Recruitment of *Coprosma wallii* at Paengaroa Mainland Island

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DOC RESEARCH & DEVELOPMENT SERIES 299

Published by
Science & Technical Publishing
Department of Conservation
PO Box 10420, The Terrace
Wellington 6143, New Zealand

DOC Research & Development Series is a published record of scientific research carried out, or advice given, by Department of Conservation staff or external contractors funded by DOC. It comprises reports and short communications that are peer-reviewed.
Individual contributions to the series are first released on the departmental website in pdf form. Hardcopy is printed, bound, and distributed at regular intervals. Titles are also listed in our catalogue on the website, refer www.doc.govt.nz under *Publications*, then *Science & technical*.

ISSN 1176–8886 (hardcopy)
ISSN 1177–9306 (web PDF)
ISBN 978–0–478–14487–1 (hardcopy)
ISBN 978–0–478–14488–8 (web PDF)

This is a client report commissioned by Wanganui Conservancy and funded from the Science Advice Fund. It was prepared for publication by Science & Technical Publishing; editing and layout by Amanda Todd. Publication was approved by the General Manager, Research & Development Group, Department of Conservation, Wellington, New Zealand.

In the interest of forest conservation, we support paperless electronic publishing. When printing, recycled paper is used wherever possible.

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Recruitment of *Coprosma wallii* at Paengaroa Mainland Island

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ABSTRACT

This study examined recruitment of the threatened shrub *Coprosma wallii* at Paengaroa Mainland Island, Mataroa, New Zealand. This is the first comprehensive survey of recruitment of *C. wallii* seedlings in the North Island. Superficially, Paengaroa appears to offer ideal conditions for *C. wallii* seedling recruitment. However, the population at Paengaroa appeared to have a scarcity of seedlings and young plants. The present study quantified seedling density and determined which factors might be hindering seedling recruitment. An intensive search was made for seedlings around 21 mature female *C. wallii* plants: 9 inside the main reserve and 12 on adjacent land that was exposed to weed control. Seedlings were present in four of these plots, with the numbers of seedlings per plot ranging from 1 to 50. The distribution of seedlings strongly suggests that germination and growth take place in areas of disturbance and high light levels, as there were very few seedlings in parts of the forest that were established, with low disturbance and dappled light. It is concluded that *C. wallii* requires a number of conditions for germination, including high light levels, ground disturbance, moisture and fertile soils. Recommendations are made for further monitoring of seedling recruitment including quantitative measurement of environmental drivers; adaptive management to improve recruitment through spray trials, planting of cultivated seedlings and pulsed grazing regimes; the inventory of a third population; and use of dendrochronlogy to establish population age structures.

Keywords: *Coprosma wallii*, regeneration, recruitment, germination, disturbance, light gaps, Paengaroa Mainland Island

Parkinson, H.M. 2008: Recruitment of *Coprosma wallii* at Paengaroa Mainland Island. *DOC Research & Development Series 299*. Department of Conservation, Wellington. 18 p.

1. Introduction

Figure 1. *Coprosma wallii* seedling at Paengaroa.

Coprosma wallii is a robust, leafy, divaricate shrub that grows to a height of about 5 m. It is long-lived, with a lifespan of perhaps over 100 years (B. Rance, Department of Conservation (DOC), pers. comm. 2007). It fruits all year round and seeds germinate as soon as they have fallen (Bishop 2005). Seedlings, which have hairy leaf margins and stalks (Fig. 1), can establish below the parent plant.

Field observations indicate that *C. wallii* requires ground disturbance to establish (Steffens & McGlynn 2006; S. Wotherspoon, DOC, pers. comm. 2007). This could be from a range of sources, including flooding, slips or snow damage. It also prefers high light levels and high soil fertility. It is typically found along forest margins and in areas subject to temperature inversion, including river terraces, frost flats, and colluvial toeslopes and alluvium (Wilson & Galloway 1993). *Coprosma wallii* has been recorded by the New Zealand Department of Conservation as occurring in Tongariro/Taupo, Wanganui, Wellington, Nelson/Marlborough, Westland, Canterbury, Otago and Southland Conservancies (Fig. 2).

Coprosma wallii is classified as threatened and in Gradual Decline (de Lange et al. 2004; Hitchmough et al. 2007), apparently as a result of recruitment failure and habitat loss. Recruitment failure has been attributed to competition from weeds (notably introduced pasture grasses and broadleaved perennials), browsing of seedlings by herbivores such as stock and hares, and the lack of disturbed ground for seedling establishment (Steffens & McGlynn 2006; P. Knightbridge, DOC, pers. comm. 2007; S. Wotherspoon, DOC, pers. comm. 2007).

There are three small populations of *C. wallii* at Paengaroa Mainland Island, near Taihape in the North Island. These contain mature plants, but seedlings and saplings are scarce. This study was undertaken in response to an apparent lack of *C. wallii* seedlings at Paengaroa, with a view to better understanding the circumstances in which adequate recruitment can take place.

Figure 2. Distribution of *Coprosma wallii* in New Zealand.

1.1 OBJECTIVES

Two previously monitored populations of *C. wallii* were re-examined at Paengaroa to:

- Investigate the recruitment of *C. wallii* seedlings in Paengaroa Mainland Island
- Determine whether there is a regeneration gap
- Explore possible causes of regeneration failure

2. Methods

2.1 PAENGAROA MAINLAND ISLAND

Paengaroa Mainland Island is about 8 km northwest of Taihape. It consists of two blocks of land: a Scenic Reserve (107 ha) and a smaller block of railway land (13 ha) (Fig. 3). Both are managed as a Mainland Island, to maintain the area's unique biodiversity values (Saunders 1999). The Mainland Island covers a flat terrace by the Hautapu River and a steep hillside rising from 510 m to 706 m above sea level (Burns et al. 1999). The climate is cool and dry with a high frequency of frosts (Burns et al. 1999; Ogle et al. 2000). Soils are fertile, particularly on the river terrace where Tongariro Ash overlays sedimentary rock (Campbell 1979). The environment in Paengaroa can be classified as both frost flat and flood plain, which is typical *C. wallii* habitat (Wilson & Galloway 1993).

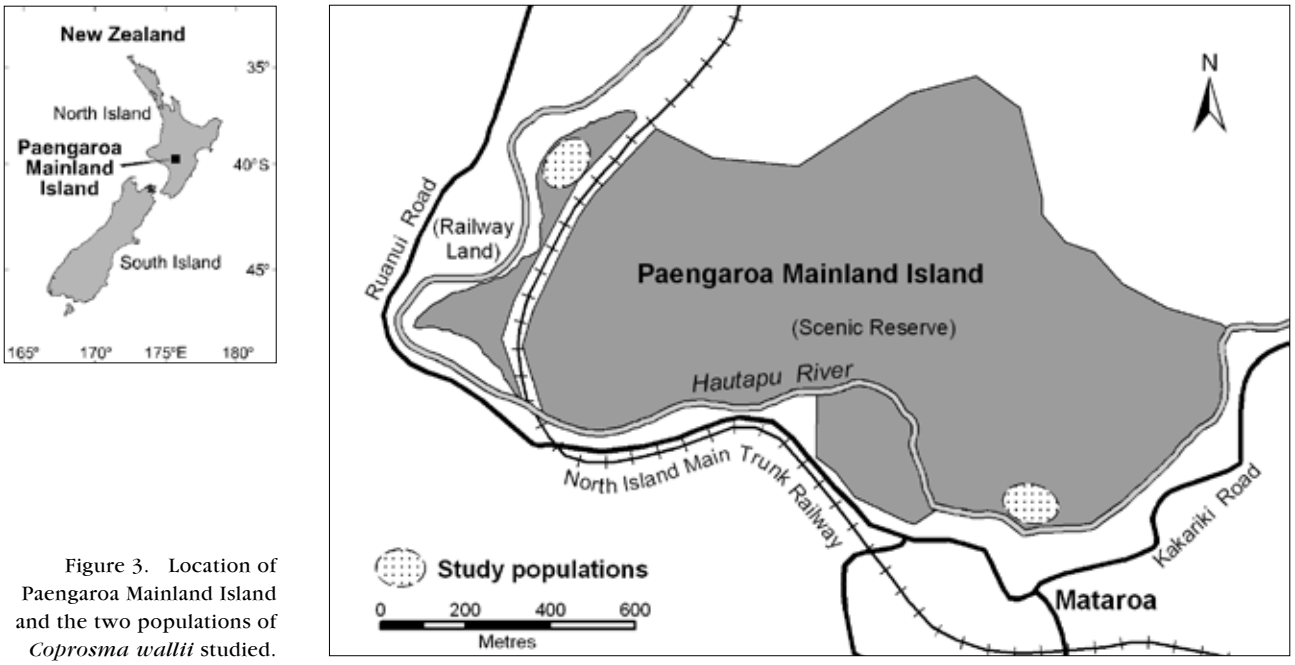

Figure 3. Location of Paengaroa Mainland Island and the two populations of *Coprosma wallii* studied.

Paengaroa is an appropriate site for this study because it has a high diversity of divaricating plants (approximately 30 species; Druce & Ogle 2002) and is important for conservation, containing *C. wallii* and eight other threatened and rare plant species (de Lange et al. 2004).

Many common alluvial broadleaved species, such as mapou (*Myrsine australis*) and tawa (*Beilschmiedia tawa*), are not found at Paengaroa. Instead, kahikatea (*Dacrycarpus dacrydioides)*, black maire (*Nestegis cunninghamii*) and matai (*Prumnopitys taxifolia*) are the emergent species, with an open subcanopy of narrow leaved lacebark (*Hoheria angustifolia*), ribbonwood (*Plagianthus regius*), kowhai (*Sophora godleyi*) and kohuhu (*Pittosporum tenuifolium* var. *tenuifolium*). Some of these are semi-deciduous and allow high light levels to reach the forest floor. These conditions, together with the cool, dry climate, are often preferred by divaricating and rare trees such as *C. wallii* (Burns et al. 1999).

The Scenic Reserve of Paengaroa has been closed to grazing since at least 1986 (Department of Lands and Survey 1986), but stock trespass was common along the river flats until the early 1990s (B. Fleury, DOC, pers. comm. 2008). The railway land has been closed to grazing since 1999. Possums (*Trichosurus vulpecula*), which are also a major threat, were controlled by poisoning with 1080 in 1992 and subsequently by trapping (Ogle & Barkla 1995).

Indigenous vegetation is threatened by weeds such as ivy (*Hedera helix*), red currant (*Ribes rubrum*), crack willow (*Salix fragilis*), Chilean flame creeper (*Tropaeolum speciosum*), spindleberry (*Euonymus europaeus*), bittersweet (*Solanum dulcamara*) and elder (*Sambucus nigra*) (DOC 1997).

2.2 STUDY METHODS

Recruitment was investigated in two populations of *C. wallii* at Paengaroa Mainland Island: one in the Scenic Reserve and one in the railway land. During the summer of 2000–2001, all *C. wallii* individuals in the two study sites were tagged and mapped. The trunk diameter of each adult tree was measured above its identification tag; an adult was defined as a tree with a diameter of over 3 cm. Sex of plants was determined by examination of flowers and fruit; where no reproductive structure could be found, sex was recorded as unknown.

Diameters of tagged plants were re-measured in 2002, 2004 and 2007. In 2001 and 2002, only the main stem of each tree was measured, but in 2004 and 2007 all other branches with diameters of greater than 3 cm at a point 1.35 m up the stem from the ground (diameter at breast height; DBH) were given new tags and measured. The existing tags were also adjusted to be at a height of 1.35 m. This meant that diameter measurements taken in 2004 and 2007 were at different heights from those taken in 2001 and 2002.

In 2007, the basal diameter of each tree was also measured, using the methods of Ecroyd (1995) and Rogers (1996). The trunk was marked at the measurement height with a nail, to allow plants to be re-measured at the same place in following years. Any new plants found were tagged, measured and mapped using GPS (Global Positioning System) and existing site maps. Plants that appeared to be dead were checked for coppicing, as at other sites it has been found that the root systems of some such plants are still alive (L. Van Dijk, DOC, pers. comm. 2007).

Nineteen plots (10 m × 10 m) were established around all known female *C. wallii* trees. Where trees were more than 1 m but less than 10 m apart, plot size was reduced so that plots were contiguous but not overlapping; this resulted in three plots being less than 100 m². In one instance, the plot was 101 m², as the canopy shadow of the *C. wallii* extended beyond the plot boundary and that area was also searched.

Typically, one plot was established for each tree, with the tree at the plot centre and the plot edges aligned with magnetic north–south and east–west. However, where two trees were close together (less than 2 m apart), two plots were established around them, centred between the two trees.

Corners of plots were marked with stakes and each plot was divided into quarters to facilitate searching. Each plot was thoroughly searched for seedlings and saplings. However, areas of mown grass were not searched, and after searches of dense rank grass in ten plots revealed very few woody seedlings, these areas were also not searched. All seedlings were counted and assigned to a height class, and up to five seedlings per plot were marked with a numbered aluminium tag and mapped on a scale drawing of the plot so that their survival could be tracked. Site conditions were also noted, e.g. the area covered in rank or mown grass, and presence of other ground cover species. The area of the plot covered by forest canopy and by adult *C. wallii* foliage was mapped, and canopy composition over any seedlings was recorded.

3. Results

Diameter measurements and mortality status of tagged trees in each survey are recorded in Appendix 1.

In the Scenic Reserve, there were 34 adult *C. wallii*, of which nine were dead. One new live tree was found and tagged in March 2007, but this did not indicate recruitment; rather, its size (DBH = 17.0 cm) indicated that it must have been present but overlooked in earlier surveys. Of the live trees of known sex, 9 were female and 14 were male, a ratio of 1:2.

In the railway land, there were 39 adult *C. wallii*, of which three were dead. Of the live trees of known sex, 13[1] were female and 23 were male, giving a similar sex ratio as found in the reserve.

Overall, annual mortality of adult trees was estimated at 3.2% over the period 2001–2007. However, rates varied during that time, being relatively low from 2001 to 2004 (less than 1% per annum) and higher from 2004 to 2007 (c. 5% per annum). No coppicing was observed during this study.

The density of *C. wallii* seedlings was mostly very low (Table 1). In the Scenic Reserve, only two seedlings were found; these occurred in two separate plots, and both were in bush edge habitat under the adult female in that plot. In the railway land, more seedlings were found, but again only in two plots: Plot 4, which contained 50 seedlings, overlapped an area that had been sprayed to promote *Olearia gardneri* growth and Plot 3 (16 seedlings) adjoined the sprayed area. The weeds present in these plots tended to be around the perimeter, leaving considerable areas of clear ground under the parent trees.

All *C. wallii* seedlings found were under 15 cm tall: three were 10 cm tall (in Plot 4), while the remaining 65 were under 5 cm.

Other native woody seedlings in the plots included kahikatea, kowhai, kaikomako (*Pennantia corymbosa*), *Parsonsia* spp., lancewood (*Pseudopanax crassifolius*), lacebark (*Hoheria* spp.), matai, other species of *Coprosma*, *Melicytus* spp., *Aristotelia* spp., *Griselinia littoralis*, kohuhu, and *Clematis* spp.

The amount of ground cover within plots was very variable. Although the density of ground cover was not quantified, its composition is shown in Table 2. Some plots had dense ground cover, dominated by shield fern (*Polystichum* spp.) and introduced species with no bare soil; the only native species growing through this cover were kowhai and kaikomako, with some kahikatea in lighter areas. Other plots had partial ground cover of weeds such as burdock (*Arctium minus*), hemlock (*Conium maculatum*) and hedge woundwort (*Stachys sylvatica*), but still had plenty of bare ground and light. The remaining plots had variable proportions of fern, grass and weed ground cover.

[1] No plot was established beneath one of these female trees.

TABLE 1. DENSITY OF *Coprosma wallii* SEEDLINGS IN PLOTS.

SITE	PLOT	FEMALE TREES	AREA (m²)	*C. wallii* COUNT	PLANTS PER 100m²
Railway land	1	2820	100	0	0.00
	2	2819	100	0	0.00
	3	2822	87.5	16	18.29
	4	2823 & 2824	93	50	53.76
	5	2815	100	0	0.00
	6	2807	100	0	0.00
	7	2713	100	0	0.00
	8	2772	100	0	0.00
	9	2715	101	0	0.00
	10	2834	100	0	0.00
	11	2830	100	0	0.00
Scenic Reserve	12	G143	100	0	0.00
	13	G141	100	1	1.00
	14	G139	69	1	1.45
	15	G137	100	0	0.00
	16	G134 & 133	100	0	0.00
	17	G126	100	0	0.00
	18	G125	100	0	0.00
	19	2791	100	0	0.00

TABLE 2. PRESENCE OF OTHER GROUND COVER VEGETATION IN PLOTS.

SITE	PLOT	*Blechnum* spp.	*Polystichum* spp.	EXOTIC GRASS	*Solanum dulcemara*	*Mycelis muralis*	*Arctium minus*	*Mimulus gulatus*	*Stachys silvatica*	*Conium maculatum*	*Rubus* spp.	NATIVE WOODY SEEDLINGS
Railway land	1			*			*			*	*	*
	2	*	*	*	*		*			*	*	*
	3	*	*	*	*		*		*	*	*	*
	4			*	*		*		*	*	*	*
	5		*	*	*		*		*	*	*	*
	6		*	*	*				*			*
	7		*	*	*		*		*	*		*
	8		*	*	*		*		*			
	9	*	*	*	*				*			*
	10		*	*	*			*	*			*
	11		*	*	*		*	*	*	*	*	*
Scenic Reserve	12			*	*	*	*			*	*	*
	13		*	*	*	*					*	*
	14	*	*	*	*	*						*
	15	*	*	*	*	*					*	*
	16	*	*	*	*	*	*			*	*	*
	17	*		*	*							*
	18	*		*	*	*	*					*
	19	*	*		*	*					*	*

4. Discussion

This is the first comprehensive survey of recruitment of *C. wallii* seedlings in the North Island. The primary objective of the survey was to determine whether there was a regeneration gap and therefore a recruitment problem for *C. wallii* in Paengaroa. The following key findings were made:

- At least some viable fruit was being produced and this had germinated at some sites
- There was large variation in the number of seedlings present (of the 68 seedlings found, only two were in the Scenic Reserve; the remainder were present in just two study plots in the railway land)
- High densities of seedlings occurred in the areas affected by spray trials
- No seedlings over 15 cm tall were found in the plots
- There was no recruitment into the adult size classes
- Of a total of 73 mature trees previously tagged, 12 had died by 2007, and there was some evidence that the mortality rate may have been increasing

In the Scenic Reserve, only two *C. wallii* seedlings were found in eight plots, despite many of these plots superficially appearing to have appropriate conditions for seedling growth (such as fruit on the trees and ground, clear ground, dappled but high light levels, and good moisture). *Coprosma wallii* may be acting as an early successional species that has already peaked at that site and is being replaced by later successional species; the bush does appear well established, with tall emergents, and thick layers of subcanopy, understorey and ground cover.

In the railway land, where more seedlings were found, subcanopy and understorey growth is younger due to the more recent exclusion of stock. At this site, some previously recorded seedlings outside the plots measured here have reached a height of 60–80 cm. These may have germinated after the removal of stock from the area in 1999, benefiting from the recent disturbance, bare ground, high light levels and, presumably, elevated soil fertility.

If the open understorey (and higher light) resulting from relatively recent stock use was the only requirement for *C. wallii* establishment, however, all plots in the railway land would have contained seedlings. In fact, most light gaps were dominated by seedlings and saplings of other species or by dense shield fern and grasses, with only a few persistent native seedlings such as kahikatea, kowhai and kaikomako. The two plots in the railway land that contained seedlings had substantial disturbance from spraying and raking, creating bare ground. Surprisingly, the major floods around Mataroa in 2004, which appear to have inundated some plots in the railway land, do not seem to have brought about a flush of seedlings. Instead, the plots that would have been affected by that disturbance are now covered in thick pasture grasses and other weeds, which have probably outcompeted *C. wallii*.

Observations made in the South Island support the conclusion that *C. wallii* seedling establishment requires weed clearance. Planted *C. wallii* seedlings have become established in stock-proofed hare-exclosure plots near Maruia; however, they require periodic hand release from exotic grasses, showing that seedlings

cannot outcompete exotic species (L. Van Dijk, DOC, pers. comm. 2007). Similarly, in the Howard Valley, some seedlings became established following the cessation of grazing, but the abundance of rank grass prevented further recruitment until areas were sprayed (these seedlings are now over 80 cm tall) (S. Wotherspoon, DOC, pers. comm. 2007).

In conclusion, it appears that *C. wallii* requires both fertile soils and high light conditions likely to be available in early successional habitats, as well as direct disturbance (to eliminate competitive exotics and expose bare soil) for seedling establishment, as has occurred in the railway land at Paengaroa.

5. Recommendations

The author recommends that:

- The plots surveyed in 2007should be re-measured in 1 or 2 years. It is possible that searching in 2007 may have caused sufficient disturbance to ground cover and litter layer to allow the recruitment of seedlings. Where possible, one person should be involved in plant monitoring from year to year, to reduce variability in measurements.
- More information should be collected from the seedling plots, including a quantitative measure of exotic grass cover, soil analysis and light measurements, to improve interpretation of these results.
- The third population of *C. wallii* on the northwestern side of the Scenic Reserve should be investigated, using the methods outlined in this report.
- Spray trials should be conducted in plots to confirm that spraying and soil disturbance improve germination. Plots selected should have no seedlings at present and rank grass surrounding the female tree (potential plots include 6, 7, 8, 10 and 11). The same chemicals and frequency of sprays should be used as for *Olearia* spray trials (Rance 2004, 2006; Steffens & McGlynn 2006). Hand release of seedlings is also recommended.
- Seed should be collected and grown on for at least 2 years, and seedlings planted out in both areas. Alternatively, seedlings from the spray plot trials could be transplanted, which would require less labour (Steffens & McGlynn 2006). Seedling planting would not only boost recruitment but would also be a good way to get the local community involved in conservation of this species and improve local knowledge of the plant.
- Pulsed grazing regimes should be considered, to provide fresh disturbance, reduce weed competition for light and moisture, and increase soil richness. It is recommended that grazing be scheduled for 1 month a year in late spring to early summer, so that it coincides with the weed growth flush but stops before peak fruit fall from *C. wallii* and other threatened plant species occurs.
- The relative importance of the seed bed versus annual seed rain (fresh seed) for recruitment should be determined.

- More work should be undertaken to better understand the tolerances and preferred establishment sites of *C. wallii*. This species does not seem to be limited to frost flats and flood plains, as it is also found on Banks Peninsula. Further work could investigate the soils and climates in various populations around the country, obtaining information about soil pH (Ecroyd 1994), soil properties, light and shade tolerances, moisture preferences, and the micro-sites of adult trees (B. Rance, DOC, pers. comm. 2007).
- Any *C. wallii* that have recently died should be aged using dendrochronlogy, and any evidence of the cause of death should be recorded, to determine whether plants had reached the end of their normal life span or had died as a result of external factors. Even if rings cannot be counted immediately, samples should be taken now before further deterioration occurs in the field. This work will also allow growth rates to be calculated, so that in the future DBH can be used to estimate plant age.

6. Acknowledgements

Thanks to Amy Hawcroft and Vivienne McGlynn for their help in the field, advice and comments on drafts of this report; Phillip Knightbridge and Brian Rance for their comments on the draft report and information about work they have conducted; and Graeme La Cock, Craig Bishop, Sandra Wotherspoon, Les Van Dijk and Wayne Reid for information about *Coprosma wallii* and work they have carried out.

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Appendix 1

STEM DIAMETERS OF *Coprosma wallii*

SITE	TAG NUMBER			DIAMETER AT BREAST HEIGHT (cm)					BASAL DIAMETER (cm)
	TREE	BRANCH	SEX	JAN 2001	JAN 2002	DEC 2002	JAN 2004	MAR 2007	MAR 2007
Railway land	O769			23.9	22.7	23.2	23.4	23.3	20.5
	B550			11.5	11.7	10.8	11.5	Dead	
		2979					4.0	Dead	
	G147		Male	16.6	16.8	16.8	17	17.1	21.4
	G146		Male	26.1	25.6	26.3		26.4	31.6
		2987					7	7.1	
	G145		Male	7.3	7.7	7.5	7.6	7.7	12.5
	G144		Male	6.7	7.8	5.0	5.5	5.8	8.9
		2979					4.9	5.1	
	G143		Female	10.8	11.2	11.8	11.8	12.4	16.8
	G142		Male	12.7	15.1	10.1	9.6	Dead	
		2980					8.2	Dead	
	G141		Female	18.1	21.0	14.5	11.7	12.2	23.9
		2981					14.3	14.4	
	G140		Male	15.1	15.2	11.0	11.0	Dead	
	G139		Female	16.2	17.4	13.7	13.8	14	18.1
		2982					10.9	10.3	
	G138			18.0	18.4	18.5	18.2	Dead	
	G137		Female	18.5	18.7	10.5	10.3	10.3	20.2
		2983					12.8	13.1	
		2984					4.3	4.7	
	G136		Male	8.6	7.1	7.1	7.3	7.6	11.9
	G135		Female	9.9	10.4	10.2	Dead		
	G134		Female	14.3	14.4	11.5	11.6	12.3	15.3
	G133		Female	10.8	10.6	10.4	10.5	11.1	12.1
	G132		Male	15.1	15.4	9.3	9.7	9.7	22.3
	G131		Male	10.8	16.1	10.7	11.1	11.1	17.5
		2985					6.9	7.0	
		2986					6.3	6.3	
	G130		Male	12.6	15.2	12.5	12.7	12.8	17.3
	G129	F*	Male				19.5	19.9	29.7
		2988					12.9	13.1	
		2989					8.1	8.3	
	G128		Male	8.0	8.0	8.1	7.9	Dead	
		2990		6.7	6.9	6.8	Dead		
	G127		Male	7.6	7.3	6.9	6.7	Dead	
		2991		6.7	6.7	6.5	6.5	Dead	
		2992					3.9	Dead	
	G126		Female	11.5	12.0	12.4	11.0	11.3	14.4
	G125		Female	17.2	19.1	15.1	15.6	15.4	25.4
		2993					5.2	5.4	
		2994		11.5	11.1	11.5	11.8	12	

Continued on next page

Appendix 1—continued

SITE	TAG NUMBER			DIAMETER AT BREAST HEIGHT (cm)					BASAL DIAMETER (cm)
	TREE	BRANCH	SEX	JAN 2001	JAN 2002	DEC 2002	JAN 2004	MAR 2007	MAR 2007
		2995					5.0	5.0	
		2996					7.6	7.7	
	G124		Male	15.3	15.6	10.3	15.3	15.6	18.0
	G117		Male	11.5	11.5	11.5	11.4	11.7	15.3
		2997		3.7	4.1	4.1	3.8	3.9	
	G116		Male	17.2		17.7	17.5	18.0	21.9
	G115		Male	16.6	14.4	14.4	14.4	Dead	
		2966					7.5	Dead	
	G114		Male	5.7	5.9	5.9	5.85	5.9	9.8
	G113		Male	8.9	9.3	9.1	9.3	9.6	12.3
	G112			4.8	5.2	5.4	4.2	5.1	
		2965					1.8	2.2	
	2791		Female	14.4	14.7	14.7	14.5	15.0	18.5
	2795		Male	10.9	12.0	11.7	10.4	Dead	
		2998		11.9	12.3	12.1	11.3	Dead	
Scenic Reserve	2821		Female	14.0	15	14.3	13.3	Dead	
	2820		Female	22.5	22.5	22.5	22.5	22.7	32.5
		2959		19.5	13.9	19.1	19.3	19.4	
	2816		Male	11.7	11.9	11.9	12.1	12.5	22.2
		2958		10.2	10.6	10.8	11.0	12.2	
	2817		Male	8.0	8.6	7.5	6.9	7.3	12.0
	2818		Male	8.5	8.6	8.8	8.5	Dead	
		2957		6.4	6.6	6.0	6.8	Dead	
		2956		7.8	8.0	8.0	7.9	7.9	20.0
	2819		Female	10.9	10.6	11.0	11.0	11.0	22.4
		2955		10.9	11.6	11.0	12.4	14.2	
	2822		Female	6.7	7.1	7.4	7.9	Dead	
		2952		25	21.6	17.9	18.6	18.8	27.3
		2951		8.5	7.6	10.7	10.4	10.5	
	2823		Female	9.6	9.8	9.9	10.2	10.7	21.1
		2950		9.6	10.0	10.1	10.4	11.3	
		2949		9.4	10.0	8.9	10.0	10.6	
	2824		Female	10	10.7	10.4	10.7	10.9	11.3
	2815		Female	16.5	16.7	13.3	13.6	13.8	19.3
		2954				9.0	9.0	10.3	
	2814		Male	23.7	16.6	16.7	16.6	16.6	24.2
		2953			11.6	11.3	11.3	11.5	
	2697		Female	3.3	5.1	3.8	4.2	6.0	7.2
	2813		Male	25.5	27.2	24.8	25.4	26.2	29.2
	2706		Female	12.3	12.3	12.3	12.0	Dead	
	2811		Male	13.1	13.4	13.1	13.4	13.7	23.1
	2807		Female	16.5	17.6	8.9	16.7	17.2	22.7
	2808		Male	6.7	7.3	7.4	7.8	9.1	11.1
	2700		Male	7.9	7.9	8.0	11.7	11.8	16.4
	2774		Male	11.5	11.5	11.8	12	12.5	16.1
	0006							17.1	18.1
	2710		Male	14.3	14.4	6.5	6.6	14.4	27.8
		2948				4.6	3.9	3.7	

Continued on next page

Appendix 1—continued

SITE	TAG NUMBER			DIAMETER AT BREAST HEIGHT (cm)					BASAL DIAMETER (cm)
	TREE	BRANCH	SEX	JAN 2001	JAN 2002	DEC 2002	JAN 2004	MAR 2007	MAR 2007
	2713		Female	7.4	7.5	8.5	7.5	7.6	13.9
		2947		9.4	9.7	24.8	9.7	10.2	
	2773		Male	18.0	19.0	17.8	18.6	18.6	23.0
		2946					4.8	4.8	
	2772		Female	15.0	15.1	15.1	15.5	15.7	21.0
	2771		Male	4.4	4.4	4.8	4.5	4.9	7.3
	2770		Male	6.2	6.1	6.8	6.6	7.7	11.5
	2769		Male	5.8	5.5	5.5	5.7	5.9	18.5
		2943		5	5	4.9	4.9	5.2	
		2944		5.3	5.3	5.2	5.3	5.4	
		2945		8.5	8.5	8.4	8.6	8.1	
	2836		Male	15.9		15.9	16	16	16
	2715		Female	18	18.7	18.1	18.2	18.5	31.8
		2942		14.3	14.6	14.7	14.7	14.2	
	2835		Male	17.3	17.1	17.2	17.3	Dead	
	2833		Male	7	7.6	6.8	7.1	7.4	10.5
	2834		Female	13.6	14.1	13.3	13.6	13.7	17.3
	2832		Male	11.3	11	13.6	11.2	11.2	14.7
	2714		Male	25.6	25.7	26.5	26.6	25.5	34.9
	2826		Male	12.5	11.5	11.6	11.5	11.7	13.6
	2827		Male	16.4	16.6	17	16.6	17.3	23.8
	2828		Male	20.8	20.9	16.5	16.5	16.9	22.9
		2940				7	7.1	7.4	
		2939				5.1	5.5	5.8	
	2830	F*	Female				12.6	13.3	25.8
		2938					12.5	14	
		2937					20.4	21.1	
	2831		Male	18	18.8	13	10.3	10.8	21
		2936				12.7	12.3	12.7	

* Branches of this tree were fused together.

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