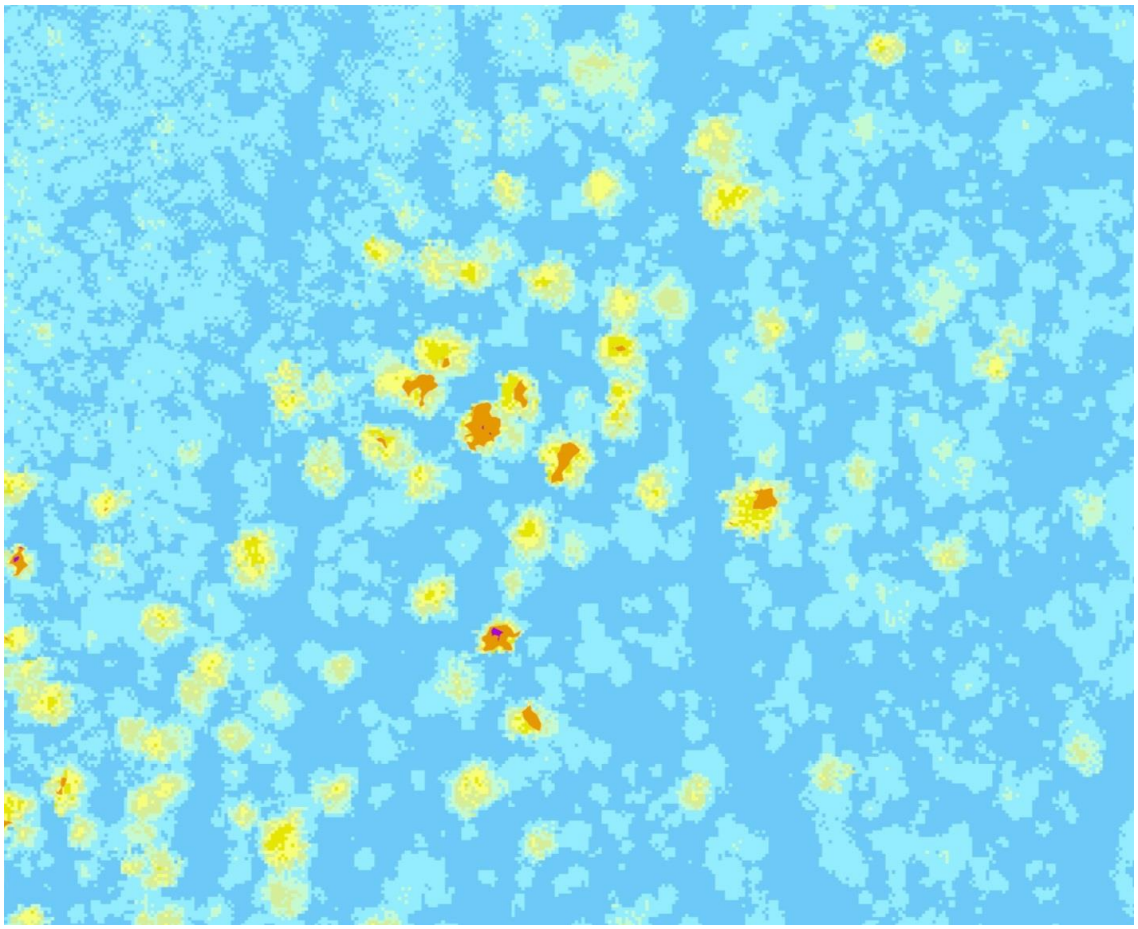
Report for the Tasmanian Wilderness World Heritage Area Natural Values Identification and Assessment Program

Giant trees and very tall forest values in the Tasmanian Wilderness World Heritage Area



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Report for the Tasmanian Wilderness World Heritage Area Natural Values Identification and Assessment Program

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Cover image: Lidar derived tree canopy height map for the Andromeda Stand of giant trees. Canopy heights between 50 m and 80 m are displayed in yellow and above 80 m shades of orange and red.

Summary

Sclerophyll forest communities within the Tasmanian Wilderness World Heritage Area (TWWHA) present the most superlative expression on the globe of tree gigantism in flowering plants. Extensive pristine forests that exceed 70 m in height and inspiring stands of trees over 90 m tall present a globally phenomenal example of very tall sclerophyll forest.

Giant individual trees and forests of exceptional height are considered to contribute towards the outstanding universal value of the TWWHA under natural criterion vii.

- Globally less than 2% of tree species can reach a height of 70 m or greater. The Dipterocarpaceae forests of Southeast Asia (Borneo) and the wet eucalypt and mixed forests of Southeast Australia contain the largest tracts of very tall hardwood forest.
- Though not containing the tallest flowering tree, the TWWHA contains the second tallest tree, Icarus Dream' (97 m) and the majority of ground measured flowering trees that exceed 90 m in height. Unverified LiDAR surveys indicate the potential for a larger number of trees exceeding 90 m in height in Borneo than found in the TWWHA. However the taller trees and the species with the greatest height potential occur within the TWWHA.
- The largest volume eucalypt recorded within the TWWHA is 'Two Towers' (386 m^3) which is bettered only by 'Kermandie Queen' (418 m^3), the largest tree in Australia which is located outside the TWWHA in southern Tasmania. These volumes are considerably less than the largest tree species on earth, *Sequoiadendron giganteum* (giant sequoia) the largest of which is 1487 m^3. Only six trees in the TWWHA are registered as giant trees by volume and there is an inadequate knowledge base and standardization of assessment method to review the significance of large volume trees in the TWWHA in this report.
- Though the area of forest over 70 m tall can't be directly compared between countries and states, forest height in the TWWHA is well documented and contains a stronghold of very tall forest in pristine valleys of high natural integrity. Over 6,300 ha of very tall forest occur in the TWWHA including a single stand of 770 ha. Superlative stands of giant trees such as the 'Andromeda stand' that contains ten trees over 90 m, some towering side by side, contribute to globally outstanding expression of very tall hardwood forest.

Objective

Sclerophyll communities within the Tasmanian Wilderness World Heritage Area (TWWHA) were assessed for their Outstanding Universal Value (OUV) against criteria established in the Operational Guidelines for the Implementation of the World Heritage Convention in 2004 (Balmer et al. 2004). The 2004 assessment considered that sclerophyll communities contributed to the OUV of the property under three of four natural criteria. One of these natural criteria for world heritage listing, previously referred to as natural criterion iii but now known as criterion vii, enables the listing of properties that "contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance" (UNESCO 2016). The very tall eucalypt forests were considered to provide an example of a superlative natural phenomenon as well as being of exceptional natural beauty and aesthetic importance. Some of the best examples globally of very tall mixed eucalypt forest were considered to occur in the TWWHA, but Balmer et al. (2004) acknowledged that taller examples of giant trees occurred outside the boundaries. In 2013 the TWWHA was extended to encompass additional areas of very tall mixed eucalypt forest and individual trees of exceptional height, reinforcing the importance of the TWWHA for its presentation of the natural phenomena of tree gigantism as well as other very tall forest values.

The objective of this report is to reassess whether tree gigantism and very tall forest within the TWWHA meet natural criteria vii and should be listed as an OUV for the TWWHA. These values are assessed using recently available aerial LiDAR derived forest canopy height maps covering key areas of the tall mixed eucalypt forests communities in the TWWHA. Comparisons with very tall forest values elsewhere in Tasmania and overseas are also discussed but remain constrained by the availability of comparable data outside the TWWHA.

As the OUV statement for the TWWHA to be prepared under the operational guidelines of the convention has not been adopted at the time of publication, the assessment presented in this document remains the opinion of the authors and does not necessarily reflect consideration or adoption of a statement of OUV by the UNESCO World Heritage Committee.

Background

Worldwide giant trees and very tall forests are valued as a timber resource, tourism attraction, plants and vegetation communities of scientific interest and as a source of spiritual and artistic inspiration (Balmer *et al.* 2004; Tng 2012). There is a deep public interest and appreciation of giant trees and very tall forests that has led to calls to protect tall forests and giant trees from logging in North America (Speece 2016) and Australia (Krein 2010). Tasmania is fortunate to have the custodianship of the world's tallest flowering trees that tower up to 99.6 m above the forest floor and majestic stands of eucalypts exceeding 70 m in height that emerge above rainforest and morning mist. These very tall eucalypt forests have their greatest extent along the south eastern boundary of the Tasmanian Wilderness World Heritage Area (TWWHA) within which a large tract of these forests is conserved.

Globally, the greatest heights attained by trees are restricted to a very small number of tree species and the very tall forests they create are similarly very rare globally (Tng *et al.* 2012). These forests are mostly confined to areas of low thermal stress (Larjavaara 2014), high rainfall relative to evaporation, fertile soils and natural protection from fire, in western USA, Southeast Asia, New Guinea and Australia (Tng *et al.* 2012; Givnish *et al.* 2014). Sites with very tall forests are inherently vulnerable to temporary or permanent loss by clearance or natural disturbances within the very small environmental and genetic domain in which they exist.

In Australia, only a small number of eucalypt species can exceed 70 m in height and form very tall forests, with the tallest of these species being present in Tasmania and within the TWWHA. One of the important areas for very tall forests is either side of the eastern boundary of the TWWHA where mature mixed eucalypt forests comprise eucalypts that tower above a canopy of rainforest trees. These forests depend on hot fires for their regeneration at an interval of no more than 500 years between fires to enable the regeneration and persistence of the eucalypts within these forests (Ashton 1981; Wood *et al.* 2010). In the absence of fire, tall mixed eucalypt forest will be replaced by rainforest.

Global distribution and comparison of giant tree values

A conifer species on the west coast of North America, *Sequoia sempervirens* (Coast redwood) grows to the greatest height of all trees on earth. The tallest tree known as 'Hyperion' is 115.9 m high (Anon 2018a). There are estimated to be about 225 trees exceeding 350 feet (106.7 m) and about 5000 trees that are 100 m or higher based on LiDAR data (Anon 2018b). These coniferous redwood forests with their old growth giant trees are inscribed on the World Heritage Area List.

Another conifer on the west coast of the North America, *Pseudotsuga menziesii* (Douglas fir), is currently the second tallest species with a maximum height of 99.8 m (Anon 2017a). This is closely followed by the third tallest species, *Eucalyptus regnans* (swamp gum or mountain ash) from Southeast Australia. It is the tallest hardwood or flowering plant species on earth (Mifsud 2002; Tng *et al.* 2012). The 'Centurian tree', is the tallest *E. regnans* measured at 99.6 m in height in 2008. Reliable historic sources indicate *E. regnans* trees had grown to at least 110 m in height prior to the loss of these trees to logging more than a century ago (Earl 2006; Tng *et al.* 2012). Therefore *E. regnans* has the potential to be much closer in height but not taller than the world's tallest softwood species, *Sequoia sempervirens*.

The tallest eucalypt trees are found in Victoria and Tasmania. Historically *Eucalyptus regnans* forests in Victoria have challenged Tasmanian forests for the largest giant trees and forest stands of exceptional height (Mifsud 2002). However, in 2012 the Victorian Black Saturday Bushfires resulted in the loss of over 40 trees greater than 85 m tall, including Victoria's then five tallest trees all of which were over 90 m (Mifsud 2012). In 2017, only 12 trees over 85 m in height are known to remain in Victoria (Mifsud 2017). In other states of Australia there are no records of eucalypts over 85 m in height (Mifsud 2012).

Giant trees in Tasmania are documented in the Giant Tree Register (Anon 2017b). These are defined as trees of at least 85 m in height or at least 280 cubic meters in modelled or calculated volume and have been measured by laser rangefinder or tape drop from the top. There are 96 documented giant trees over 85 m in height on the register. Of these, 24 are over 90 m in height and 14 (58%) occur within the TWWHA. The tallest hardwood on earth, the 'Centurian tree' is located outside the boundary of the TWWHA in southern Tasmania. Contained within the TWWHA is the second tallest hardwood known, 'Icarus Dream' (*E. regnans*) which stands at 97 m in height.

Of the majority of trees exceeding 85 m on the register, 49 of 96 (51%), occur within the TWWHA (Figure 1). Approximately 58 additional trees in the TWWHA may exceed 85 m, however as they were identified by LiDAR survey they will require ground measurement to verify their height.

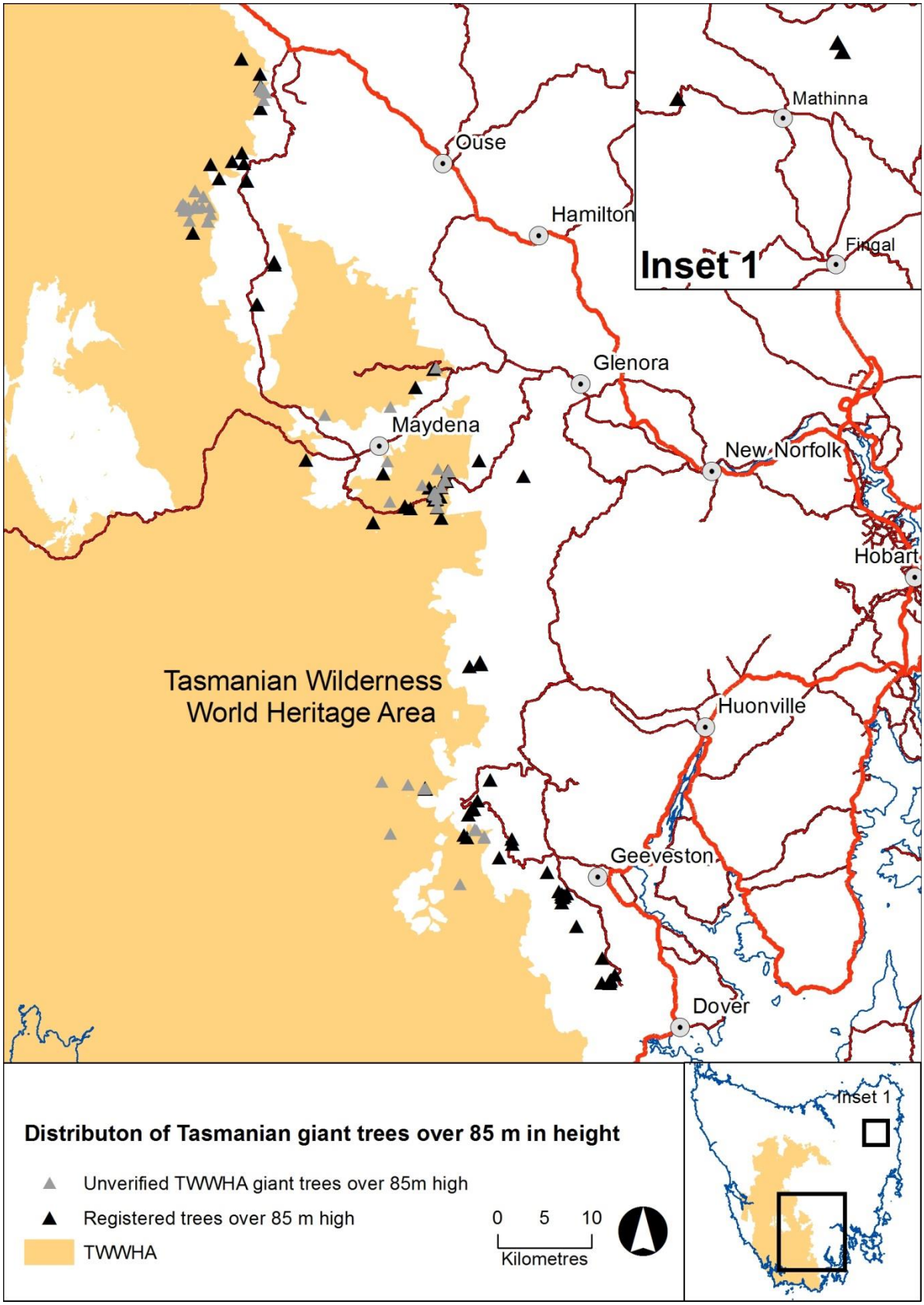

Figure 1 Distribution of registered giant trees over 85 m high in Tasmania and potential giant trees within the TWWHA identified from LiDAR data.

Nearly all of the giant trees in the TWWHA are *Eucalyptus regnans*. A few exceptional *E. delegatensis* (gum-topped stringybark) and *E. obliqua* (stringybark) trees also exceed 85 m in height. *E. delegatensis* attains its greatest height (87.4 m) within the TWWHA. Australia's most impressive stand of giant trees, the 'Andromeda stand' contains 12 giant trees, including 'Icarus Dream' and another nine trees over 90 m tall. This area was included within the TWWHA in the 2013 extension of the property. Though the majority of tall forests that are prospective for giant trees have been surveyed by LiDAR there are areas of tall forest that have not, leading to an incomplete understanding of tall giant trees values in the TWWHA.

Other eucalypt species that are known to exceed 85 m in height on rare occasions include *Eucalyptus globulus* (Tasmanian bluegum) and *E. viminalis* (white gum), which reach heights of 91.0 and 90.7 m, respectively in north east Tasmania. The tallest measured *E. obliqua* is 87.0 m in height but only two trees of this species over 85 m are documented (DPIPWE unpublished data; Anon 2017b).

Historic records from both Tasmania and Victoria suggest trees of greater height than extant trees were once present, however many of these records are considered to be unreliable (Mifsud 2002). The tallest credible historic measurement of a eucalypt tree was a 114 m tall *E. regnans* in Victoria that was measured by a surveyor in 1880 (Cornthwaite 1934 cited in Mifsud 2002). There is potential for trees of greater height than those currently present in Tasmania and Victoria in the future. The 'Centurian' tree, that lies outside the TWWHA, has the appearance of having lost its crown a century or so ago and is continuing to actively grow (Mifsud 2012), suggesting it may again exceed 100 m in height. In Victoria, regrowth *E. regnans* trees that are around 80 m in height have a growth rate of one metre every five years and are predicted to again reach heights of 90 m or more if forest fires can be managed in the coming 50 years (Mifsud 2002; Mifsud 2012). Similarly, it is plausible *E. regnans* trees not currently recorded as giants may attain heights in excess of 90 m within the TWWHA when forests reach optimal age for maximum height.

Comparable tall hardwood trees are found in Southeast Asia. The tallest species is *Shorea faguetiana* (Seraya kuning siput or yellow meranti) in the Dipterocarpaceae. A tree in Sabah, Malaysia, measuring 94.1 m was reported to be the tallest known tropical tree following a LiDAR survey in Borneo in 2016 (Gaworecki 2016; Sabah Forestry Dept. 2017). The same LiDAR survey identified an additional 49 trees in old growth rainforest exceeding 90 m in height. However, there are no ground measurements published to confirm the heights of the 49 other trees. Potentially the forests of Sabah may contain more 90 m trees than the TWWHA. These tropical trees challenge eucalypts for height but are not documented as exceeding current or historic records attained by *Eucalyptus regnans* in the TWWHA and Australia (DPIPWE data; Anon 2017a).

Africa's tallest documented tree is an 81.5 m high *Entandrophragma excelsum* (Muyovu) located in 2017 during a survey of the slopes of Mount Kilimanjaro (Hemp *et al*. 2017). However that survey found few trees of this species exceeding 70 m and therefore it is unlikely that Africa provides exemplary examples of the tallest forests or tallest trees on earth.

Measurement of giant tree volume is more problematic than height as appreciable variation in estimates arises from the different measurement methods in use. Assessments considered here are based on "single trees" excluding volumes for clonal forests (e.g. *Populus tremuloides*). The largest volume tree species is a conifer, *Sequoiadendron giganteum* (giant sequoia) which grows on the west coast of North America. The largest volume *S. giganteum* tree in the world is 'General Sherman' which is estimated to have a volume of 1,487 m^3 (Earle 2006; National Parks Service 2012). Other species with exceptional

volumes over 500 m^3 include *S. sempervirens*, *Taxodium mucronatum* (Montezuma cypress) and *Agathis australis* (Kauri) (Earle 2006).

By comparison eucalypt species are low in volume. Australia's largest volume eucalypt is 'Kermandie Queen', an *E. regnans* of 418 m^3 located outside the TWWHA near Geeveston. The TWWHA contains six registered giant eucalypt trees with a trunk and large branch volume over 300 m^3 including 'Two Towers', an *E. regnans* of 386 m^3 and 'Gothmog', an *E. obliqua* at 337 m^3, respectively (DPIPWE data; Anon 2017b). Other eucalypt species that can exceed 300 m^3 include *E. globulus*, and *E. delegatensis*. In this context, the TWWHA contains substantial populations of three eucalypt species achieving volumes over 300 m^3. However, data deficiencies prevent meaningful assessments of the global significance of the of large volume giant trees in the TWWHA.

All tree measurements need to be considered in the context of change over time and measurement accuracy. It is recognized that the trees may be either growing in height or declining with the loss of their crowns due to wind damage, lightning, fire and old age. Trees that may lose crowns do not necessarily lose the capability to regain height (Mifsud 2012) as in the case with the 'Centurian tree'. Changes in the distribution status of giant trees over time are inevitable with the ebb and flow of tall eucalypt forests.

Global comparison of hardwood tall forest values

Forest tree species that exceed 70 m in height are globally rare representing only 6% of conifer species and 2% of eucalypt species (Tng *et al.* 2012). In the absence of an accepted national or international definition of very tall forest, in this report we define forests that contain trees over 70 m as very tall forests of global significance. These may be represented by mapping peak canopy height over a defined area, in this case a maximum canopy height equal to or exceeding 70 m per hectare.

Very tall eucalypt forests are centered on the high rainfall cool temperate forests of Southeast Australia where six of the tallest eucalypt species occur (Tng *et al.* 2012). *Eucalyptus delegatensis* forms very tall forests at higher elevations on the Great Western Tiers and southeast of Lake St. Clair. At lower elevations, *E. regnans* and *E. obliqua* form very tall forests. Closely growing giant *E. regnans* form forest stands of exceptional height with the most phenomenal example of very tall hardwood forest in the world being the 'Andromeda stand' in the Styx Valley. This forest stand contains ten of the 24 tallest eucalypts known and eight of the ten tallest trees in the TWWHA. This stand is readily accessible to the public.

Approximately 6,300 ha of very tall forest exceeding 70 m in height have been mapped in areas where LiDAR data is available for the TWWHA. Areas containing a high density of trees exceeding 70 m include Beech Creek, Coles Creek and Gordon Range in the northern Florentine Valley area; Gee Creek, Andromeda Creek and southeast of Marriots Lookout in the Styx Valley; and Barnback and Truggara Creeks in the Picton Valley area. The greatest extent of over 70 m forest is in the Gordon Range area where over 1,000 ha is present including 770 ha in a single patch of very tall old growth forest (Figure 2). This is likely to be the largest single patch of very tall forest in Tasmania. Additional areas of very tall forest not covered by LiDAR mapping are possible such as *E. delegatensis* wet forest in the Butlers Gorge area.

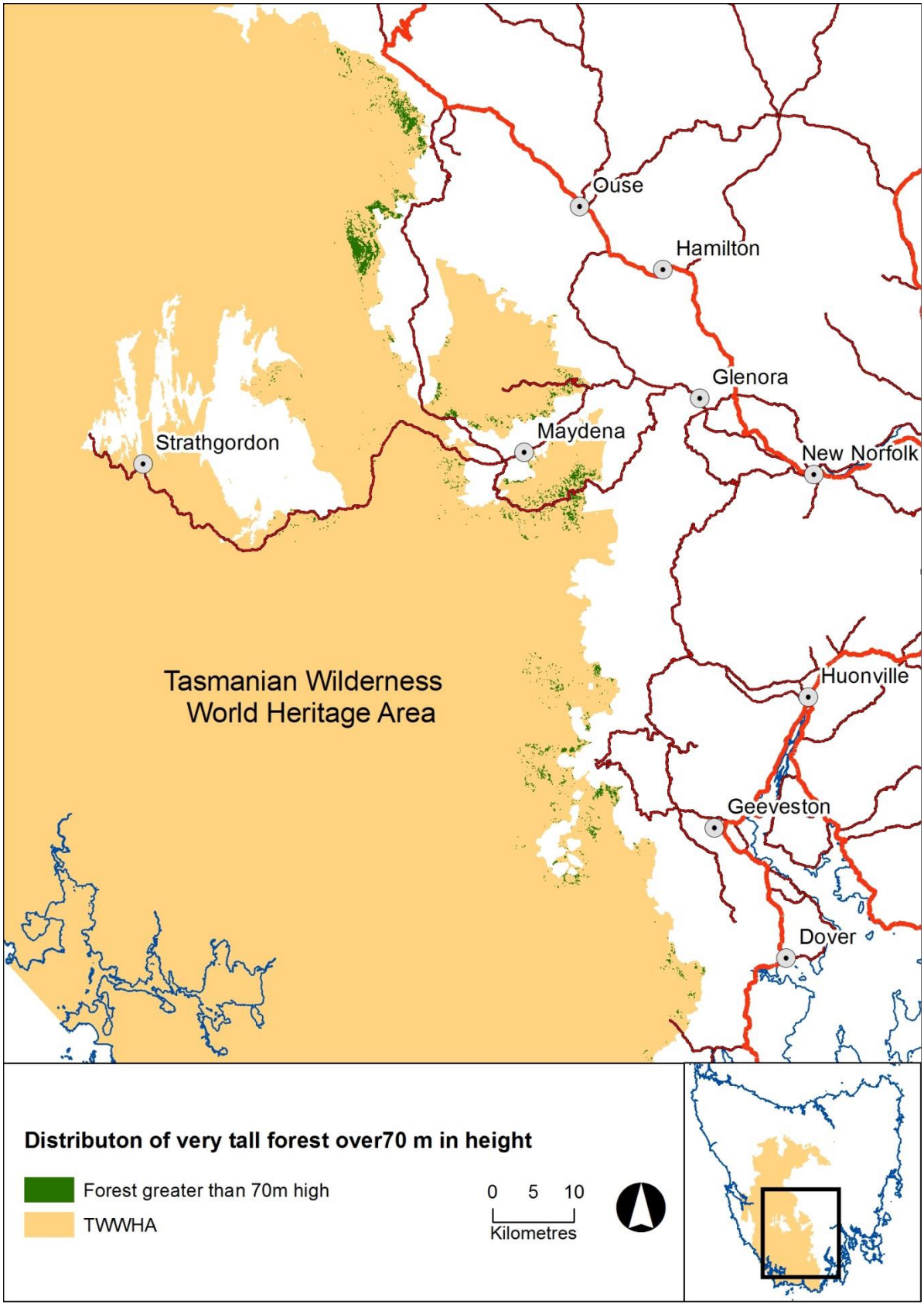

Figure 2 Distribution of very tall forest with trees 70 m or more in height mapped on a 1 ha scale

A single global dataset is not yet available that will provide sufficiently accurate forest height information for global comparison of very tall forest values. Simard *et al.* (2011) produced a Global 1 km canopy height map based on ICESat 2005 LiDAR data however the calculated error is relatively high over some locations including the Southern Ranges bioregion in Tasmania. In this case, the global forest height map failed to identify the very tall forests in Tasmania while detecting the very tall forest in Victoria and on the island of Borneo. Comparable airborne LiDAR data for very tall forest in Victoria is not currently available.

Tropical forests that contain the tallest hardwood species achieve similar heights to wet eucalypt forests (Tng *et al.* 2012; Gaworecki 2016). The height of selected forests in Borneo has recently been mapped (Carnegie airborne LiDAR). Although forest height data has not yet been made available for comparison purposes, it is possible that the extent of very tall forest in Sabah province may be appreciable. It is not anticipated that the phenomenal stand height of the Andromeda stand will be equaled or surpassed based on the maximum heights that have been reported for hardwood tree species in Borneo.

Security of Australian giant tree and very tall forest values

Fire is significant driver of loss of giant trees (Mifsud 2012) and very tall forest values in the short term, while it also acts as to renew and maintain these values in the longer term (Ashton 1981; Tng *et al.* 2012). During this century, climate change is expected to increase fire risks in the southern slope areas of Southeast Australia, which encompasses tall eucalypt forests in both Victoria and Tasmania. Changes may be more significant in Victoria than western Tasmania due to higher base incidence of severe fire weather in that state (Grose *et al.* 2015) and potential for continuing lower incidence of fire weather in western Tasmania. Less human access and fewer sources of ignition in TWWHA tall forests may also provide greater security from fire for very tall eucalypt forest values than other locations in Australia. However, when fires do occur, fire suppression is extremely challenging in the remote tall eucalypt forests in the TWWHA.

Climate change may be a more significant risk as it may affect tree gigantism and habitat for very tall species and forests. For instance, the vascular structure that manages moisture stress appears to be genotypic in origin (Pfautsch 2016) and may not easily adapt to increasing moisture stress if genetic adaptation is outpaced by climate change.

Modelling by DPIPWE (unpublished data) suggests there may be a substantial geographic shift and a contraction in the area of suitable climate for giant trees in Tasmania by 2100. Some refugia areas for giant trees are predicted to persist. Notably, these climate pressures exist in an intact landscape not subject to logging. The Victorian context for tall forests differs in that a high fire risk and logging combine and may lead to a landscape trap (Lindenmayer *et al.* 2011; Burns *et al.* 2014) where short rotation disturbance events occur reducing the likelihood of mature forests that are needed to create and maintain giant trees and very tall forests.

Although natural events such as wind throw or lightning will continue to cause impacts, the TWWHA very tall forests are situated in a spatial and management context that is likely equal or better than that of equivalent Victorian forests for maintenance of giant tree and very tall forest values over time. Nevertheless it is anticipated giant tree and tall forest values will be subject to natural flux and climate change pressures.

Conclusion

If the tropical hardwood trees in Southeast Asia and their associated forests are found to provide the most outstanding universal example of giant hardwood trees and forests, then the TWWHA trees and

forests would still retain international significance as the best Australian examples of very tall sclerophyll forest and the best examples of gigantism in hardwood trees. For the moment, however, this report considers that the giant trees and very tall forest within the TWWHA provide a phenomenal example of gigantism among hardwood trees and, as such, contribute to the OUV of the TWWHA under criterion vii for world heritage listing.

Very tall forest and giant tree values in the TWWHA where enhanced by the 2013 extension of the property to include tracts of wet eucalypt forest on the eastern border of the TWWHA. The property encapsulates the greatest representation of giant eucalyptus trees exceeding 85 m in height including the majority of the tallest eucalypts known. Very tall eucalypt forests such as the pristine upper McLeod's Creek catchments are unmatched in extent and integrity elsewhere. The wide distribution of the values across the property, undisturbed nature of many of the very tall forests and the range in forest ages enhances the potential for ongoing retention of giant tree and tall forest values within the ecological dynamic of this fire driven ecosystem. Though there are risks for maintenance of gigantism values in the TWWHA, the TWWHA provides the stronghold and most secure representation of giant angiosperm trees and very tall eucalypt forests in the world. The contribution of giant tree and tall forest values to the OUV of sclerophyll communities in the TWWHA is enhanced and more secure than when assessed against the property values in 2004 (Balmer *et al.* 2004).

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