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Front cover: A Blotched Blue-tongued Lizard *Tiliqua nigrolutea* basking. Photo by Anne Morton.
Back cover: Grass tree *Xanthorrhoea minor* flower spike, and bee. Photo by Anne Morton

Victoria's giant trees: a contemporary survey

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Abstract
Victoria's largest trees occur in the high rainfall, wet sclerophyll forests of Southern Victoria. Reaching heights of over 90 m and girths of 20 m they are of cultural, historical and scientific importance. Once relatively common in the mid to late 19th century, land clearing, logging and frequent fires over the past 160 years have greatly reduced their number. The objective of this study was to undertake a comprehensive survey of the location and condition of Victoria's remaining giant trees. A further objective was to raise the public profile of giant trees in Victoria. This work highlights the importance of forest management practices, including fire protection, which can impact on the survival of Victoria's largest trees. (*The Victorian Naturalist* **133** (2) 2016, 36–45)

Keywords: giant trees, Mountain Ash, *Eucalyptus regnans*, remnant trees

Introduction

Since the mid 19th century, Victoria's largest trees have been sought out and celebrated by naturalists (Griffiths 2001), including such notable persons as Baron Ferdinand von Mueller (Mace 1996). In recent times, old growth (>120 years old) Mountain Ash *Eucalyptus regnans* forest has been recognised for its importance in the provision of ecosystem services such as water catchment management (Vertessy *et al.* 2001) and carbon storage and sequestration (Keith *et al.* 2009; Wood *et al.* 2010). Large old *E. regnans* are keystone ecological structures which provide important habitats for arboreal mammals, birds and reptiles, especially in their late senescent stages (Lindenmayer *et al.* 2012; Lindenmayer *et al.* 2014). *Eucalyptus regnans* also holds the distinction of being the world's tallest flowering plant (angiosperm) (Tng *et al.* 2012).

In Victoria, areas of high annual rainfall (>1200 mm per year) (Lindenmayer *et al.* 1996) with deep, fertile, loamy soils provide the conditions for *E. regnans* to achieve prodigious growth rates, and this usually has been associated with producing very tall trees (Ashton 1981; Mifsud 2002). Young *E. regnans* can increase in height by up to 2 m per year for the first 20 to 25 years and can reach 80 m in height in 60 years (Ashton 1975). Once *E. regnans* reach an age of 400 years and older, these trees show their potential to become 'giants' in terms of trunk girth and wood volume in addition to height (Ashton 1976). There are living *E. regnans* which exceed 6.5 m in diameter over bark at 1.4 m above the ground (Mifsud 2015) and there is historical evidence that trees from the past vastly exceeded these figures (Forests Commission 1976; Griffiths 2001).

Prior to this study, the size, location and condition of Victoria's largest trees had not been reported. In Victoria, large trees are now recognised as giants if they exceed 4 m in diameter or 85 m in height (VicForests 2013). These dimensions are achieved by very few trees as shown by Lindenmayer *et al.* (2014), who during ~30 years of surveying over 1550 large old trees in Victorian Mountain Ash forest, found only four trees that met these proportions. At a broad spatial scale the scarcity of very large *E. regnans* is explained by the requirement for a growth period (>400 years) in which they remain unaffected by land clearance, logging or stand replacing fires. In the Strzelecki and Otway Ranges, Mountain Ash forest was extensively cleared for agriculture during the late 19th century (Forests Commission 1976; Griffiths 2001; State of Victoria 2014). In the Central Highlands, two widespread and devastating fires in 1939 and 2009, with the addition of lesser but still significant fires in 1926 and 1983, has meant there are few pre-1750 Mountain Ash trees remaining. Lindenmayer *et al.* (2012) estimate that less than 1.2% (approximately 1890 ha) of pre-1900 forest remains in the Central Highlands. At a

finer spatial scale within remnant landscape, features such as topography, aspect, wind exposure, soil depth and water availability influence the development and persistence of the largest trees (Ashton 1975; Mifsud 2002; Lindenmayer *et al.* 2011).

Methods

In an attempt to document the remaining giant trees, over 70 very large *Eucalyptus* trees were identified during ground-based surveys, and accurate trunk volumes of the 20 largest were calculated using trunk diameter measurements obtained by climbing. The largest Mountain Ash had trunk volumes exceeding 200 m^3 and were all located in small remnant stands (<20 ha) in the Central Highlands, the Otway Ranges and the Strzelecki Ranges. Very large Errinundra Shining Gum *E. denticulata* and Mountain Grey Gum *E. cypellocarpa* were recorded in the Central Highlands and East Gippsland. Based upon trunk volume measurements and species growth rates, it is estimated that the largest trees are over 450 years old and possibly more than 500 years old. The structural condition, overall health and land tenure of each tree was identified.

The search for giant tree candidates began in 1992 and has continued until 2015, with approximately 1000 field survey days undertaken during this period (Mifsud, unpubl. data). Survey sites were selected using previous records of tall tree occurrence (Hickey *et al.* 2000; Kostoglou 2000), forestry mapping (DEPI 2014a) and satellite imaging (Google Inc. 2014), the latter covering both public and non-crown land. Priority was given to searches in stands below 800 m in elevation that contained evidence of older trees which predominantly consisted of Mountain Ash *E. regnans* or Errinundra Shining Gum *E. denticulata*.

All very large trees located during field surveys were initially measured using a girth tape to record diameter at breast height (1.4 m above the mid-point of ground level) and a height estimate using a laser rangefinder. Prior to 2010, height measurements were undertaken with a Bushnell Yardage pro rangefinder combined with a Suunto clinometer and, from 2010 onwards, a Nikon Forestry 550 rangefinder with in-built hypsometer. Further estimates of bole diameter at various heights up the trunk were undertaken with a reloskop (a calibrated inverted macroscope) used in combination with a rangefinder. Trees which had a huge base (>10 m circumference) and maintained a large bole size for at least 30 m height were then measured by climbing the tree with rope access techniques and physically measuring the trunk at various heights up the trunk (Fig. 1). Between 15 and 20 trunk diameter measurements were recorded at 2.5 m intervals for the lower 15 m of trunk and at 5 m increments for heights above 15 m.

Tree volume was calculated following the system of Flint (2002), which takes account of all the wood contained in the main trunk including any bifurcation of the trunk and reiterated trunks. A reiterated trunk is a large, vertically oriented stem that has developed from an epicormic bud (a dormant bud below the bark) (Sillet 1999). Voids between buttresses are excluded from the volume calculation, whereas hollows which had previously contained wood are included. A regression plot of tree volume of *E. regnans* of known age from Wallaby Creek, Victoria (Sillet *et al.* 2010) was undertaken with statistical software (XLSTAT Version 2014.3.02) and used to estimate the ages of trees where they were unknown.

Results

Surveys identified 32 very large trees which were estimated to equal or exceed 180 m^3 in volume (mean 201 ± 18.9) and, of these, 21 had diameters of equal or greater than 4 m and were therefore classified as giants under VicForests (2013) criteria (Table 1). Victoria's largest tree is 'The Broken Giant', a senescing *E. regnans* growing in the Baw Baw National Park, which has an estimated volume of 244 m^3 and a diameter of 4.7 m at 1.4 m above upper ground level (Fig. 2). The majority (93%) of Victoria's largest trees are *E. regnans*; however, examples of giant *E. denticulata* (227 m^3) and Mountain Grey Gum *E. cypellocarpa* (190 m^3) were recorded in the Central Highlands and East Gippsland. Interestingly, a giant Shining Gum in the Central Highlands, previously thought to have been *E. nitens,* has now been identified as *E. denticulata* (D. Nicolle pers. comm) and is the largest known living specimen of this species. Most

Fig. 1. Brett Mifsud undertaking a climbing survey of an old Mountain Ash *Eucalyptus regnans* near Toolangi, Victoria. The tree is named 'Blackbeard' and is one of Victoria's largest trees of known volume. Photo GJ Harris.

Table 1. Victoria's Largest Trees by Estimated Volume Rank. Trees are Mountain Ash *Eucalyptus regnans* unless otherwise stated.

Vol Rank	Tree name	Volume estimate (m^3)	Circumference at 1.4 m above ground (m)	Height (m)	Height of main trunk	Locality	Year first noted	Volume estimate measurement method	Relative tree health	Tree description
1	Broken Giant	244.4	14.85	50	41.5	Baw Baw National Park	2004	Tape wraps via climbing	Poor	Hulk, few remaining branches
2	Ada Tree	237	14.85	68	57	Yarra State Forest Walking track public access	1986	Tape wraps via climbing	Fair	Broken top, some original branches
3	Eroica	235	14.3	74	70	Baw Baw National Park	2004	Tape wraps via climbing	Good	Mostly intact, many original branches
4	Black Beard	Was 245.5 now 230	12.5	73	Was 73, now 55 after storm in 2014	Toolangi State Forest	1992	Tape wraps via climbing	Fair	Broken top, some original branches
5	Whitelaw tree *Eucalyptus denticulata*	229.5	14.9	57.5	51	Thomson State Forest. Walking track public access	1980s	Tape wraps via climbing	Fair	Broken top, epicormic branches
6	King Kobra	224.9	11.8	75	75	Tarago La Trobe State Forest	1993	Tape wraps via climbing	Good	Broken top, some original branches
7	Old Smiley	218.9	12.0	75.5	67	Thomson State Forest	2009	Tape wraps via climbing	Excellent	Mostly intact many original branches
= 8	Mount Fatigue Giant	215.4	18.85	41	40	Gunyah Reserve, Strzelecki Ranges	1980s	Tape wraps via climbing	Fair	Hulk
= 8	Baroness Bertha	215.4	15.05	57	54	Powelltown State Forest	2012	Tape wraps via climbing	Very Good	Broken top many original branches
10	His Royal Antechinus	206.5	14.1	65	58	Toolangi State Forest	2014	Tape wraps via climbing	Very Good	Broken top many original branches
11	Scarlett Scarface	202.3	10.3	70	66	Toolangi State Forest	1992	Tape wraps via climbing	Good	Broken top some original branches
12	King Kalatha	201.0	13.85	65.5	52	Toolangi State Forest. Walking track public access	1992	Tape wraps via climbing	Good	Broken top some original branches

Table 1. cont'd.

Vol Rank	Tree name	Volume estimate (m^3)	Circumference at 1.5 m above ground (m)	Height (m)	Height of main trunk	Locality	Year first noted	Volume estimate measurement method	Relative tree health	Tree description
13	Growler's Hulk	205	12.5	40+	37	Tanjil State Forest	2007	Ground based reloskop	Poor	Hulk epicormic branches
14	Darejo *Eucalyptus denticulata*	200	14.2	61	50	Errinundra National Park. Walking track public access	2003	Estimate from base measurement and photos of upper trunk	Good	Broken top many original branches
15	Lone Black Ranger (aka Crotty Creek Giant)	199	14.8	47	48	Narbethong State Forest	Known from at least the 1970s – relocated 2013	Tape wraps via climbing	Fair	Broken top, few original branches
= 16	Old Smoothie	195	10.0	64	60	Thomson State Forest	1980s	Ground based reloskop	Good	Broken top, many original branches
= 16	Brahman of Barham	195	13.5	79.5	75	Great Otway National Park	1990s	Ground based reloskop	Excellent	Mostly intact
= 16	Moss Wall Tree	195	13	75	65	Great Otway National Park	1990s	Ground based reloskop	Excellent	Mostly intact
19	The Gambler	190	11.5	72+	60	Great Otway National Park	2011	Ground based reloskop	Very Good	Mostly intact
= 20	Thor	190	13.7	~70	60	Baw Baw National Park	2010	Ground based reloskop	Very Good	Mostly intact
= 20	Akanarl	190	13.9	40	40	Yarra Ranges National Park	2012	Ground based reloskop	Poor	Hulk
= 23	Hairy Maclary *Eucalyptus denticulata*	187	10.7	58	50	Thomson State Forest	2013	Tape wraps via climbing	Very Good	Broken top, many original branches
24	Ellery Camp Tree *Eucalyptus cypellocarpa*	187	13.2	55	45	Errinundra National Park. Walking track public access	Known from at least the 1980s	Ground based reloskop	Excellent	Mostly intact
25	Long John Silver	185.8	13.0	81	75	Powelltown State Forest	2010	Tape wraps via climbing	Excellent	Mostly intact
=26	Whitey	185	12.9	69	55	Baw Baw National Park	2005	Ground based reloskop	good	Broken top, many original branches

Table 1. cont'd.

Vol Rank	Tree name	Volume estimate (m^3)	Circumference at 1.5 m above ground (m)	Height (m)	Height of main trunk	Locality	Year first noted	Volume estimate measurement method	Relative tree health	Tree description
=26	Pastorale	185	11.0	73	72	Baw Baw National Park	2004	Ground based reloskop	Good	Broken top, many original branches
28	Cherry Spout	183	10.3	62	55	Toolangi State Forest	2012	Tape wraps via climbing	Good	Broken top, some original branches
=28	Serendipity	183	12.4	70	65	Toolangi State Forest	First noted 1992	Tape wraps via climbing	Good	Broken top, many original branches
30	Erica Twin	182	13.6	58	45	Baw Baw National Park	2004	Ground based reloskop	Poor	Hulk
=30	Fireline Beauty	180	10.6	83	75	Tarago La Trobe State Forest	2010	Ground based reloskop	Excellent	Mostly intact
32	King Nettle	180	11.7	77	77	Great Otway National Park	2011	Ground based reloskop	Very Good	Broken top
=32	Dr McCavity	180	15.7	46	45	Private forested land	2013	Ground based reloskop	Fair	Hulk

Tree condition:
Mostly intact, tree with an original crown, often with a branchless trunk bole for 35–45 m.
Broken top, head is broken or dead although it may not be obvious from the ground.
Original branches, the tree has large branches with growth habit characteristic of original branches.
Hulk, tree is essentially a hulk where the main trunk is broken between 25–45 m up.
Epicormic branches, the tree crown composed mostly of epicormic branches which have regrown after damage to the original crown, usually following fire but can also occur after insect defoliation.

Data compiled from B. Mifsud's personal observations 1992–2015
Tree names are given by the authors and are used to differentiate the various trees rather than identifying each tree by a number. The names are usually derived from the following examples:
Historic Name based on location – e.g. 'The Ada Tree'
Name based on a given tree characteristic – 'The Broken Giant' 'Erica Twin'
Name based on an event when climbing or locating the tree 'His Royal Antechinus', 'King Nettle'
Name based on a real or fictional character 'Thor' 'Blackbeard'

Fig. 2. The 'Broken Giant' is an old Mountain Ash *Eucalyptus regnans* located in Baw Baw National Park and the largest tree (by volume) found by the authors. The white arrow shows the position of Grant Harris as he ascends to undertake a climbing survey of the tree. Photo BM Mifsud.

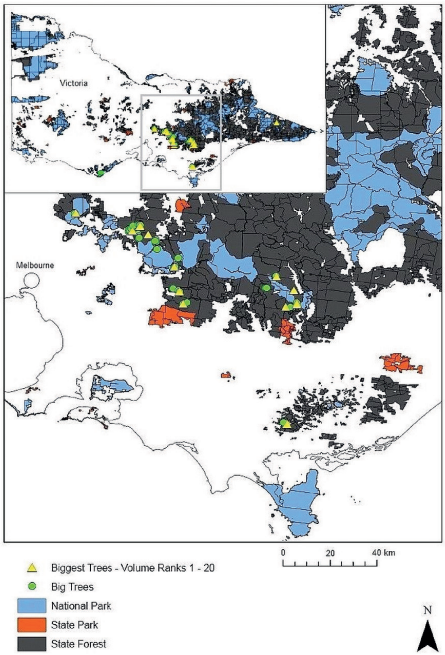

Fig. 3. Locations where big trees have been discovered and measured on crown land in Victoria.

of Victoria's currently known very large trees grow within State Forests (53%) or State and National Parks (45%), with one giant tree found on non-crown land in the Gunyah forest region in the Strzelecki Ranges (Fig. 3).

The structural condition of the very large trees identified varied widely between those with intact original crowns and those in advanced senescence, or the 'hulk' phase. The term 'hulk' refers to an over-mature (Ashton 1975) or senescent tree which is characterised by a trunk broken between the height of 25 m and 40 m and loss of most of the original branches. Six of the giant trees identified are in the hulk stage with trunks broken at or below 40 m. Seventeen trees have broken tops where the diameter of break point is between 40 and 80 cm. They also have a small part of their upper trunk that is dead and decayed. Nine of Victoria's largest trees have intact original crowns with only a small proportion of dead branches in the canopy. The linear equation ($y = 1.68x + 104$) generated by a regression analysis ($R^2 = 0.62$) ($p < 0.001$) of *E. regnans* of known ages and volumes in the Wallaby Creek Catchment, Victoria (Sillett *et al.* 2010) was used to estimate the age of Victoria's largest trees (Fig. 4). Whilst this equation shows considerable variability, it suggests that Victoria's largest trees are over 400 years old and possibly even up to 500 years old.

Discussion

Victoria's giant eucalypts are the largest known measured trees on the Australian mainland, with their nearest rivals being the Karri *E. diversicolor* (201 m^3) and Red Tingle *E. jacksonii* (180 m^3) from the south-west region of Western Australia (R du Guesclin pers. comm.) and large Moreton Bay Figs *Ficus macrophylla* (pos-

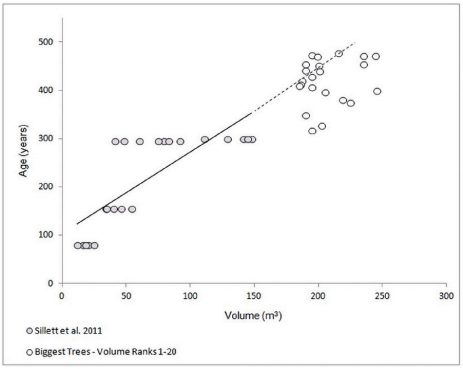

Fig. 4. The linear equation (y = 1.68x + 104) generated by a regression analysis (R^2 = 0.62, p <0.001) of *Eucalyptus regnans* of known ages and volumes (Sillett *et al.* 2010) was used to estimate the age of Victoria's largest trees (volume ranks 1–20). The solid black line represents the regression analysis trend line.

sibly 160–180 m^3) (McIntosh 2015). There are no trees of any species in South Australia or the Northern Territory that are known to exceed 100 m^3, although large River Red Gums *E. camaldulensis* could approach that size, while in New South Wales and Queensland the largest Blackbutts *E. pilularis*, and Flooded Gums *E. grandis* are around 160 m^3 (Russell pers. comm.). Victoria's largest trees are significantly exceeded in size by *E. regnans* in Tasmania, where there are known to be 8 trees that exceed 300 m^3, the largest being 380 m^3, and outsized specimens of Blue Gum *E. globulus* (368 m^3) and Messmate *E. obliqua* (337 m^3) (Mifsud pers. obs).

During 23 years of surveying the largest trees in Victoria, only 25 met the VicForests threshold of 12.5 m girth to be classified as a giant (see Table 1) and thus afforded the protection this status conveys. This supports the assertion of Lindenmayer *et al.* (2014) that the criterion for recognition of giant trees in Victoria's State forest is unrealistically demanding and includes too few trees to effectively contribute to maintenance of a viable population of large old trees. Reducing the dimensions required for recognition of giant trees to 3 m diameter or 70 m height would encompass many more old growth trees of ~ 250–350 years of age and could assist in protecting a population of large old trees.

Much previous work on *E. regnans* gave a maximum age of between 350 and 450 years (Ashton 1976; Hickey *et al.* 2000). However, evidence from dendrochronological and radiocarbon studies of Celery Top Pine *Phyllocladus aspleniifolius*, a long-lived conifer associated with *E. regnans* in the Styx Valley, Tasmania, has identified *E. regnans* of greater than 500 years in age (Wood *et al.* 2010). Although a recent study has determined that there are genetic differences between the Victorian and Tasmanian *E. regnans* (Nevill *et al.* 2009), this still suggests that the oldest trees in Victoria could be up to 500 years of age. Most of Victoria's largest trees have lost their original crown and now display dead and decaying tops. It is likely that within the next 100 years many of the trees listed in this paper will have collapsed through the progression of decay in combination with stochastic wind and fire events (Hickey *et al.* 2000; Lindenmayer and Wood 2010; Lindenmayer *et al.* 2012). Due to the history of forest management and fire regimes of the last 80 years, there are very limited stands of healthy 200–300 year-old cohort trees for recruitment as future giants (Mifsud 2014 unpubl. data). As a consequence, it may take 300 or more years before Victoria has trees of this size and age again.

The greatest threat to giant trees on both State Forest and National Park land is widespread and intense bushfire. Even in areas where the 2009 fires burned at a lower intensity, older trees were much more severely affected by the fire than adjacent 1939 regrowth trees. This is because the older trees, with their numerous rot hollows from ground level right up to the higher branches, have many more fire entry points (Mifsud 2012).

Most (53%) of the giant trees identified in this work are growing within State Forest and are afforded a certain degree of protection during timber harvesting operations under the VicForests' giant tree protection policy (VicForests 2013). Techniques to conserve giant trees during clear-felling operations include the use of buffer zones and clearing of coarse woody debris to reduce fire spread during regeneration burns (VicForests 2011; DEPI 2014b). Giant tree protection measures in State Forest areas have not always been successful. A notable ex-

ample was the death of Tasmania's largest *E. regnans*, 'El Grande', during a regeneration burn in 2003 (Herrmann 2006). Mature trees have limited adaptive capacity to respond to changes in environmental conditions (Matheny and Clark 1991) and the nominal ~100 m buffer zone commonly applied (Herrmann 2006) has proved to be ineffective in protecting some trees selected for retention, especially when the regeneration burn escapes the logging coupe (Gibbons *et al.* 2000; Lindenmayer *et al.* 2012). In Victoria, many large trees retained within a logged coupe have died from the subsequent regeneration fires (Mifsud 2014 unpubl. data).

Very few, if any of the giant trees in National Parks listed in this paper are visited by the general public. Nevertheless, heavily visited 'tourist' trees in both National Parks and State Forest do run the risk of damage by soil compaction if safeguards such as boardwalks and fences are not put in place. A further risk to giant trees is contamination of the soil by root rotting Cinnamon Fungus *Phytophthora cinnamomi*, which can be transported by soil on the shoes and/or vehicles of visitors. With regards to easy public access to giant trees, at the time of writing there were walking tracks with boardwalk facilities to three of the giant trees, 'The Ada Tree' in State Forest near Powelltown, 'The Kalatha Giant' in State Forest near Toolangi, and 'Darejo' in State Forest near the Errinundra National Park in East Gippsland. There are also short walking tracks to the 'Ellery Camp Tree' near Mt Ellery in Errinundra NP in East Gippsland and 'The Whitelaw Tree' in the Thomson State Forest, Baw Baw Ranges. Furthermore, excellent walking tracks take visitors past imposing Mountain Ash trees at Cumberland Scenic Reserve (although the old growth trees in the southern section of this track were killed in the 2009 fires) and at Maits Rest off the Great Ocean Road west of Apollo Bay.

There are important differences between native forests and urban environments but there are also similarities between the processes which damage trees during forestry operations and urban development, such as soil compaction, mechanical damage to root systems and altered exposure. The Australian Standard 4970–2009, Protection of Trees on Development Sites, provides guidance on best management practices for protecting trees that have been selected for retention from land use practices which threaten their survival (Standards Australia 2009). To help prevent the untimely loss of Victoria's largest trees during forestry operations, the precedent set by the Australian Standard 4970-2009 could be applied to development of a robust protocol for the protection of giant trees during forestry operations.

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98 years ago

The Tall Trees of Australia

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Search for Tall Trees Encouraged

An attempt was made to gather reliable information about our tall or big trees in order to place it on show at the Centennial Exhibition, Melbourne, in 1888. A reward of £20 was offered to anyone who would guide the authorities to a tree of 400 feet in height, with an additional reward of £3 for every 5 feet in excess. The Hon. James Munro personally offered £100 in addition to the foregoing. We may be sure that land surveyors, cattle men, forest rangers, paling splitters, miners fossicking for tin along the mountain forest streams, and others, were on the look-out for tall trees. Then, if ever, was the time for the fabulous giants to materialize; but, although Government surveyors and others were instructed to report, and the money reward widely advertised, the tallest tree found was only 326 feet 1 inch in height, with the small girth of 25 feet 7 inches at 6 feet from the ground. This tree was discovered on a spur of Mount Baw Baw, Gippsland, about 90 miles from Melbourne. The tree of greatest girth was found near Neerim township, about 80 miles easterly from Melbourne; it measured 55 feet 7 inches round at 6 feet from the ground, and 227 feet up to where the top was broken off. The seven trees of note were photographed and measured, and the record shown at the Exhibition was an atlas, folio size, entitled "The Giant Trees of Victoria", the survey and photography having been effected by a party including Mr. J. Duncan Pierce, civil engineer and photographer, and Mr. C.R. Cunningham, surveyor; Mr. W. Davidson, late chief engineer of the Public Works Department, was associated with these. The work cost £600, the cost being borne by the Lands Department, the Public Library trustees, and the Exhibition Commissioners.

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