402	642	Ca. Berteleda	7	2.57
888	403	636	Or. Deadwood	19	1.95
888	404	580	Or. Coos Bay	10	1.60
888	405	641	Or. Fourmile	6	3.17
888	406	658	Ca. Stewart Point	14	4.43
888	407	642	Ca. Berteleda	15	4.53
888	408	631	Wa. Snohomish	9	1.11
888	409	635	Or. Florence	16	2.38
888	410	649	Ca. Dehaven	11	5.27
888	411	636	Or. Deadwood	14	2.36
888	412	660	Ca. Santa Cruz	13	4.54
888	413	649	Ca. Dehaven	4	4.25
888	414	584	Or. Olney	16	2.38
888	415	660	Ca. Santa Cruz	17	5.41
888	416	642	Ca. Berteleda	2	4.50
888	417	659	Ca. Mt. Tamalpais	7	1.14
888	418	659	Ca. Mt. Tamalpais	2	5.50
888	419	658	Ca. Stewart Point	3	2.67
888	420	654	Ca. Fort Bragg	14	2.86
888	421	518	Wa. Olympic	14	1.79
888	422	517	Wa. Snoqualmie	8	2.13
888	423	282	NZ Ashley	16	1.00
888	424	494	Wa. Granite Falls	13	2.38
888	425	523	Or. Siuslaw	2	1.00
888	426	518	Wa. Olympic	13	1.54
888	427	518	Wa. Olympic	11	2.45
888	428	494	Wa. Granite Falls	11	1.00
888	429	523	Or. Siuslaw	6	1.33
888	430	654	Ca. Fort Bragg	3	3.33
888	431	654	Ca. Fort Bragg	7	2.29
888	432	654	Ca. Fort Bragg	14	3.50
888	433	654	Ca. Fort Bragg	6	3.00
888	434	654	Ca. Fort Bragg	1	5.00
888	435	744	Ca. Santa Cruz	2	5.00
888	436	744	Ca. Santa Cruz	3	5.00
888	437	744	Ca. Santa Cruz	3	5.00
888	438	744	Ca. Santa Cruz	1	6.00
888	439	744	Ca. Santa Cruz	14	5.93
888	440	744	Ca. Santa Cruz	20	5.25
888	441	744	Ca. Santa Cruz	11	4.36

TABLE 1. continued

series	clone	seedlot	provenance	n. trees	flush
888	442	744	Ca. Santa Cruz	15	4.60
888	443	744	Ca. Santa Cruz	1	6.00
888	444	744	Ca. Santa Cruz	5	3.60
888	445	654	Ca. Fort Bragg	5	2.80
888	446	659	Ca. Mt. Tamalpais	1	5.00
888	447	631	Wa. Snohomish	9	2.78
888	448	635	Or. Florence	5	2.80
888	449	636	Or. Deadwood	1	2.00
888	450	642	Ca. Berteleda	6	3.17
888	451	658	Ca. Stewart Point	2	5.00
888	452	660	Ca. Santa Cruz	13	4.54
888	453	642	Ca. Berteleda	4	3.50
888	454	580	Or. Coos Bay	2	3.50
888	455	647	Ca. Mad River	6	3.83
888	456	580	Or. Coos Bay	13	2.85
888	457	660	Ca. Santa Cruz	7	4.86
888	458	654	Ca. Fort Bragg	14	2.86
888	460	641	Or. Fourmile	6	2.67
888	461	635	Or. Florence	18	2.22
888	464	584	Or. Olney	4	1.00
888	465	518	Wa. Olympic	7	2.14
888	466	518	Wa. Olympic	4	1.50
888	467	517	Wa. Snoqualmie	11	2.00
888	468	282	NZ Ashley	13	1.46
888	469	494	Wa. Granite Falls	3	1.67
888	470	401	Wa. Wiskah	6	1.67
888	471	523	Or. Siuslaw	2	2.50
888	482	659	Ca. Mt. Tamalpais	13	4.31
888	483	659	Ca. Mt. Tamalpais	15	1.67
888	484	642	Ca. Berteleda	15	3.40
888	485	654	Ca. Fort Bragg	20	3.10
888	486	658	Ca. Stewart Point	9	3.67
888	487	660	Ca. Santa Cruz	7	4.71
888	488	647	Ca. Mad River	2	6.00
888	489	660	Ca. Santa Cruz	7	5.14
888	490	658	Ca. Stewart Point	4	4.50
888	491	647	Ca. Mad River	7	4.57
888	492	654	Ca. Fort Bragg	18	3.72
888	493	649	Ca. Dehaven	14	4.93
888	494	641	Or. Fourmile	11	4.55
888	495	584	Or. Olney	18	1.17
888	496	642	Ca. Berteleda	16	2.81
888	498	631	Wa. Snohomish	14	1.64

TABLE 1. continued

series	clone	seedlot	provenance	n. trees	flush
888	499	641	Or. Fourmile	14	3.21
888	500	636	Or. Deadwood	18	3.06
889	522	649	Ca. Dehaven	18	3.50
889	523	660	Ca. Santa Cruz	13	4.69
889	524	654	Ca. Fort Bragg	10	4.60
889	525	647	Ca. Mad River	15	4.00
889	526	642	Ca. Berteleda	13	3.38
889	527	580	Or. Coos Bay	14	3.50
889	528	654	Ca. Fort Bragg	15	4.07
889	529	584	Or. Olney	11	1.91
889	530	641	Or. Fourmile	17	3.82
889	531	635	Or. Florence	17	3.18
889	532	636	Or. Deadwood	9	2.00
889	533	636	Or. Deadwood	10	3.80
889	534	647	Ca. Mad River	17	4.76
889	535	631	Wa. Snohomish	18	4.72
889	536	660	Ca. Santa Cruz	13	4.85
889	537	642	Ca. Berteleda	18	3.72
889	538	658	Ca. Stewart Point	8	5.50
889	539	654	Ca. Fort Bragg	15	2.87
889	540	660	Ca. Santa Cruz	12	5.42
889	541	659	Ca. Mt. Tamalpais	14	5.57
889	542	621	Or. Bandon	14	4.07
889	543	593	NZ Ashley	13	3.08
889	544	593	NZ Ashley	16	2.75
889	545	621	Or. Bandon	10	2.80
889	546	622	Or. Langlois	20	3.05
889	547	627	Or. Tahkenitch	17	4.06
889	548	919	NZ Kaingaroa	19	2.79
889	554	.	NZ Ashley	27	3.70
889	555	.	NZ Ashley	6	4.50
889	557	.	NZ Ashley	15	3.07
889	558	.	NZ Ashley	29	2.17
889	559	.	NZ Ashley	29	3.10
889	560	.	NZ Ashley	31	3.94
889	561	.	NZ Ashley	29	3.86
889	562	282	NZ Ashley	11	1.18
889	563	518	Wa. Olympic	18	3.11
889	564	282	NZ Ashley	12	1.25
889	565	494	Wa. Granite Falls	11	1.64
889	566	401	Wa. Wiskah	11	1.00
889	567	518	Wa. Olympic	11	1.64
889	568	523	Or. Siuslaw	17	2.06

TABLE 1. continued

series	clone	seedlot	provenance	n. trees	flush
889	569	517	Wa. Snoqualmie	8	2.25
889	570	494	Wa. Granite Falls	10	1.00
889	571	282	NZ Ashley	4	2.25
889	572	401	Wa. Wiskah	13	2.15
889	573	647	Ca. Mad River	27	4.70
889	574	649	Ca. Dehaven	25	5.44
889	575	658	Ca. Stewart Point	21	4.76
889	576	660	Ca. Santa Cruz	26	5.92
889	577	641	Or. Fourmile	27	5.26
889	578	636	Or. Deadwood	23	2.96
889	579	636	Or. Deadwood	22	2.86
889	580	580	Or. Coos Bay	29	3.24
889	581	642	Ca. Berteleda	37	4.78
889	582	649	Ca. Dehaven	8	4.50
889	583	647	Ca. Mad River	13	4.92
889	584	635	Or. Florence	48	3.08
889	585	649	Ca. Dehaven	32	4.56
889	586	654	Ca. Fort Bragg	21	3.48
889	587	660	Ca. Santa Cruz	22	6.32
889	589	659	Ca. Mt. Tamalpais	1	1.00
889	590	636	Or. Deadwood	3	3.67
889	591	658	Ca. Stewart Point	10	5.60
889	592	584	Or. Olney	26	4.38
889	593	494	Wa. Granite Falls	9	2.22
889	595	282	NZ Ashley	26	1.00
889	596	282	NZ Ashley	11	1.00
889	597	518	Wa. Olympic	21	1.76
889	598	518	Wa. Olympic	14	1.93
889	599	518	Wa. Olympic	12	3.08
889	600	523	Or. Siuslaw	19	3.00
889	601	517	Wa. Snoqualmie	11	2.27
889	602	401	Wa. Wiskah	15	2.13
889	603	580	Or. Coos Bay	28	4.32
889	604	580	Or. Coos Bay	24	3.96
889	605	584	Or. Olney	23	1.65
889	606	631	Wa. Snohomish	12	1.33
889	607	635	Or. Florence	19	3.05
889	608	636	Or. Deadwood	21	3.05
889	609	636	Or. Deadwood	23	2.87
889	610	641	Or. Fourmile	28	2.96
889	611	642	Ca. Berteleda	25	4.60
889	612	642	Ca. Berteleda	18	4.11
889	613	647	Ca. Mad River	23	3.87

TABLE 1. continued

series	clone	seedlot	provenance	n. trees	flush
889	614	647	Ca. Mad River	22	6.23
889	615	649	Ca. Dehaven	14	3.57
889	616	654	Ca. Fort Bragg	15	3.67
889	617	654	Ca. Fort Bragg	30	3.97
889	618	658	Ca. Stewart Point	24	3.63
889	619	658	Ca. Stewart Point	1	3.00
889	620	658	Ca. Stewart Point	24	5.08
889	621	659	Ca. Mt. Tamalpais	14	5.29
889	622	660	Ca. Santa Cruz	19	4.58
889	633	593	NZ Ashley	15	3.33
889	634	622	Or. Langlois	19	3.68
889	635	919	NZ Kaingaroa	19	2.89
889	636	621	Or. Bandon	17	3.35
889	637	627	Or. Tahkenitch	14	2.57
889	639	.	NZ Ashley	1	2.00

TABLE 2.

seedlot	provenance	latitude	n. clones	flush
660	Ca. Santa Cruz	37°05'	12	5.08
744	Ca. Santa Cruz	37°07'	10	5.07
659	Ca. Mt. Tamalpais	37°53'	8	3.68
658	Ca. Stewart Point	38°39'	11	4.35
654	Ca. Fort Bragg	39°21'	16	3.44
649	Ca. Dehaven	39°36'	8	4.50
647	Ca. Mad River	40°55'	10	4.69
642	Ca. Berteleda	41°48'	12	3.76
622	Or. Langlois	42°57'	2	3.37
641	Or. Fourmile	43°02'	7	3.66
621	Or. Bandon	43°05'	3	3.41
580	Or. Coos Bay	43°25'	7	3.28
627	Or. Tahkenitch	43°50'	2	3.32
635	Or. Florence	43°58'	6	2.78
523	Or. Siuslaw	44°00'	5	1.98
636	Or. Deadwood	44°06'	11	2.78
584	Or. Olney	46°05'	6	2.08
517	Wa. Snoqualmie	47°00'	4	2.16
518	Wa. Olympic	47°05'	10	2.09
282	Wa. Wiskah	47°10'	7	1.31
494	Wa. Granite Falls	48°05'	6	1.65
631	Wa. Snohomish	48°15'	5	2.32
Seed stand	NZ Ashley	.	8	3.29
593	NZ Ashley	.	3	3.05
919	NZ Kaingaroa	.	2	2.84
401	NZ Dusky	.	4	1.74

PART 2: HEALTH ASSESSMENT OF DOUGLAS FIR CLONES IN WAIKUKU SEED ORCHARD

Summary

Tree health was scored subjectively on a one to three scale on the Douglas fir grafts, aged two to four years, in Proseed's Waikuku seed orchard. Over 80% of the trees, and 30% of the clones assessed showed no signs of ill health. Ranked mean health scores are provided for each clone assessed.

A number of the clones in this orchard were grafted onto plants raised from "compatible rootstock" seed supplied by the Pacific Northwest Research Station, Corvallis, Oregon. Overall mean health scores for compatible and routine rootstocks were similar. Rootstock families were ranked so that the best performers could be used if seed was re-ordered by family numbers.

Introduction

Between 1989 and 1991, an average of about 14 ramets per clone of 186 Douglas fir clones were planted as grafts in Proseed's Waikuku seed orchard. These form an important resource for potential seed production material and as a clonal archive for scion production and controlled-crossing. There is variation in the health of these trees due to apparent grafting incompatibility and other causes, so this project was initiated as an attempt to identify which of these clones might have health and compatibility problems. Unselected rootstocks were used for all except the 1991 plantings.

Method

In October 1993, before the trees began to flush, each tree in every block was scored using the following scale:

- 1 healthy
- 2 intermediate
- 3 sick (including yellow)

Results and Discussion

A total of 2563 grafted trees were assessed, 81.5% of which were rated as healthy. Clone mean health scores ranged between 1.0 (100% healthy) and 2.5 with the overall mean score being 1.22 (Table 1). Clone means based on five or more ramets ranged between 1.00 and 1.90, and 90% of these clones ranged between 1.00 and 1.67. There were significant health differences between provenances and between clones within provenances but not between age classes, as shown in the ANOVA table below.

ANOVA table

Source	DF	Mean Square	F	Probability
AGE	2	0.1246	0.60	0.55
PROV	22	1.2295	5.89	0.0001
CLONE(PROV)	154	0.5317	2.55	0.0001
ERROR	2214	0.2086		

Many of the trees in this orchard received different forms of flower induction treatment in 1991 and 1992 (gibberellins, root pruning, girdling). Any adverse effect of these treatments on tree health that might have occurred cannot be separated from general tree health and what is considered to be graft incompatibility.

A production orchard would normally be propagated with 20 to 40 clones from the best provenances. The establishment of such an orchard should involve using the most healthy clones from the best ranked provenances with 10 or more ramets.

The trees planted in 1991 were grafted onto plants raised from families of "compatible rootstock" seed supplied by the Pacific Northwest Research Station, Corvallis, Oregon (Dr D Copes). However, as there were insufficient scions per clone available to graft onto each rootstock family, all rootstocks could not be adequately evaluated with a set of scion clones. Mean health scores were calculated for each rootstock family and are presented in Table 2.

Rootstock families were grafted with different scion clones, so although some of the rootstock families had 100% healthy trees this could be due to the clones with which they were grafted. There was no difference between the overall mean health score of the "compatible" and routine rootstocks.

It is recommended that, if possible, seed of the five best rootstock types be obtained for further use.

Acknowledgment

Proseed NZ assessed this material as an in-kind contribution to the Douglas Fir Cooperative.

TABLE 1.

Clone means and score frequency for Douglas fir ramets, Waikuku, 1993

clone	seedlot	provenance	health	n.	frequency		
					#1	#2	#3
555	.	NZ Ashley	1.00	6	6	.	.
639	.	NZ Ashley	1.00	1	1	.	.
469	494	Wa. Granite Falls	1.00	3	3	.	.
421	518	Wa. Olympic	1.00	14	14	.	.
425	523	Or. Siuslaw	1.00	2	2	.	.
456	580	Or. Coos Bay	1.00	13	13	.	.
543	593	NZ Ashley	1.00	13	13	.	.
545	621	Or. Bandon	1.00	10	10	.	.
447	631	Wa. Snohomish	1.00	9	9	.	.
448	635	Or. Florence	1.00	5	5	.	.
531	635	Or. Florence	1.00	17	17	.	.
449	636	Or. Deadwood	1.00	1	1	.	.
499	641	Or. Fourmile	1.00	14	14	.	.
530	641	Or. Fourmile	1.00	17	17	.	.
416	642	Ca. Berteleda	1.00	2	2	.	.
450	642	Ca. Berteleda	1.00	6	6	.	.
453	642	Ca. Berteleda	1.00	4	4	.	.
611	642	Ca. Berteleda	1.00	25	25	.	.
401	647	Ca. Mad River	1.00	2	2	.	.
455	647	Ca. Mad River	1.00	6	6	.	.
488	647	Ca. Mad River	1.00	2	2	.	.
410	649	Ca. Dehaven	1.00	11	11	.	.
413	649	Ca. Dehaven	1.00	4	4	.	.
574	649	Ca. Dehaven	1.00	25	25	.	.
430	654	Ca. Fort Bragg	1.00	3	3	.	.
433	654	Ca. Fort Bragg	1.00	6	6	.	.
434	654	Ca. Fort Bragg	1.00	1	1	.	.
445	654	Ca. Fort Bragg	1.00	5	5	.	.
528	654	Ca. Fort Bragg	1.00	15	15	.	.
616	654	Ca. Fort Bragg	1.00	15	15	.	.
617	654	Ca. Fort Bragg	1.00	30	30	.	.
406	658	Ca. Stewart Point	1.00	14	14	.	.
451	658	Ca. Stewart Point	1.00	2	2	.	.
490	658	Ca. Stewart Point	1.00	4	4	.	.
575	658	Ca. Stewart Point	1.00	21	21	.	.
591	658	Ca. Stewart Point	1.00	10	10	.	.
618	658	Ca. Stewart Point	1.00	24	24	.	.
619	658	Ca. Stewart Point	1.00	1	1	.	.
446	659	Ca. Mt. Tamalpais	1.00	1	1	.	.
541	659	Ca. Mt. Tamalpais	1.00	14	14	.	.
589	659	Ca. Mt. Tamalpais	1.00	1	1	.	.
621	659	Ca. Mt. Tamalpais	1.00	14	14	.	.

TABLE 1 continued

clone	seedlot	provenance	health	n.	frequency		
					#1	#2	#3
412	660	Ca. Santa Cruz	1.00	13	13	.	.
457	660	Ca. Santa Cruz	1.00	7	7	.	.
489	660	Ca. Santa Cruz	1.00	7	7	.	.
536	660	Ca. Santa Cruz	1.00	13	13	.	.
576	660	Ca. Santa Cruz	1.00	26	26	.	.
436	744	Ca. Santa Cruz	1.00	3	3	.	.
437	744	Ca. Santa Cruz	1.00	3	3	.	.
438	744	Ca. Santa Cruz	1.00	1	1	.	.
439	744	Ca. Santa Cruz	1.00	14	14	.	.
441	744	Ca. Santa Cruz	1.00	11	11	.	.
443	744	Ca. Santa Cruz	1.00	1	1	.	.
444	744	Ca. Santa Cruz	1.00	5	5	.	.
577	641	Or. Fourmile	1.04	27	26	1	.
604	580	Or. Coos Bay	1.04	24	23	1	.
620	658	Ca. Stewart Point	1.04	24	23	1	.
613	647	Ca. Mad River	1.04	23	22	1	.
614	647	Ca. Mad River	1.05	22	21	1	.
587	660	Ca. Santa Cruz	1.05	22	21	1	.
600	523	Or. Siuslaw	1.05	19	18	1	.
535	631	Wa. Snohomish	1.06	18	17	1	.
537	642	Ca. Berteleda	1.06	18	17	1	.
415	660	Ca. Santa Cruz	1.06	17	16	1	.
407	642	Ca. Berteleda	1.07	15	14	1	.
442	744	Ca. Santa Cruz	1.07	15	14	1	.
637	627	Or. Tahkenitch	1.07	14	13	1	.
595	282	NZ Ashley	1.08	26	25	1	.
572	401	Wa. Wiskah	1.08	13	12	1	.
424	494	Wa. Granite Falls	1.08	13	12	1	.
452	660	Ca. Santa Cruz	1.08	13	12	1	.
564	282	NZ Ashley	1.08	12	11	1	.
599	518	Wa. Olympic	1.08	12	11	1	.
427	518	Wa. Olympic	1.09	11	10	1	.
494	641	Or. Fourmile	1.09	11	10	1	.
585	649	Ca. Dehaven	1.09	32	30	1	1
597	518	Wa. Olympic	1.10	21	19	2	.
570	494	Wa. Granite Falls	1.10	10	9	1	.
593	494	Wa. Granite Falls	1.10	10	9	1	.
546	622	Or. Langlois	1.10	20	19	1	.
622	660	Ca. Santa Cruz	1.11	19	17	2	.
408	631	Wa. Snohomish	1.11	9	8	1	.
612	642	Ca. Berteleda	1.11	18	16	2	.
636	621	Or. Bandon	1.12	17	15	2	.
422	517	Wa. Snoqualmie	1.13	8	7	1	.
559	.	NZ Ashley	1.13	31	27	4	.

TABLE 1 continued

clone	seedlot	provenance	health	n.	frequency		
					#1	#2	#3
633	593	NZ Ashley	1.13	15	13	2	.
525	647	Ca. Mad River	1.13	15	13	2	.
483	659	Ca. Mt. Tamalpais	1.13	15	13	2	.
586	654	Ca. Fort Bragg	1.14	22	19	3	.
584	635	Or. Florence	1.14	50	43	7	.
405	641	Or. Fourmile	1.14	7	6	1	.
402	642	Ca. Berteleda	1.14	7	6	1	.
491	647	Ca. Mad River	1.14	7	6	1	.
615	649	Ca. Dehaven	1.14	14	12	2	.
458	654	Ca. Fort Bragg	1.14	14	12	2	.
487	660	Ca. Santa Cruz	1.14	7	6	1	.
440	744	Ca. Santa Cruz	1.15	20	17	3	.
482	659	Ca. Mt. Tamalpais	1.15	13	11	2	.
635	919	NZ Kaingaroa	1.16	19	16	3	.
560	.	NZ Ashley	1.16	31	26	5	.
606	631	Wa. Snohomish	1.17	12	10	2	.
460	641	Or. Fourmile	1.17	6	5	1	.
547	627	Or. Tahkenitch	1.18	17	14	3	.
567	518	Wa. Olympic	1.18	11	9	2	.
539	654	Ca. Fort Bragg	1.19	16	14	1	1
608	636	Or. Deadwood	1.19	21	17	4	.
592	584	Or. Olney	1.19	26	22	3	1
561	.	NZ Ashley	1.20	30	25	4	1
571	282	NZ Ashley	1.20	5	4	1	.
466	518	Wa. Olympic	1.20	5	4	1	.
485	654	Ca. Fort Bragg	1.20	20	16	4	.
527	580	Or. Coos Bay	1.21	14	11	3	.
542	621	Or. Bandon	1.21	14	11	3	.
610	641	Or. Fourmile	1.21	28	23	4	1
493	649	Ca. Dehaven	1.21	14	12	1	1
420	654	Ca. Fort Bragg	1.21	14	12	1	1
432	654	Ca. Fort Bragg	1.21	14	11	3	.
573	647	Ca. Mad River	1.22	27	23	2	2
582	649	Ca. Dehaven	1.22	9	8	1	.
562	282	NZ Ashley	1.23	13	11	1	1
583	647	Ca. Mad River	1.23	13	10	3	.
568	523	Or. Siuslaw	1.24	17	13	4	.
605	584	Or. Olney	1.25	24	21	3	.
607	635	Or. Florence	1.25	20	16	3	1
554	.	NZ Ashley	1.26	27	20	7	.
557	.	NZ Ashley	1.27	15	11	4	.
602	401	Wa. Wiskah	1.27	15	12	2	1
596	282	NZ Ashley	1.27	11	8	3	.
601	517	Wa. Snoqualmie	1.27	11	8	3	.

TABLE 1 continued

clone	seedlot	provenance	health	n.	frequency		
					#1	#2	#3
529	584	Or. Olney	1.27	11	8	3	.
533	636	Or. Deadwood	1.27	11	9	1	1
524	654	Ca. Fort Bragg	1.27	11	9	1	1
563	518	Wa. Olympic	1.28	18	14	3	1
431	654	Ca. Fort Bragg	1.29	7	5	2	.
578	636	Or. Deadwood	1.30	23	18	3	2
598	518	Wa. Olympic	1.32	19	14	4	1
429	523	Or. Siuslaw	1.33	6	5	1	.
498	631	Wa. Snohomish	1.33	15	11	3	1
486	658	Ca. Stewart Point	1.33	9	7	1	1
538	658	Ca. Stewart Point	1.33	9	7	1	1
540	660	Ca. Santa Cruz	1.33	12	8	4	.
558	.	NZ Ashley	1.34	29	19	10	.
544	593	NZ Ashley	1.35	17	13	2	2
467	517	Wa. Snoqualmie	1.36	11	7	4	.
403	636	Or. Deadwood	1.37	19	14	3	2
603	580	Or. Coos Bay	1.38	29	20	7	2
468	282	NZ Ashley	1.38	13	9	3	1
492	654	Ca. Fort Bragg	1.39	18	14	1	3
609	636	Or. Deadwood	1.39	23	15	7	1
464	584	Or. Olney	1.40	5	4	1	.
590	636	Or. Deadwood	1.40	5	3	2	.
409	635	Or. Florence	1.41	17	11	5	1
565	494	Wa. Granite Falls	1.42	12	8	3	1
426	518	Wa. Olympic	1.43	14	9	4	1
461	635	Or. Florence	1.44	18	10	8	.
566	401	Wa. Wiskah	1.45	11	7	3	1
579	636	Or. Deadwood	1.46	24	14	9	1
581	642	Ca. Berteleda	1.48	40	25	11	4
470	401	Wa. Wiskah	1.50	6	3	3	.
471	523	Or. Siuslaw	1.50	2	1	1	.
404	580	Or. Coos Bay	1.50	10	6	3	1
414	584	Or. Olney	1.50	16	9	6	1
522	649	Ca. Dehaven	1.50	18	10	7	1
418	659	Ca. Mt. Tamalpais	1.50	2	1	1	.
634	622	Or. Langlois	1.53	19	11	6	2
548	919	NZ Kaingaroa	1.53	19	10	8	1
465	518	Wa. Olympic	1.57	7	4	2	1
526	642	Ca. Berteleda	1.57	14	8	4	2
484	642	Ca. Berteleda	1.60	15	8	5	2
580	580	Or. Coos Bay	1.61	33	15	16	2
523	660	Ca. Santa Cruz	1.62	13	6	6	1
496	642	Ca. Berteleda	1.65	17	9	5	3
534	647	Ca. Mad River	1.65	17	7	9	1

TABLE 1 continued

clone	seedlot	provenance	health	n.	frequency		
					#1	#2	#3
569	517	Wa. Snoqualmie	1.67	9	4	4	1
495	584	Or. Olney	1.67	18	9	6	3
500	636	Or. Deadwood	1.67	18	8	8	2
419	658	Ca. Stewart Point	1.67	3	1	2	.
423	282	NZ Ashley	1.69	16	6	9	1
428	494	Wa. Granite Falls	1.69	13	6	5	2
411	636	Or. Deadwood	1.86	14	4	8	2
417	659	Ca. Mt. Tamalpais	1.88	8	2	5	1
532	636	Or. Deadwood	1.90	10	3	5	2
435	744	Ca. Santa Cruz	2.00	2	1	1	.
454	580	Or. Coos Bay	2.50	2	1	1	.