PO Box 1127
Rotorua 3040
Ph: + 64 7 921 1883
Fax: + 64 7 921 1020
Email:info@ffr.co.nz
Web: www.ffr.co.nz

Theme: Diverse Species

Task No: F30103 **Report No. : DS065**
Milestone Number:1.03.48

Breeding Orchard Inventory and Establishment Plan for Initial Crossing and Development of Cypress Hybrid Cuttings

Author:
Charlie Low

Research Provider:
Scion

Date: October 2013

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The forest industry would like to grow *Cupressus macrocarpa,* but many stands have been severely affected by cypress canker. We (Scion) were reluctant to advise anyone to plant it, although there are some fine stands in cooler areas in Southland. We have tried to find *C. Macrocarpa* trees that are immune to cypress canker, but have found no clones where all ramets are healthy, or any 100% healthy family. However, after many years of trying to find canker-resistant trees among those infected for at least fifteen years, we have found healthy individuals and identified families with high levels of resistance to canker.

We have now selected healthy, canker-resistant trees in infected stands, climbed them for scions, and propagated them by grafting. These *C. macrocarpa* propagules and propagules from other cypress species were established in PROSEED's Amberley orchard in 2012, where cypress flowering is much better than it is near Rotorua. There are two new archives: a *C. macrocarpa* breeding orchard comprising 100 clones in a fully randomised layout, and a hybrid archive with the "best" 20 *C. macrocarpa* clones and best available clones of *C. lusitanica*, *C. guadalupensis* and *Chamaecyparis nootkatensis* to facilitate hybrid crossing.

The plants have been assembled so that they can produce seed to form a new, canker-resistant *C. macrocarpa* breeding population and new and exciting hybrid combinations. The cypress development plan outlines general crossing themes. This document provides specific plans. One is the creation of an "elite" by controlled crossing amongst twenty best *C. macrocarpa,* and another is the creation of more Leyland clones using parents that are more resistant to canker.

It has cost a lot of time and money to select these trees and get the archives planted. The seed that will be produced from them will result in plants of the highest quality. Initial plantings will be genetic gain and progeny trials with some smaller "survival tests" for warm Northland sites. Unfortunately the plants were knocked around by the severe storm of the 11th of September 2013, so should not be stimulated for flower and pollen development until they have recovered.

The availability of new selections provided an opportunity to rogue PROSEED's production orchards to retain the ten best clones of *C. macrocarpa* and *C. lusitanica*. The gaps thus created can be filled with new selections, ensuring an adequate seed supply until the new selections get into seed production.

INTRODUCTION

A symposium run by the Forest Research Institute in 1971 identified cypresses as forest tree species that could grow well in New Zealand. Some stands of New Zealand grown *Cupressus macrocarpa* and *C. lusitanica* had produced high quality timber that could command much higher prices than pine timber.

Breeding programmes for both species were set up in 1982, and these have since provided superior trees for seed orchards and second generation progeny trials[2]. The second generation progeny trials have been assessed recently (2012-2013), and further seed orchard selections have been made. PROSEED had established seed orchards of both species in the mid-1990s, and these are ready to be rogued and the poorer parents replaced by better ones. The timeline and sites of the *C. macrocarpa* breeding programme are outlined in Figure 1, and Figure 2 provides details of the *C. lusitanica* programme.

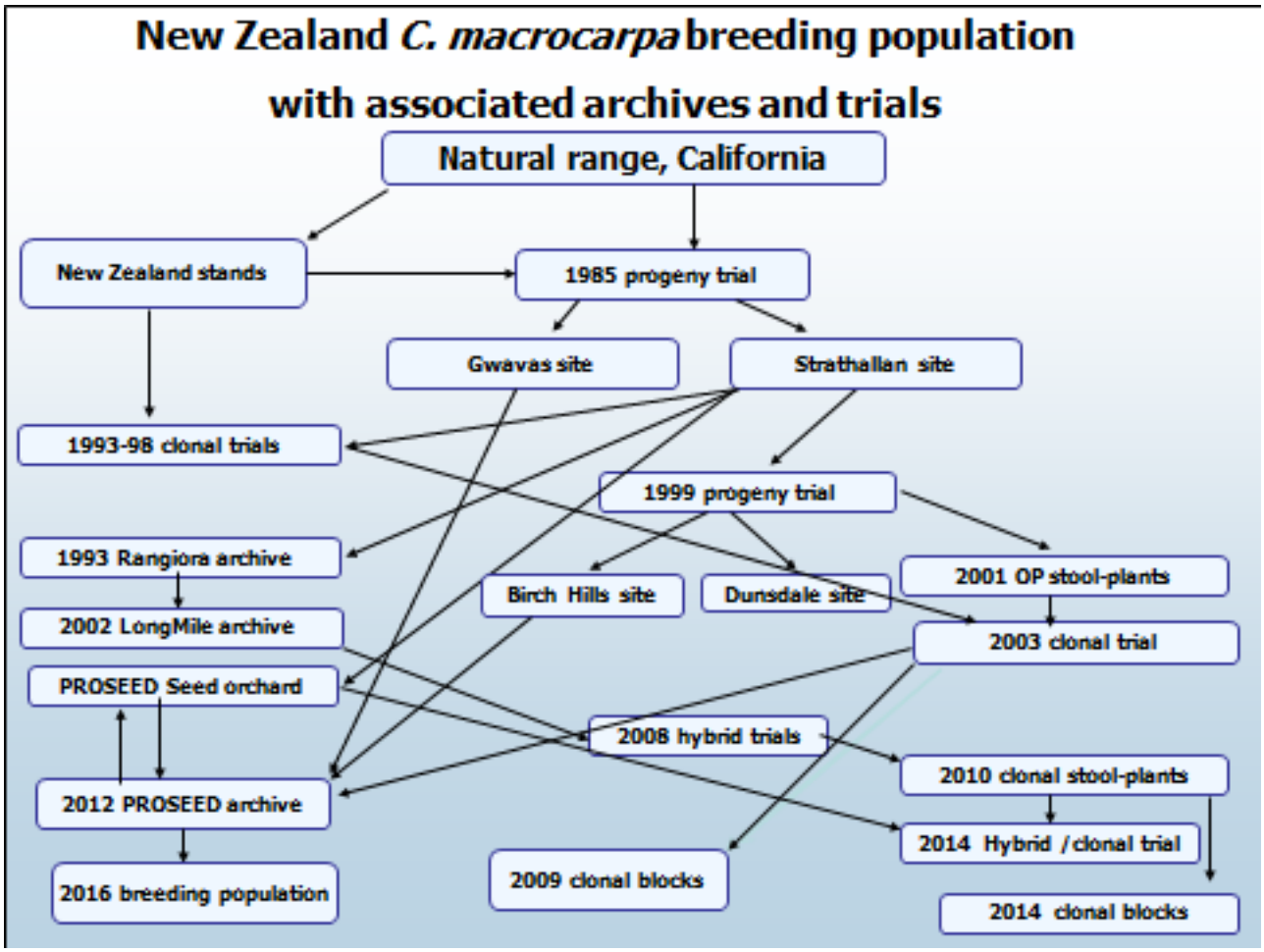

Figure 1. New Zealand *C. macrocarpa* breeding population with associated archives and trials

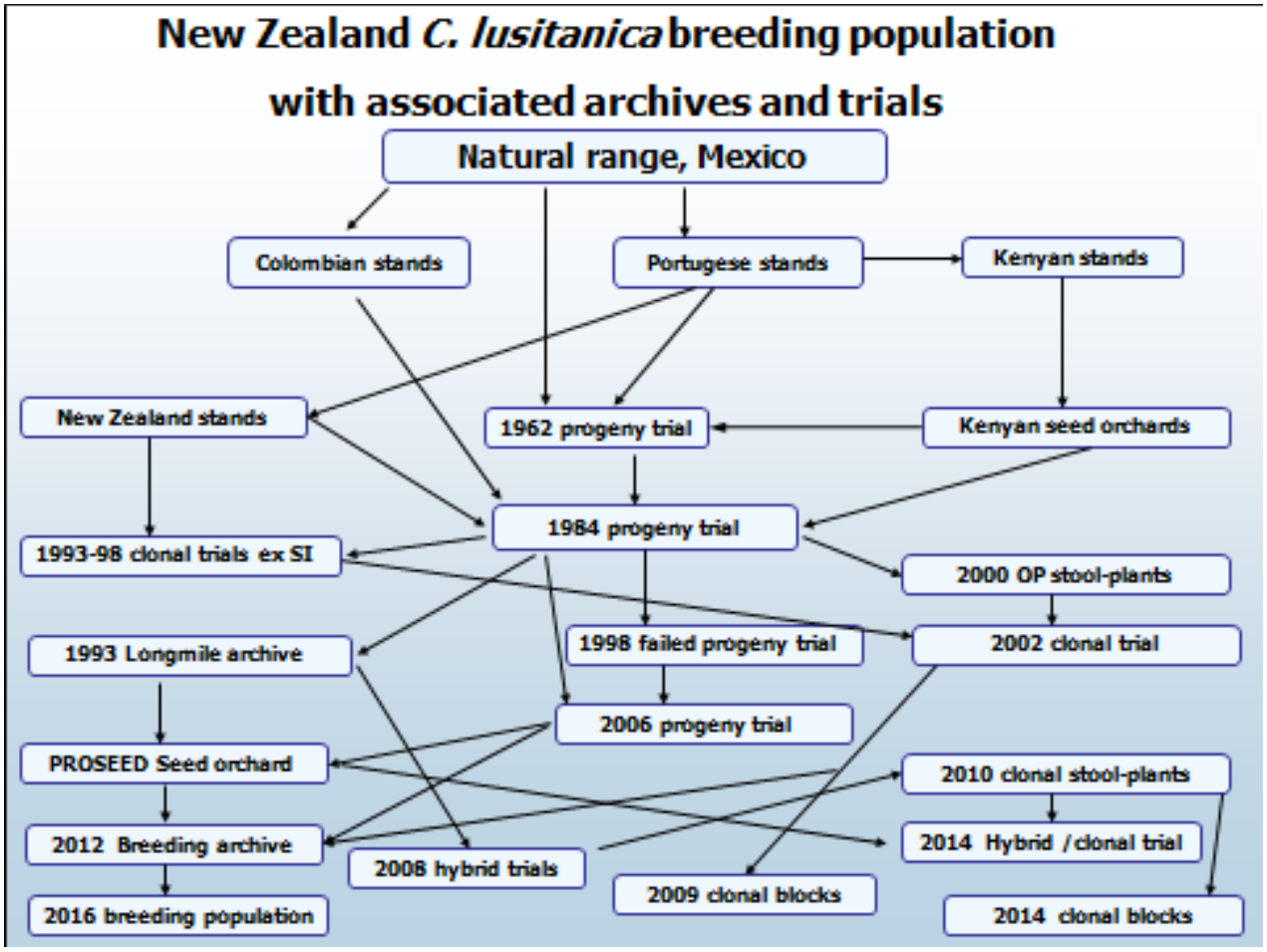

Figure 2. New Zealand *C.lusitanica* breeding population with associated archives and trials

The species in the cypress genus interbreed very readily, and early plans for cypress breeding have included plans for hybrid crosses. The original plan was to identify the best potential parents in each species, then create hybrids from these to benefit from the selection process as well as hybrid vigour. However, accidental hybrids between *C. lusitanica* and *C. macrocarpa* were found to be no more resistant to cypress canker than pure *C. macrocarpa*, so we needed at least one hybrid parent with resistance to canker.

Fortunately, John Russell sent us seed of selected *Chamaecyparis nootkatensis* from British Columbia, so we were able to establish small scale progeny trials in this species in 1996 and 1997 and select the best trees from these. Seed of the rare *C. guadalupensis* (reputed to be immune to cypress canker) had been sown with seed from *C. arizonica, C. torulosa* and *C. duclouxiana* for a cypress species trial in 1986. *C. guadalupensis* is a shy flowerer but the trees finally started to flower at age 17.

Some hybrid crosses were attempted in 2004 using trees in the Long Mile archive on Scion grounds. More were attempted using *Ch. nootkatensis* pollen shipped from British Columbia in a collaboration with John Russell in 2005, and these were successful, but very few trees were flowering. Stimulation with the gibberellin GA7 was tried and this was very successful. However, none of the team members had enough spare time to make the crosses and little land for archives was available on Scion grounds.

Cypress canker had run rampant through the warmer sites of the *C. macrocarpa* progeny trials and by 1996 we feared that it was capable of killing every tree. At Gwavas the canker infection and associated mortality were bad at age eight and twice as bad at age eleven. However, an assessment at age 19 revealed that canker was at the same level as at age 11 and several

updated shortly afterwards and it was decided to select the best of the healthy trees and install them into a breeding archive to provide open-pollinated seed for a future progeny test.

Healthy trees were mapped and the best-formed 80 were selected from a visual inspection in 2010 when the trees were 25 years old. The eighty selected trees were climbed in winter 2010 for scion material, and cones were collected. The scions were grafted and PROSEED agreed to make land available for them.

Land for planting cypress archives was made available in 2012 by PROSEED NZ. There were two main areas – a *Cupressus macrocarpa* breeding orchard designed for wind pollination, and a hybrid breeding orchard where clones were planted as rows for controlled or supplementary mass pollination. The design for the breeding orchard was produced using program COOL[1] assuming that all clones would have five ramets, leaving gaps to be filled later. There were sufficient plants to establish around 100 clones in the *C. macrocarpa* block and 40 clones into the hybrid block in winter 2012. There were shortages of plants in some clones, so there are gaps to be filled in both archives.

Some plants were very tall, and these were topped after planting to reduce the risk of damage by high winds. However an unusually wet winter culminated in the worst storm experienced in Canterbury since the “big blow” of 1975 and the plants suffered from socketing and being thrashed by the wind. Marauding hares also pruned back some of the smaller plants. The actual mortality was relatively light compared to many stands of nearly mature trees, hay barns, pivot irrigators and implement sheds that were flattened or wrecked during the storm.

The recent assessments of second generation progeny trials have resulted in new selections. This has created an opportunity to rogue out the poorer performing parents from the seed orchards and replace these with better parents.

METHODS

The maps of the archive areas and tables of tree numbers are listed as Appendices 1 through 5. Table 1 contains the clone numbers that could be crossed to form ten elite *C. macrocarpa* families. The rank numbers refer to the trial from which the trees were selected. The clones from the 2003 trial were selected several years before the final assessment and ranking, so some of the better clones exist only in the Long Mile trial.

After the flogging that the trees received from the September 2013 storm, crossing should not be attempted next year as was previously hoped. The crossing steps are as follows:

1. Mix 0.1 grams of GA3 (ProGIBB SG plant growth regulator) per litre of water (100 parts per million) and add surfactant oil at 0.25 grams (millilitres) per litre.
2. Spray GA3 solution to the foliage of the selected trees in early March, repeating at intervals of two weeks until the trees have each been sprayed four times.
3. Pollen and flowers should appear about two months after the first spray, but may not be ready for crossing until July. Readiness of pollen is signalled by some strobili starting to shed. Readiness of flowers is signalled by their swelling up, with receptivity announced by a drop of liquid exuding from the flower (pollination droplet).
4. Bag female flowers to exclude unwanted pollens. Choose a branch with many female flowers and remove all pollen strobili. Place a pollination bag over the prepared branch and wrap non-absorbent cotton wool around the stem so that the bag can be tied onto the branch, sealing it against pollen but not cutting off the flow of sap. A wire frame may be installed inside the bag to hold the surface of the bag off the flowers and provide support for the branch if required.
5. Collect and extract pollen. Wait until some strobili start to shed pollen. Cut off branches with many strobili and arrange in a flower vase in a warm room. Put the vase on a sheet of paper and leave overnight. Collect fallen pollen in the morning and store it by vacuum packing it into airtight bags.
6. When pollination droplets appear on bagged flowers, take pollen out of storage and put into a pollen puffer. Pierce pollination bag with the hypodermic needle of the pollen puffer and puff pollen upwards above the flowers, so that the pollen can fall back onto the flowers. Not all flowers will become receptive at the same time, so the process needs repeating until all flowers have produced pollination droplets.
7. Pollinated flowers will swell up quickly and the openings that permitted pollen entry will close, so that they start to look like cones. At this stage, the pollination bags can be removed.

Table 1. *C. macrocarpa* clones at Amberley that could be crossed to make ten elite families.

Female (from Gwavas)				Male (from 2003 clonal trial)			
Series	**Clone**	**mother**	**rank**	**Series**	**Clone**	**G_mother**	**rank**
2010	116	254	3	2002	642	273	11
2010	119	261	9	2002	376	253	65
2010	121	263	10	2002	660	332	58
2010	124	265	1	2002	426	263	10
2010	126	267	8	2002	614	254	1
2010	129	268	5	2002	351	300	18
2010	134	273	7	2002	442	265	7
2010	135	275	2	2002	517	297	3
2010	145	300	6	2002	519	297	4
2010	148	303	4	2002	437	265	19

RESULTS

Plans were drawn up to rogue the cypress seed orchards. There were 35 clones in the *C. lusitanica* orchard and not all were represented in the second generation trial. However, we now have clones selected from the 2002 clonal trial, and twenty new selections that were grafted up from the Welcome Bay site of the 2006 trial to choose from. The orchard is a heavy seed producer, so only the best 10 clones out of 35 will be kept, represented by 193 trees (Table 2). Table 3 lists the clones selected in the Welcome Bay progeny trial that will be planted into the seed orchard.

Table 2. Numbers of ramets for clones in the PROSEED *C. lusitanica* orchard as at 2012

series	clone	84 code	To be cut out	To remain
890	123	42	7	0
890	127	86	0	4
890	163	86	6	0
893	401	5	0	72
893	402	17	7	0
893	403	18	1	0
893	404	18	0	8
893	408	36	3	0
893	409	39	2	0
893	411	42	8	0
893	412	44	0	6
893	415	47	0	4
893	416	48	2	0
893	417	49	29	0
893	418	51	0	13
893	419	53	3	0
893	421	67	27	0
893	422	68	0	31
893	423	85	13	0
893	424	85	18	0
893	425	603	0	16
893	426	603	32	0
893	427	604	3	0
893	428	605	13	0
893	429	605	0	25
893	430	615	1	0
893	431	616	13	0
893	432	620	2	0
893	434	625	4	0
893	435	627	0	14
893	436	628	10	0
893	437	632	5	0
893	439	?	6	0
893	440	hybrid	4	0
893	441	?	1	0
Total			**220**	**193**

Table 3. *C. lusitanica* clones selected and grafted up from Welcome Bay 2006 trial for planting into rogued seed orchard

Series	Clone	F_series	F_clone	Grandmother	G_grandmother
2012	1	893	401	5	
2012	2	897	731	50	
2012	3	897	762	606	
2012	4	893	410	41	
2012	5	893	435	627	
2012	6	897	710	16	
2012	7	897	758	89	
2012	8	897	760	601	
2012	9	2004	207	893.414	45
2012	10	897	752	80	
2012	11	897	773	624	
2012	12	2004	243	893.404	18
2012	13	897	766	610	
2012	14	897	733	53	
2012	15	897	734	54	
2012	16	897	728	42	
2012	17	893	429	605	
2012	18	2004	235	893.430	615
2012	19	2004	254	890.136	614
2012	20	893	418	51	
2012	21	897	758	89	

There were 27 clones in the *C. macrocarpa* orchard, and not very many were represented in the second generation trial at Birch Hills station and Dunsdale forest. However, we now have clones selected from the 2003 clonal trial and twenty new selections that were grafted up from the Birch Hills site of the 1999 trial. There has been little demand for *C. macrocarpa* seed, so the best 10 clones out of 27 will be kept, represented by 66 trees (Table 4). Table 5 lists the clones selected in the Birch Hills progeny trial that will be planted into the seed orchard.

The seed orchard strategy will be to retain the original clones to provide a supply of seed until the new selections are in reasonable seed production. Then, the orchards should be re-visited to replace the worst of the older clones with other selected clones. Since the new propagules will not arrive at Amberley until 2014, a decision can be taken whether to plant the new propagules into the breeding / hybrid archives or the seed orchards – or both. In the case of the *C. macrocarpa*, there should have been extra plants propagated from the same clones in the hybrid archive as potential seed orchard trees, as they represent the best of the clones from Gwavas. Some of the Gwavas clones have parents whose progeny were not planted at Birch Hills.

Table 4. Numbers of ramets for clones in the PROSEED *C. macrocarpa* seed orchard as at 2012

Series	Clone	85 code	To be cut out	To remain
892	4	48	2	0
892	10	252	1	0
892	15	265	0	8
892	17	289	1	0
892	22	306	14	0
892	24	317	3	0
892	27	324	0	6
892	33	340	5	0
892	40	135	3	0
892	46	262	0	2
892	50	350	4	0
892	44	75	2	0
896	708	275	0	10
896	709	294	2	0
896	711	300	0	7
896	714	253	18	0
896	716	300	1	0
896	720	263	0	3
896	721	265	0	9
896	727	303	0	1
896	731	306	13	0
896	733		2	0
896	735	303	0	9
896	736	325	0	11
896	745	322	8	0
896	747	311	1	0
896	748	280	1	0
Total			**81**	**66**

Table 6. *C. macrocarpa* clones selected and grafted up from Birch Hills Station 1999 progeny trial for replacing clones rogued from the seed orchard

Series	Clone	F_series	F_clone	Grandmother
2012	201	892	27	324
2012	202			340
2012	203	896	863	279
2012	204	896	734	348
2012	205	896	828	299
2012	206			268
2012	207	892	1	613
2012	208			273
2012	209	896	824	619
2012	210	896	806	277
2012	211	896	712	267
2012	212			297
2012	213	896	750	332
2012	214			300
2012	215			317
2012	216	896	810	350
2012	217	896	816	328
2012	218	896	756	252
2012	219	896	870	253
2012	220			325

CONCLUSION

FFR has funded a lot of work assessing the second generation trials, selecting and grafting seed orchard candidates that were freighted to the Amberley orchard. When they start to produce seed it should be of better quality than anything presently available and ought to produce vigorous stands of healthy well-formed trees.

ACKNOWLEDGEMENTS

The author would like to thank FFR for their funding, Patrick Milne for support and encouragement, PROSEED NZ for providing land and expertise for orchards and archives and the Forest Genetics staff for assessing and analysing trials and propagating select trees.

REFERENCES

1. Bell, G. F., Fletcher A. M. (1978). Computer organised orchard layouts (COOL) based on the permutated neighbourhood design concept. *Silvae Genetica, 27*, 223-225
2. Miller, J. T. (1989). Introduced forest trees in New Zealand: Recognition, Role and Seed Source. 9. The cypresses. *FRI Bulletin, 124*.

APPENDICES

Appendix 1. *C. macrocarpa* grafts established at Amberley, June 2012

Series	Clone	CODE	Durable Tree#	Hybrid plants	Orchard plants	seed	dbh25	Index rank	Canker rank
2010	102	13			2	27	462	66	75
2010	103	57			3	5.1	496	85	97
2010	104	79			2	2.7	362	55	45
2010	105	95	20		4	43	534	14	27
2010	106	97			5	8	508	63	19
2010	107	111			5	13.6	370	67	51
2010	108	121			2	20.2	400	117	90
2010	109	126			2	0		64	41
2010	110	134			2	41.5	490	103	24
2010	111	139			1	23.7	282	96	67
2010	112	140			7	0	436	61	49
2010	113	252			6	6.7	463	33	50
2010	114	253	1	4	5	10	430	26	22
2010	115	253			4	0	406	26	22
2010	116	254	9	5	5	25.3	438	18	3
2010	117	260	17X		2	9.3	599	34	25
2010	118	260			4	14	450	34	25
2010	119	261		2	5	4.8	523	41	9
2010	120	261			6	0	442	41	9
2010	121	263		4	5	36.1	419	12	10
2010	122	263			2	8.6	371	12	10
2010	123	265			0	0.9	533	4	1
2010	124	265	2		5	44.1	489	4	1
2010	125	265			2	45	422	4	1
2010	126	267		4	5	13.5	475	16	8
2010	127	267			1	0	433	16	8
2010	128	267			2	6.7	419	16	8
2010	129	268	16		4	11.8	660	7	5
2010	130	268			5	4.7	484	7	5
2010	131	268			2	33.3	474	7	5
2010	132	269			4	24.9	408	27	20
2010	133	273			1	0	532	10	7
2010	134	273			4	27.5	450	10	7
2010	135	275	6	3	5	1.6	398	6	2
2010	136	276			3	18.3	496	29	31
2010	137	276			0	19.9	465	29	31
2010	138	277			2	20.9	545	37	39
2010	139	279			4	1.2	528	44	55
2010	140	280		5	6	12.6	650	24	28
2010	141	280			0	36.1	440	24	28

Series	Clone	CODE	Durable Tree#	Hybrid plants	Orchard plants	seed	dbh25	Index rank	Canker rank
2010	143	289			2	25	482	56	33
2010	144	294	11X	5	7	8.9	399	8	18
2010	145	300			2	9.1	630	2	6
2010	146	300	18	4	5	14	630	2	6
2010	147	302			0	0	331	73	77
2010	148	303		4	5	32.5	487	5	4
2010	149	303			0	1.5	454	5	4
2010	150	303			0	0.8	389	5	4
2010	151	305	10		2	89.6	355	28	29
2010	152	306		4	5	38.8	442	23	46
2010	153	307			2	16.4	412	62	52
2010	154	309			5	17.2	493	32	35
2010	155	311			0	0	437	21	26
2010	156	311			3	0	372	21	26
2010	157	312			8	3.6	348	47	44
2010	158	317			2	13.2	407	38	76
2010	159	319			0	0	388	36	36
2010	160	324			3	18.4	532	3	15
2010	161	324			0	0	404	3	15
2010	162	325	5		4	27	513	1	12
2010	163	325			2	5.7	443	1	12
2010	164	328		3	5	7	433	57	34
2010	165	330		1	5	1.3	439	20	30
2010	166	332	19	2	5	12.5	494	17	13
2010	167	337			3	6.3	315	93	133
2010	168	338			5	12.4	470	35	37
2010	169	339		5	9	45.3	461	69	38
2010	170	339			1	5.2	365	69	38
2010	171	340			1	2.7	368	15	53
2010	172	341		5	9	43	517	46	60
2010	173	341			3	19.8	460	46	60
2010	174	342	13X	5	9	29.8	562	11	21
2010	175	348			7	11.3	404	22	16
2010	176	351			0	18.7	560	13	40
2010	177	351	3	4	5	9.8	463	13	40
2010	178	354			4	12.2	365	45	81
2010	179	355			3	29.1	313	49	94
2010	180	357		3	5	20.1	595	88	126
D.	Hock3				5				

Appendix 2. – *C. macrocarpa* clones from the 2003 clonal trial planted into the *C. macrocarpa* breeding orchard

species	code	Fseries	fclo	#plants	series	clone	fam	cl_code
C. macrocarpa	333	882	294	5	896	706	3	3
C. macrocarpa	334	882	294	5	896	706	3	4
C. macrocarpa	348	882	300	5	896	711	4	3
C. macrocarpa	351	882	300	5	896	711	4	6
C. macrocarpa	355	882	300	5	896	711	4	10
C. macrocarpa	376	882	253	5	896	714	6	1
C. macrocarpa	407	882	275	5	896	751	9	2
C. macrocarpa	419	882	275	5	896	751	9	14
C. macrocarpa	426	882	263	5	896	720	10	6
C. macrocarpa	437	882	265	5	896	721	11	2
C. macrocarpa	442	882	265	5	896	721	11	7
C. macrocarpa	452	882	324	1	896	726	13	2
C. macrocarpa	474	882	325	5	896	728	14	9
C. macrocarpa	488	882	316	5	896	732	17	8
C. macrocarpa	504	882	342	5	892	34	18	9
C. macrocarpa	517	882	297	4	896	752	20	7
C. macrocarpa	519	882	297	5	896	752	20	9
C. macrocarpa	551	882	268	5	896	737	22	11
C. macrocarpa	592	882	305	5	896	749	32	7
C. macrocarpa	601	882	254	5	896	896	33	1
C. macrocarpa	614	882	254	5	896	896	33	14
C. macrocarpa	642	882	273	5	892	15	36	12
C. macrocarpa	660	882	332	5	892	30	37	15

Appendix 3. – *C. macrocarpa* breeding orchard layout.

Shaded cells have been planted in 2012; cells not shaded need plants to be grafted up. Most of the plants were grafted up, but were deemed not yet ready for planting in 2013. All 26 columns of trees are in a single block, but the map was cut into two sections to fit onto one page

col	26	25	24	23	22	21	20	19	18	17	16	15	14
row													
1	135	133	142	126	145	148	129	174	158	162	136	151	123
2	488	114	162	123	105	114	121	123	169	144	117	164	129
3	145	333	174	157	160	144	116	176	168	111	140	119	103
4	113	148	175	130	117	172	140	112	160	146	138	135	160
5	124	106	142	126	169	146	174	135	148	130	165	166	139
6	115	178	141	151	176	105	133	119	102	121	127	106	164
7	601	112	158	122	103	109	136	115	117	141	333	115	156
8	348	134	504	120	407	125	175	169	442	125	161	138	120
9	143	149	131	161	153	132	163	176	131	143	348	112	DH3
10	125	334	117	141	DH3	134	348	601	127	134	166	172	139
11	407	157	474	106	122	156	165	178	115	103	474	165	115
12	167	151	504	111	376	173	168	112	151	136	437	117	419
13	488	175	551	351	149	169	161	166	174	131	143	128	351
14	426	170	452	614	437	642	144	426	DH3	104	614	150	174
15	156	376	173	138	104	165	109	171	180	419	179	452	157
16	167	137	474	110	157	132	355	488	519	173	106	158	660
17	177	442	355	105	108	551	164	174	112	442	551	642	128
18	DH3	103	107	519	152	153	158	138	108	137	153	355	519
19	128	172	118	419	660	592	102	109	660	180	592	488	165
20													

col	13	12	11	10	9	8	7	6	5	4	3	2	1
row													
1	517	144	135	142	114	144	160	145	129	116	157	144	107
2	145	112	126	123	129	140	121	126	109	171	113	123	104
3	174	116	121	119	102	133	152	162	172	140	108	156	110
4	162	114	172	179	145	180	153	178	517	166	142	129	133
5	124	133	333	135	148	142	333	130	124	119	333	114	174
6	146	141	167	130	124	140	132	175	116	126	160	121	146
7	122	108	116	504	107	113	163	146	134	168	148	162	124
8	517	163	127	179	119	DH3	517	169	407	504	151	136	167
9	143	334	136	171	175	110	122	172	120	152	157	334	130
10	504	161	348	407	125	334	161	131	180	125	141	122	348
11	488	601	166	131	163	134	149	351	601	163	143	113	111
12	105	132	149	139	157	120	376	127	407	517	176	642	175
13	113	158	171	173	109	426	177	102	592	173	120	334	138
14	119	642	452	152	437	601	113	107	437	140	376	660	426
15	437	164	112	355	519	474	150	351	110	551	118	419	351
16	102	118	137	128	419	592	660	157	452	474	179	170	111
17	178	592	150	174	172	118	170	426	137	139	175	DH3	152
18	614	551	107	442	614	376	103	177	180	128	442	168	642
19	110	144	139	177	111	156	132	105	106	104	164	172	178
20		170	118	137	168	167	150	172	179	355	171	614	519

Appendix 4. *C. lusitanica* clones from the 2002 clonal trial, planted into the hybrid orchard

species	code	Fseries	fclone	#plants	series	clone	family	cl_code
C. lusitanica	9	882	18	4	897	789	1	9
C. lusitanica	13	882	18	4	897	789	1	13
C. lusitanica	72	882	44	5	893	412	5	11
C. lusitanica	93	882	47	5	893	415	7	3
C. lusitanica	124	882	49	5	897	787	9	4
C. lusitanica	145	882	53	5	893	419	10	10
C. lusitanica	153	882	67	5	893	421	11	3
C. lusitanica	166	882	85	5	893	424	12	1
C. lusitanica	203	882	603	5	897	790	14	8
C. lusitanica	206	882	603	5	897	790	14	11
C. lusitanica	229	882	605	5	893	428	16	4
C. lusitanica	285	882	625	5	897	782	19	5
C. lusitanica	289	882	628	5	893	436	20	4
C. lusitanica	311	882	632	5	897	785	21	11

Appendix 5. *C. guadalupensis* and *Ch. nootkatensis* clones planted into the hybrid orchard

species	series	clone	#plants	series	clone	Location
Ch. nootkatensis	2003	6	1	894	605	Kaingaroa cpt 1204
Ch. nootkatensis	2003	7	1	894	602	Kaingaroa cpt 1204
Ch. nootkatensis	2003	9	1	894	601	Kaingaroa cpt 1204
Ch. nootkatensis	2003	10	1	894	608	Kaingaroa cpt 1204
Ch. nootkatensis	2003	11	1	894	602	Kaingaroa cpt 1204
C. guadalupensis	2003	13	2			Long Mile, Scion
C. guadalupensis	2003	15	2			Long Mile, Scion
C. guadalupensis	2011	1	2			Gwavas cpt 55
C. guadalupensis	2011	3	2			Gwavas cpt 55