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Assessment of 2009 Cypress Clonal Block Plantings

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EXECUTIVE SUMMARY

The ability to produce and plant out many copies of an outstanding tree is the ultimate goal of tree growers. For most forest tree species it has proved difficult to overcome problems of producing good root systems on cuttings from older plants while competing with the minimal costs of seedling plants. Cypresses have proved more amenable to multiplication by cuttings than pines, but still pose problems for nursery staff.

Leyland cypresses have been propagated by cuttings for a hundred years, but it takes time to produce large plants with good root systems, and that makes the plants expensive. Research at Scion nurseries identified techniques to produce vigorous plants in a single year from young stool plants, but percentage of rooted plants dropped off with age for many clones. In the early 2000s researchers sowed seed from progeny-tested parents and set up large scale clonal trials for *C. lusitanica* and *C. macrocarpa*. Field trials were planted in 2002 and 2003 and assessed in 2007 (*C. lusitanica*) and 2012 (*C. macrocarpa*). Meanwhile the stool-plants had been kept by hedging, and cuttings were set from the better clones to trial rooting hormones and propagation facilities.

A large scale propagation trial was set up in 2008. Eight hundred cuttings were taken from each of the best performed clones of both *C. Lusitanica* (15 clones) and *C. Macrocarpa* (18 clones) and set in the Scion propagation facility. Most *C. lusitanica* clones furnished hundreds of vigorous plants, but the *C. macrocarpa* clones had become much more difficult to propagate than they were in 2002.

Establishment was good, overall survival exceeding 90% for both species. No canker symptoms were seen and the trees are now much taller (at just over three metres in height) than any weeds. Tree form was very good except for one *C. lusitanica* clone where the top metre of the leaders lacked apical dominance. That clone was not released to FFR members.

The *C. lusitanica* clones that were released to FFR members are performing well, with the best clone now averaging 3.7 metres tall at 3.5 years of age. The site had been windrowed with five rows of trees between windrows. Tree growth is significantly better in the rows adjacent to the windrows. The *C. lusitanica* x *Ch. nootkatensis* hybrid seedlings look very good and are similar in size to the trial average, as are two rows of the Ovensii clone in the adjacent commercial planting.

The FFR Diversified Species Theme has made hybrid crosses between different cypress species using selected parents from genetic trials. Selections were made from the best formed plants, and these were set up as stool-plants in the Scion nursery. The stool-plants are now large enough to propagate hundreds of cuttings this winter.

This clonal trial will be excellent for demonstrations and for future growth and wood quality assessments, which will inform future breeding and clonal development and/or deployment.

INTRODUCTION

Cupressus macrocarpa and *C. lusitanica* have been identified as cypress species that are well suited to New Zealand climate and soils. *C. macrocarpa* is the most well-known, but its growth in the warmer sites has been compromised by cypress canker[1] (*Seiridium unicorne*, *S. cardinale* and *S. cupressi*), and *C. lusitanica* is therefore preferred for planting.

Improvement programs were set up for both species by John Miller in the early 1980s[2] and progeny trials were planted out. The improved quality of the trees in the progeny trials was noted early on and cuttings were taken from some of the best phenotypes in 1990 for vegetative propagation. Clonal trials of 20-30 clones and seedling controls were planted from 1991 onwards, but most of the clones developed problems of canker, poor growth or poor form. In 2000 larger scale clonal trials were planned.

Second generation selections had been made in the progeny trials in the late 1990s. Seed was collected from the second generation selections for planting progeny trials, and was also available to set up stool-plants for clonal trials. Seedlings were raised in containers, then 15 seedlings from each of 21 *C. lusitanica* families were lined out as potential stool-plants in 2000. Forty cuttings were taken from each stool-plant in 2001, and the best 10 clones from the best 15 families (selected for ease of propagation) were planted into clonal trials in 2002[3]. The stool-plants were then hedged back annually and kept for further research on propagation.

The process was repeated for *C. macrocarpa,* and clonal trials were planted in 2003, 2004 and 2005 using seed from selected trees from families that showed resistance to cypress canker. Inoculation studies were carried out on surplus plants that were potted up in the nursery in 2002 and 2003 to try to identify clones with resistance or immunity to canker. However, while the inoculation studies showed significant differences between the damage caused by the different canker strains, results for clones varied greatly from year to year.

Early assessments were made in the clonal trials at age three, and some promising clones were provisionally selected. These clones were used for further research in vegetative propagation, culminating in a large scale propagation trial in 2008. Eight hundred cuttings were set from each stool-plant, and some produced large numbers of rooted plants. Rooting percentages and plant vigour were very good for most of the *C. lusitanica* clones, but the numbers of plants from the *C. macrocarpa* clones were nowhere near as good as those produced by the first propagations in 2003 and 2004.

The *C. lusitanica* clonal trials had a comprehensive assessment in 2007-2008.The final assessment of the *C. macrocarpa* trial was delayed until 2012 to capture the cumulative effect of nine years of infection by cypress canker.

The *C. lusitanica* clones were released to nurseries who were FFR members for commercial propagation, but thousands of good cypress plants needed a home. It was decided to plant them out in large 100-tree blocks to create a resource for long term evaluation. Kaingaroa Timberlands agreed to host them and offered an almost flat site with a gentle East / West slope in compartment 179 in Kaingaroa Forest where radiata pine had just been harvested.

This area near the western boundary of Kaingaroa Forest had been cleared for grazing by the Lands department in the 1920s.However, it was handed to the Forest Service to plant with trees when unacceptable numbers of cattle kept dying from unknown causes. The cattle deaths were eventually traced to cobalt deficiency which could have been easily corrected by fertilising. However, the organic enrichment of the soil from the conversion into improved pasture and the grazing has made this part of Kaingaroa better suited to growing cypresses than other parts where trees were planted into areas cleared of manuka and bracken and the organic topsoil layer was thin.

The logging slash on the site had been cleared into windrows running roughly East/West with clear bays of about 15 metres between windrows – enough room for five rows of trees. Pegs were put in at 30-metre intervals down either side of every second cleared bay, and the trees were planted at a spacing of 1111 stems per hectare (3 metres by 3 metres) in July 2009. Seven of the 57 100-tree blocks were planted as 10-tree clonal rows featuring all clones to provide a short term (<10 years) demonstration of clonal differences. Some clones had only enough plants for 10-tree demonstration rows while others had enough for five 100-tree blocks.

Extra seed of a cypress hybrid of *C. lusitanica* crossed with *Chamaecyparis nootkatensis* had been sown to furnish plants for the 2008 cypress hybrid trial. The extra seed was not sown early enough to grow the plants large enough for planting in 2008, so they were available for this trial. There were enough plants for one 100-tree block of hybrids. The area to the south of the clonal blocks was planted with 1/1 cuttings from the Ovensii clone, which was the same hybrid cross (but with different parents) as the hybrid seedlings.

Table 1 lists the details of the *C. macrocarpa* clones and Table 2 lists the details of the *C. lusitanica* clones. Some clones share the same mother. Figure 1 shows the origins of the clones and Figure 2 shows the layout of the clonal blocks.

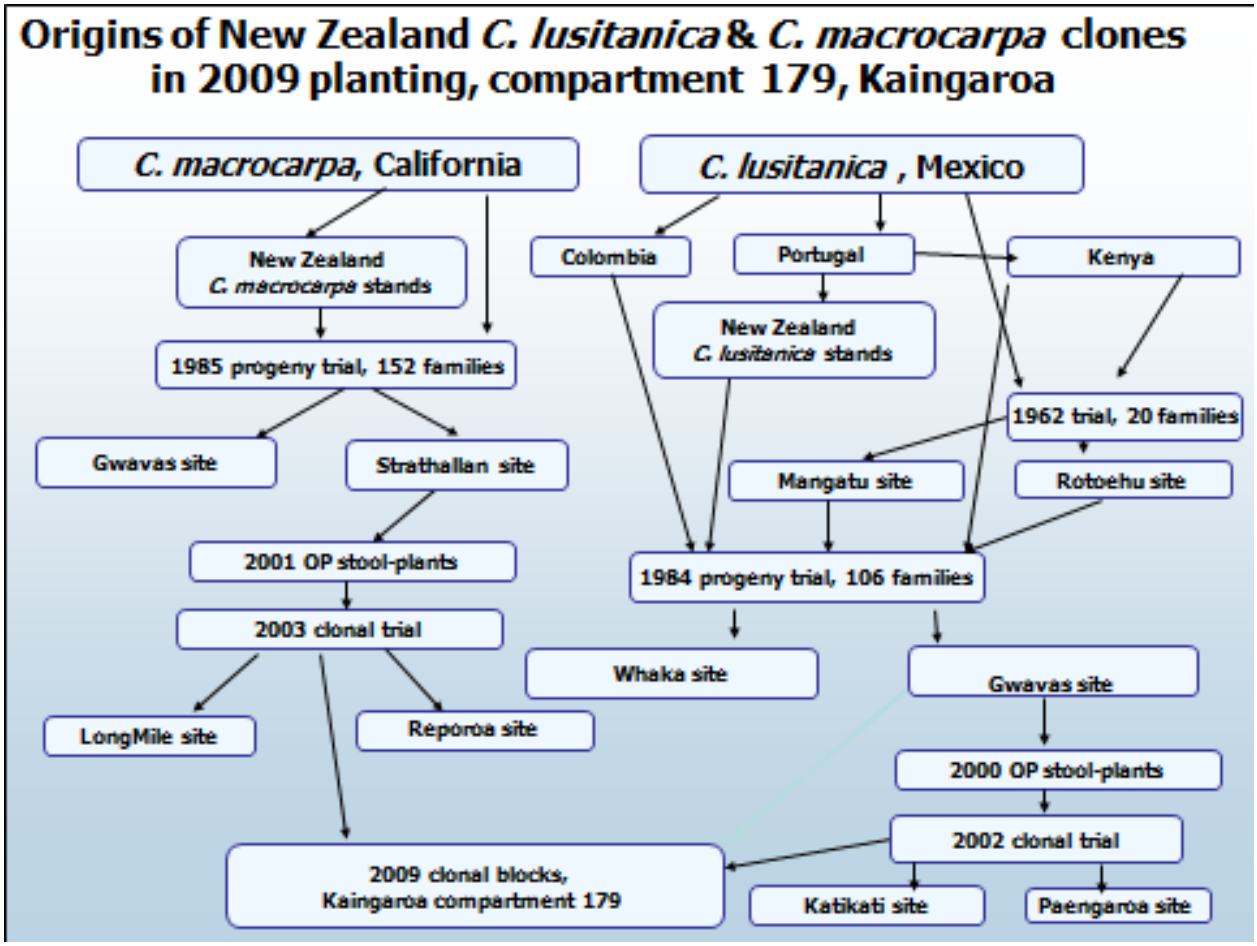

Figure 1. The origin of the clones

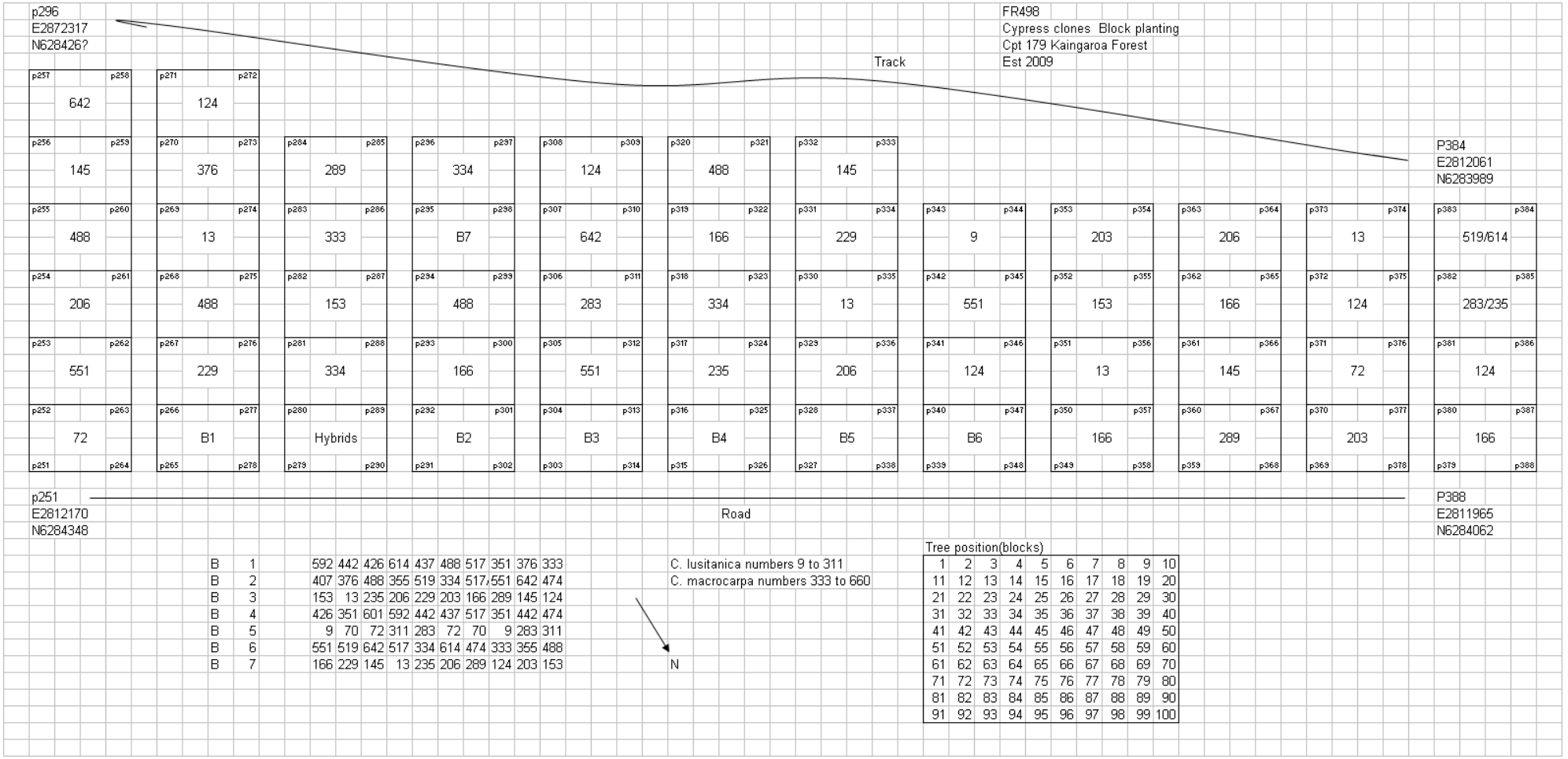

Figure 2. Layout of clonal blocks

Table 1. Clones and numbers of blocks for *C. macrocarpa*

C. macrocarpa clones				Block type	
Code	**Family**	**Clone**	**Family**	**100-tree blocks**	**10-tree rows**
333	3	3	294	1	2
334	3	4	294	3	2
351*	4	6	300	0	3
355	4	10	300	0	2
376	6	1	253	1	2
407	9	2	275	0	1
426*	10	6	263	0	2
437*	11	2	265	0	2
442	11	7	265	0	3
474	14	9	325	0	3
488	17	8	316	4	3
517*	20	7	297	0	4
519*	20	9	297	0.5	1
551	22	11	268	3	2
592	32	7	305	0	2
601	33	1	254	0	1
614*	33	14	254	1.5	2
642*	36	12	273	2	2

* clones that performed well in the 2012 assessment of the 2003 trial

Table 2. Clones and numbers of blocks for *C. lusitanica*

C. lusitanica clones				Block type	
Code	**Fam**	**Clone**	**Family**	**100-tree blocks**	**10-tree rows**
9*	1	9	18	1	2
13*	1	13	18	4	1
70*	5	10	44	0	2
72*	5	12	44	1	2
124*	9	4	49	5	2
145*	10	10	53	3	2
153*	11	3	67	2	2
166	12	1	85	5	2
203*	14	8	603	2	2
206*	14	11	603	3	2
229	16	4	605	2	2
235	16	10	605	1.5	2
283*	19	13	625	1.5	2
289	20	4	628	2	2
311	21	11	632	0	2

* Clone released to commercial nurseries by FFR

METHODS

Assessment

Previous experience with cypress clonal trials indicated that it would not be necessary to assess all trees in a 100-tree block of the same clone to get a good estimate of clonal means. It was decided to assess all trees in the 10-tree row plots, but only the trees in the central column of each cleared bay to furnish 20 trees per 100-tree block. This would also allow the assessors to look at the trees in the two columns either side of the central column and spot any problems over the entire trial.

The trees were assessed over 21- 22 January 2013. Total tree height was measured to the nearest 10 cm by height pole, and trees were rated for acceptability where 1 is an acceptable tree and 0 is used for trees rated as unacceptable for reasons of poor performance in any of growth rate, stem straightness, malformation, breakage or health. All trees in the demonstration blocks were assessed, along with 20 trees from each 100-tree block (columns 3 & 8). Twenty trees of the adjacent planting of the Ovensii clone were also assessed.

Analysis

The trial layout had been planted to provide demonstration rows close to the road and to intermix the 100-tree blocks of *C. lusitanica* and *C. macrocarpa* clones (Figure 1). Where clones had multiple blocks, these were spread across the layout as much as possible. Previous trials of cypress progenies had shown that it can be impossible to allocate replicates to differing microsites, so formal replication was not tried. The 100-tree blocks were assigned to a row and column layout initially, then individual row and column positions were assigned to each tree.

The data were analysed with a model featuring clones within species, but there was no difference between species. The data were then analysed for each species separately to note clonal differences within species. The first analysis considered the effect of row and column tree positions, but there appeared to be little spatial effect, possibly because only two columns of trees were assessed out of ten columns per block. A second analysis considered the effect of the rows and columns of blocks.

The data were analysed by species as randomised complete blocks with rows and columns of blocks assigned as random effects and clone a fixed effect. The effect of columns was not significant and caused problems with the analysis of the *C. macrocarpa* clones, so this effect was dropped. A second analysis looked at the demonstration rows only and looked at the effect of column within bay to see whether columns that were sheltered by windrows had an advantage over columns without shelter. The unbalanced nature of the trial layout meant that the interaction term of clones by rows of blocks could not be included in the model.

RESULTS

The analysis for each species revealed a significant growth gradient where the tallest trees were found in the blocks that were near the road (row 6) and growth declined with distance from the road (rows 1 & 2). F tests are shown in Table 3 for the *C. macrocarpa* clones and Table 4 for the *C. lusitanica* clones.

Table 3. F tests from analysis of variance for *C. macrocarpa* clones

Source	DF	F tests	
		Height	Acceptability
Row	4	6.56***	6.99***
Clone	17	4.66***	3.06***
Error	650		

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$

Table 4. F tests from analysis of variance for *C. lusitanica* clones

Source	DF	F tests	
		Height	Acceptability
Row	5	2.83*	4.78***
Clone	14	21.48***	12.97***
Error	879		

The analysis showed that there were significant differences between clones and significant differences between the rows of blocks. Consequently it was decided to estimate least squares means for both rows of blocks (Tables 5 & 6) and clones (Tables 7 & 8) for each species. The clone means were adjusted for row differences and were slightly different from the straight arithmetic means that could be compared by the Tukey test option in Tables 9 & 10.

Table 5. Least squares means (LS mean) and their standard error (S.E.) for *C. macrocarpa* clones by row of blocks.

row	Height (metres)		Acceptability	
	LS mean	S.E.	LS mean	S.E.
1	2.85	0.14	0.51	0.12
2	2.94	0.08	0.58	0.07
3	3.06	0.07	0.57	0.06
4	3.04	0.07	0.67	0.06
5	3.32	0.09	0.84	0.07
6	3.25	0.03	0.83	0.02

Table 6. Least squares means (LS mean) and their standard error (S.E.) for *C. lusitanica* clones by row of blocks.

Row	Height (metres)		Acceptability	
	LS mean	S.E.	LS mean	S.E.
1	2.83	0.16	0.49	0.13
2	2.99	0.09	0.59	0.08
3	3.25	0.05	0.71	0.04
4	3.01	0.06	0.71	0.05
5	3.24	0.05	0.78	0.04
6	3.16	0.05	0.74	0.04

Table 7. Least squares means (LS mean) and their standard error (S.E.) for *C. macrocarpa* clones

Clone	Height (metres)		Acceptability	
	LS mean	S.E.	LS mean	S.E.
333	2.93	0.09	0.58	0.07
334	3.12	0.06	0.71	0.05
351	2.93	0.10	0.73	0.08
355	2.95	0.11	0.33	0.10
376	3.18	0.09	0.83	0.07
407	2.99	0.16	0.63	0.13
426	3.39	0.11	0.73	0.10
437	3.17	0.12	0.61	0.10
442	3.13	0.10	0.80	0.08
474	2.76	0.10	0.50	0.08
488	3.14	0.05	0.63	0.05
517	3.16	0.09	0.76	0.08
519	2.54	0.10	0.48	0.08
551	3.16	0.07	0.65	0.06
592	3.15	0.11	0.73	0.10
601	3.41	0.16	0.72	0.14
614	3.14	0.10	0.69	0.08
642	3.16	0.07	0.86	0.06

Table 8. Least squares means (LS mean) and their standard error (S.E.) for *C. lusitanica* clones

Clone	Height (metres)		Acceptability	
	LS mean	S.E.	LS mean	S.E.
9	2.56	0.10	0.57	0.09
13	2.87	0.08	0.63	0.07
70	3.29	0.13	0.90	0.11
72	2.96	0.09	0.79	0.08
124	2.94	0.05	0.71	0.04
145	2.99	0.08	0.62	0.07
153	3.73	0.09	0.92	0.07
166	2.88	0.06	0.61	0.05
203	3.15	0.08	0.71	0.07
206	2.84	0.08	0.73	0.07
229	3.45	0.09	0.54	0.08
235	3.14	0.09	-0.04	0.08
283	3.29	0.09	0.83	0.07
289	2.67	0.08	0.58	0.07
311	3.44	0.13	0.95	0.11

In general, the trees have established well and little damage from strong winds or animal browsing was evident. Survival was good with most clones at 90% or better, and the worst clone at 78%. No symptoms of cypress canker were seen. Crown and stem form were also good, with most clones

achieving more than 50% acceptable stems, the main reason for rejection being small size (less than 2.5 metres in height). One notable exception was *C. lusitanica* clone 235, which scored only 20% acceptable stems. Clone 235 showed early signs of plagiotropism and all ramets currently feature the top 50-100 cm of the leader tip at right angles to the vertical (Figure 3). More typically well-formed trees are shown in Figure 4 (*C. lusitanica*) and Figure 5 (*C. macrocarpa*).

Table 9. *C. macrocarpa* clone means

Clone	Number of trees		Survival	Height (metres)			Accept
	Visited	Assessed	%	Mean[1]	Min	Max	(0-1)
333	40	36	90	3.01 cd	1.5	3.8	0.61 abc
334	80	76	95	3.18 abc	1.6	4.1	0.78 abc
351	30	30	100	3.10 bcd	2.4	3.8	0.90 ab
355	20	20	100	3.13 abc	2.4	3.9	0.50 c
376	40	40	100	3.20 abc	2.4	4.1	0.88 abc
407	10	10	100	3.16 abc	2.6	4.0	0.80 abc
426	20	20	100	3.57 ab	2.7	4.2	0.90 ab
437	20	18	90	3.34 abc	2.4	4.2	0.78 abc
442	30	29	97	3.30 abc	1.5	4.1	0.97 a
474	30	30	100	2.93 cd	1.6	3.8	0.67 abc
488	110	107	97	3.14 abc	1.6	4.4	0.64 abc
517	40	38	95	3.33 abc	1.8	3.8	0.92 ab
519	30	29	97	2.64 d	1.2	4.1	0.55 bc
551	80	78	98	3.32 abc	1.5	4.4	0.78 abc
592	20	20	100	3.32 abc	2.4	3.9	0.90 ab
601	10	9	90	3.58 a	3.2	4.0	0.89 abc
614	30	26	87	3.24 abc	1.5	4.0	0.77 abc
642	60	57	95	3.15 abc	1.9	4.1	0.84 abc
Least Significant Difference				0.47			0.40

[1] Clone means sharing a letter are not considered to be significantly different at $p \leq 0.05$ by the Tukey multiple range test option

Table 10. *C. lusitanica* clone means

Clone	Number of trees		Survival	Height (metres)			Accept
	Visited	Assessed	%	Mean	Min	Max	(0-1)
9	40	37	93	2.66 g	1.7	3.4	0.62 cd
13	90	85	94	2.99 efg	1.2	4.0	0.71 abcd
70	20	19	95	3.46 abc	2.8	4.3	0.95 ab
72	60	47	78	3.14 cde	1.2	4.0	0.81 abcd
124	130	120	92	2.93 efg	1.7	3.8	0.73 abcd
145	80	64	80	3.09 def	1.2	4.1	0.59 d
153	60	60	100	3.73 a	2.6	4.7	0.98 ab
166	120	113	94	2.93 efg	1.1	4.0	0.70 bcd
203	60	56	93	3.24 cde	1.6	4.1	0.79 abcd
206	80	76	95	3.01 def	1.3	4.2	0.76 abcd
229	60	59	98	3.65 ab	2.4	4.8	0.59 d
235	50	43	86	3.15 cde	1.3	4.4	0.02 e
283	50	48	96	3.33 bcd	2.0	4.4	0.90 abc
289	60	54	90	2.76 fg	1.2	3.7	0.61 cd
311	20	18	90	3.61 ab	3.1	4.3	1.00 a
Least Significant Difference				0.34			0.29

Table 11.Species means and means of hybrid seedlings and the Ovensii clone

Clone	Number of trees		Survival	Height (metres)			Accept
	Visited	Assessed	%	Mean	Min	Max	(0-1)
C. lusitanica	980	899	92	3.12	1.1	4.8	0.71
C. macrocarpa	700	673	96	3.18	1.2	4.4	0.77
Ovensii	20	19	95	3.43	2.5	4.0	0.84
Hybrid	20	20	100	3.41	2.9	4.1	0.80

There was a substantial spread of heights within species, but it may be too soon to count out clones on the basis of poor growth at this early age.

The *C. macrocarpa* clones that performed spectacularly well (614, 517, 642) after nine years of growth in the 2003 trial in the Long Mile (Figure 1) have average growth in this trial so far. However, their great advantage in the Long Mile trial lay in superior resistance to cypress canker that allowed them to grow well while their neighbours were checked and/or malformed by cypress canker.

The hybrid seedlings (Table 11) had grown faster than their *C. lusitanica* mothers in the recent assessment of the 2008 cypress hybrid trial. They were also expected to grow faster than ramets of the Ovensii clone that had got away to a good start in the 2002 *C. lusitanica* clonal trial, but then lost ground against most of the *C. lusitanica* clones. However, the hybrid seedlings have virtually identical growth to the Ovensii ramets at this stage.

The analysis of rows within cleared bays showed that the trees growing closest to the windrows were growing better than trees that were surrounded by open ground (Table 12). It is likely that some of this advantage can be explained by shelter and some may be due to extra topsoil scraped off the centre rows and deposited in the windrows. Column 5 was the best location, being immediately north of the windrow, benefitting most from the windrow sheltering the trees from the cold southerly wind.

Table 12. Column means from 10-tree demonstration plots

Column	Number	Height (metres)		
	of trees	Mean	Min	Max
1	130	3.25 ab	1.5	4.3
2	133	3.15 b	1.6	4.3
3	129	3.21 b	1.9	4.4
4	133	3.14 b	1.2	4.0
5	129	3.38 a	1.3	4.5
LSD		0.16		

Figure 3. *C. lusitanica* clone 235, showing poor apical dominance (plagiotropism)

A comparison by species (Table 13) shows that *C. lusitanica* and *C. macrocarpa* clones were very close in growth rate. The hybrids appear to be ahead in growth rate, but this was achieved by greater consistency as the smallest hybrid trees were substantially larger than the smallest *C. lusitanica* or *C. macrocarpa* trees. Individual *C. lusitanica* and *C. macrocarpa* clones were growing faster (Tables 7, 8, 9 & 10) than the hybrids. Also, the Ovensii cuttings were in the nursery for two years prior to lifting and the hybrid seedlings had been in the nursery for 19-20 months, while the ramets of the clones were one-year plants. The tallest clone was *C. lusitanica* clone 153 (released by FFR in 2011) at 3.7 metres.

Table 13. Overall species means

Species/taxa	Number of trees		Survival	Height (metres)			Accept
	Visited	Assessed	%	Mean	Min	Max	(0-1)
C. lusitanica	980	899	92	3.1	1.1	4.8	0.71
C. macrocarpa	700	673	96	3.2	1.2	4.4	0.77
Hybrids	40	39	98	3.4	2.5	4.1	0.82
Overall	1720	1611	94	3.2	11	48	0.73

Figure 4. A block of the fine-branched *C. lusitanica* clone 124

Figure 5. One of the good *C. macrocarpa* clones

CONCLUSION

This trial has established very well, with overall survival at over 90%. One *C. lusitanica* clone (235) has problems with a lack of apical dominance, resulting in poor straightness, although its performance in the 2002 trial was good. Most of the trees of all other clones have excellent stem and crown form with very few malformed or forked trees. The trial has become a good demonstration of the potential of cypress clones.

It is too early to pick certain winners. Most of the *C. lusitanica* clones that were released by FFR have grown well, particularly clone 153 that has grown faster than anything else at this stage and has good form. Clone 124 is slower growing than average, but has light branching that some growers consider to be worth a trade-off in growth rate. The clones released by FFR are in the cypress archives in the Amberley seed orchard and will be available for future crossing. There was some selection for improved wood density when choosing the parents of the clones of both species. The first ramets propagated from these clones are now 10-11 years old, so some of them will be large enough to test wood properties very soon.

No symptoms of cypress canker were observed, although some of the *C. macrocarpa* clones (333 & 334) had suffered from canker in the 2003 trial and are likely to be susceptible if and when canker appears at this site. Most of the *C. macrocarpa* clones on this site showed good resistance to canker in the 2003 trial, as did all of their parents in the 1984 progeny trial.

The block of hybrid seedlings (*C. lusitanica x Ch. nootkatensis*) are growing well and have excellent form. Some of the hybrid clones being propagated this year have the same parents, so should be just as good.

Further assessments on growth and wood quality will follow in this trial at later ages to inform on breeding and clonal development and/or deployment.

ACKNOWLEDGEMENTS

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