IVG Forest Conservation Report 3C

Report for the Independent Verification Group of the Tasmanian Forests Intergovernmental Agreement on Tasmania's eucalypt diversity

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Summary

This report outlines significant features of the eucalypt flora of the island of Tasmania, the patterns of distribution and the natural values in reserves proposed under the Tasmanian Forests Intergovernmental Agreement for the maintenance of eucalypt phylogenetic and genetic diversity. Over 70, 000 distributional records were compiled and used to assess species distributions, presence in proposed reserves, and change in the percentage of records of each species in reserves associated with the proposed reserve system. The species that appear to be most favoured by the proposed reserve system in terms of the percentage of compiled records falling in reserves were *E. johnstonii*, *E. regnans*, *E. sieberi*, *E. delegatensis*, and *E. obliqua*, as well as the newly described *E. nebulosa*. Reserves with higher eucalypt species richness tended to occur in the east of the island but proposed ENGO reserves with specific values for the different species were identified throughout the island.

Objectives

This section of the report on the significance of the reserves proposed under the Tasmanian Forests Intergovernmental Agreement addresses their natural values in terms of the maintenance of eucalypt phylogenetic and genetic diversity. It is considered that genetic diversity and evolutionary robustness of the eucalypt flora as a whole will be increased when all species are well-represented across their natural geographic and ecological ranges, and in diverse community assemblages. This report aims to use point distribution records as well as the distribution of TASVEG communities defined by a target eucalypt species to obtain insights into the current reservation status of the island's eucalypt gene pools overall, as well as their representation across reserves in the nine Tasmanian IBRA bioregions as a surrogate of variation in geography, ecology, biotic communities and evolutionary history. While recognising multiple types of bias in record data associated with intensity of sampling and cross tenures and geographic regions, we used this data to assess the change in the reservation status of the 30 Tasmanian eucalypt species records that would occur with the proposed reserve system and document proposed reserves with noteworthy values for the various eucalypt species or variants of these species (e.g. natural hybrids, intergrades or atypical populations).

Background: The island's eucalypt flora

Significance

Eucalypts are endemic to Australia and islands to its north but are now among the most planted hardwood trees in the world (Doughty 2000). While of Gondwanic ancestry, the modern diversity of the genus mainly arose in the last 23 million years in response to cooler, drier and more seasonal climates, and increased fire (Crisp *et al.* 2004; Crisp *et al.* 2011; Gandolfo et al. 2011). There are over 700 recognised species distributed from the tropics to cool temperate regions (Slee *et al.* 2006), with the most southerly occurring on the island of Tasmania. The eucalypt flora of Tasmania is internationally well-known and has a long-history of discovery, exploitation and scientific research (Potts and Reid 2003). It includes the type of the genus (*Eucalyptus obliqua* from Adventure Bay), one of the first species to be widely spread around the world (*E. globulus* subsp. *globulus* - Doughty 2000) and the world's tallest flowering (angiosperm) plant species (*E. regnans* – 'Centurian' tree near Geeveston at 99.6 m tall; http://www.gianttrees.com.au/). Tasmania is renowned for its tall eucalypt forest and, based on height or volume, the island has giant trees of *E. regnans*, *E. delegatensis*, *E. obliqua*, *E. globulus* and *E. viminalis* (Hickey *et al.* 2000; Kramer 2000; Petit *et al.* 2010 ; see also D. Bowman report). In the case of *E. regnans*, these giant trees may be more than 500 years old (Wood *et al.* 2010). Native forest silviculture in Tasmania is focused on wet-sclerophyll forest dominated by the well-known ash species - *E. obliqua*, *E. regnans* and *E. delegatensis* (Forestry_Tasmania 2009; Baker and Read 2011). The Tasmanian flora contains one of the most frost resistant eucalypt species (*E. gunnii* – of which the threatened subsp. *divaricata* is the most frost resistant form; Potts *et al.* 2001), one of the smallest eucalypt species, the alpine shrub *E. vernicosa* (McGowen *et al.* 2001), and one of Australia's rarest eucalypt species (*E. morrisbyi* - Wiltshire *et al.* 1991).

Most eucalypt species are heteroblastic and change from a juvenile to adult leaf form before flowering. However, three of the Tasmanian eucalypts rarely develop adult-type foliage in nature and flower in the juvenile leaf stage (*E. perinniana* and endemics *E. risdonii* and *E. cordata*), a characteristic exhibited by only a few other eucalypt species (Potts and Wiltshire 1997; Wiltshire *et al.* 1998). The floral emblem of Tasmania, *Eucalyptus globulus* is the hardwood species most widely planted in pulp-wood plantations in temperate regions of the world (Potts *et al.* 2004), including Australia (Gavran and Parsons 2011). The gene pool of *E. globulus* is therefore internationally important. It has become a model tree species for genetic research (Potts *et al.* 2011) and is one of the few forest trees for which the genomes has been sequenced (chloroplast - Steane 2004; full genome – released 7th April 2011 by the U.S. Department of Energy (DOE) Joint Genome Institute).

Detailed discussion of the Tasmanian species, their ecology and natural distributions are given in Reid and Potts (1999) and Williams and Potts (1996), with the exception of the more recently described serpentine peppermint (*E. nebulosa*) (Gray 2008) (Table 1). While dominating the forests of northern and eastern Tasmania, eucalypts occur throughout the island, occupying habitats from sea level (e.g. *E. globulus*) to the alpine tree line (e.g. *E. coccifera*), from the dry, cold midlands (e.g. *E. pauciflora*) to wet temperate mixed forests of central Tasmania (e.g. *E. regnans*). They range in habit from the shrub *E. vernicosa*, which grows on the summits and ridges of the western mountains, multi-stem mallees such as *E. risdonii*, spreading open woodland trees (e.g. *E. pauciflora*, *E. gunnii* subsp. *divaricata*) and tall forest trees (e.g. *E. regnans*). As with most foundation species (Whitham *et al.* 2006), both dead and alive the eucalypts are important food, habitat and substrate for dependent biotic communities. Eucalypts provide the hollows for dens and nest sites for many of the island's native birds and marsupials (Koch 2009; Koch and Baker 2011); their decaying logs and litter are important habitat and substrate for a great diversity of native invertebrates (Barbour *et al.* 2009a; Grove and Forster 2011; Grove and Forster 2011), as well as fungi, mosses, liverworts and ferns (Barbour *et al.* 2009b; Browning *et al.* 2010; Gates *et al.* 2011a; Gates *et al.* 2011b; Turner *et al.* 2011). The large flowers of *E. globulus* are an important food source for the endangered swift parrot (*Lathamus discolour*; Brereton *et al.* 2004; Hingston *et al.* 2004), and in eastern Tasmania *E. viminalis* is prime habitat for the endangered Forty-Spotted Pardalote (*Pardalotus quadragintus*).

Table 1. The Tasmanian *Eucalyptus* species, their common names and taxonomic classification, the number of 10 x 10 km cells occupied based on the present records and Williams and Potts (1996), the percentage of hectares or records currently in formal (A1, National Reserve Estate) and all types (i.e. Tasmanian Reserve Estate: reserve classes A1, A2, FR, IR, P2 – see Table 2) of reserves for TASVEG communities defined by the focal species (see Table 3 for details) and the compiled point distribution records, and proportion of the reserved TASVEG hectares or records that fall in formal reserves as well as both formal and informal reserves. See Note below table.

SUBGENUS: *Eucalyptus*	**SECTION:** *Eucalyptus*		extent (# of cells)	extent (# of cells) Willams & Potts (1996)	% TASVEG in formal reserves	% TASVEG in formal and informal reserves	% records in formal reserves (A1)	% records in informal and formal reserves (A1, A2, FR, IR, P2)
Series	**Eucalypt species/subspecies**	**Common name**						
Regnantes	*E. regnans*	Giant Ash	170	171	15	29	17	31
Eucalyptus	*E. obliqua*	Stringybark	433	436	23	34	26	37
Radiatae	*E. radiata subsp. radiata*	Forth River Peppermint	12	7			15	68
Radiatae	*E. pulchella*	White Peppermint	126	126	23	34	34	51
Radiatae	*E. amygdalina*	Black Peppermint	421	417	27	33	35	46
Radiatae	*E. nitida*	Western Peppermint	293	292	83	86	49	60
Radiatae	*E. nebulosa*	Serpentine Peppermint	3				25	38
Radiatae	*E. coccifera*	Snow Peppermint	127	139	85	89	70	79
Radiatae	*E. risdonii*	Risdon Peppermint	8	4	35	35	28	41
Radiatae	*E. tenuiramis*	Silver Peppermint	133	118	31	34	49	60
Pauciflorae	*E. pauciflora subsp. pauciflora*	Cabbage Gum	178	170	19	29	13	31
Fraxinales	*E. delegatensis subsp. tasmaniensis*	Gumtopped Stringybark	341	349	29	39	38	49
Psathyroxyla	*E. sieberi*	Ironbark	49	37	22	32	38	46
SUBGENUS: *Symphyomyrtus*	**SECTION:** *Maidenaria*							
Series	**Eucalypt species/subspecies**	**Common name**						
Foveolatae	*E. ovata var. ovata*	Black Gum	426	412	22	28	20	31
Foveolatae	*E. brookeriana*	Brookers Gum	118	81	21	33	40	51
Foveolatae	*E. barberi*	Barbers Gum	22	17			50	69
Foveolatae	*E. rodwayi*	Swamp Peppermint	159	135	11	20	25	38
Semiunicolores	*E. vernicosa*	Varnished Gum	68	76			92	93
Semiunicolores	*E. subcrenulata*	Alpine Yellow Gum	72	62	87	93	71	78
Semiunicolores	*E. johnstonii*	Yellow Gum	55	47			40	52
Orbiculares	*E. archeri*	Alpine Cider Gum	18	20			85	92
Orbiculares	*E. gunnii*	Cider Gum	96	100	85	87	35	45
Orbiculares	*E. gunnii subsp. divaricata*	Miena Cider Gum					10	16
Orbiculares	*E. gunnii subsp. gunnii*	Cider Gum	NA					
Orbiculares	*E. urnigera*	Urn Gum	35	29			66	73
Orbiculares	*E. morrisbyi*	Morrisbys Gum	3	2	63	76	50	50
Orbiculares	*E. cordata*	Tasmanian Silver Gum	24	25	98	98	36	47
Orbiculares	*E. cordata subsp. cordata*	Eastern Tas. Silver Gum					22	37
Orbiculares	*E. cordata subsp. quadrangulosa*	Western Tas. Silver Gum					61	65
Orbiculares	*E. perriniana*	Spinning Gum	4	4	-	100	91	91
Viminales	*E. rubida subsp. rubida*	Candlebark	90	86			36	48
Viminales	*E. dalrympleana subsp. dalrympleana*	Mountain White Gum	203	176	13	33	27	39
Viminales	*E. viminalis*	White Gum	441	424	13	16	30	42
Viminales	*E. viminalis subsp. hentyensis*	Henty White Gum					50	50
Globulares	*E. globulus subsp. globulus*	Tasmanian Blue Gum	221	211	21	25	31	43
Globulares	*E. globulus subsp. pseudoglobulus*	Gippsland Blue Gum	NA					
	ALL SPECIES				35	43	32	43

Footnote Table 1: The taxonomic classification follows (Brooker 2000) with modifications following the latest unpublished taxonomic treatment by Dr. Dean Nicolle (Currency Creek Arboretum, S.A.) (i.e. Brooker's series *Insulanae* has been included in series Radiatae by Nicolle; Brooker's series Psathyroxylon (Brooker) [ie *E. sieberi*] is *Psathyroxyla* in Nicolle; Nicolle has also recognized *E. ambigua* for the old *E. nitida* [maintained herein]). [1]Note that recent molecular data suggests that *E. perriniana* has closer affinities to the series *Viminales* (McKinnon *et al.* 2008; Steane *et al.* 2011). Where multiple subspecies occur in Tasmania, all have been combined in the species total, and additional information only presented at the subspecies level where sub-specific assignment is clear. The area of which the assessment has been undertaken is that indicated in Figure 1 (ie. excluding King Island, the Furneaux Group and islands further north). Common names are those indicated in the Natural Values Atlas (NVA). The reservation status of the threatened *E. morrisbyi* is under estimated from the electronic records as the vaste majority of the species occurs in two disjunct reserved populations and other records are for just two small patches of mature trees, one of which may be planted. Estimates of formally reserved TASVEG hectares were not presented for *E. perriniana* as a significant component of the community was mapped in an IBRA bioregion in which the species does not occur.

Taxonomy

Thirty eucalypt species are recognised as native to Tasmania (Table 1). The island has a high level of eucalypt endemism with 18 (60%) endemic species, one endemic subspecies formally recognised (*E. delegatensis* subsp. *delegatensis*) and one informally recognised (*E. dalrympleana* subsp. 'Tasmania' in Nicolle 2006). In addition, molecular studies have revealed significant genetic differentiation between Tasmanian and mainland populations of several non-endemic taxa (e.g. *E. regnans* - Nevill *et al.* 2010, Nevill 2010; *E. perriniana* - Rathbone *et al.* 2007; *E. globulus* - Dutkowski and Potts 1999; Steane *et al.* 2006; Wallis *et al.* 2011; Yeoh *et al.* 2012). Numerous studies have also revealed significant genetic variation between populations within most of the Tasmanian species at a local or regional scale. Progeny trials have also revealed significant geographic variation in virtually all of the endemics studied which in the future may result in subspecific or variety recognition. For example, genetic differentiation between northern and southern populations of several of the endemic species have been reported but not taxonomically described (e.g. *E. tenuiramis* - Wiltshire *et al.* 1992, Turner *et al.* 2001; *E. barberi* - McEntee *et al.* 1994; *E. gunnii* - Potts and Reid 1985; *E. urnigera* - Matthews 2010). However, four species are represented by two formally recognised subspecies. Subspecies are recognised within the endemics *E. gunnii* (Potts *et al.* 2001) and *E. cordata* (Nicolle *et al.* 2008). A localised west coast population of *E. viminalis* has been described as a separate subspecies (subsp. *hentyensis*) to the wide-spread *E. viminalis* subsp. *viminalis* (Brooker and Slee 2007). Most Tasmanian *E. globulus* is classified as *E. globulus* subsp. *globulus,* although populations on several of the Bass Strait islands have morphological affinities to *E. globulus* subsp. *pseudoglobulus* (Jordan *et al.* 1993; Wallis *et al.* 2011). However this latter taxon is poorly defined on molecular data (Jones 2009). The pattern of genetic variation that exists within the Tasmanian eucalypt species has been best studied in *E. globulus* and has been summarised using an informal system of geographic races and subraces. There are eight races (Dutkowski and Potts 1999) in Tasmania which group into two major molecular lineages (western [incl. King Island] and eastern [incl. Furneaux Group]) - (Steane *et al.* 2006; Yeoh *et al.* 2012), and upon which local adaptive clines are superimposed (Foster *et al.* 2007; Dutkowski and Potts 2011). Even within the more-or-less continuously distributed *E. globulus* subsp. *globulus* in eastern Tasmania there are significant differences in numerous adaptive traits, particularly between northern and southern races (e.g. drought tolerance – Dutkowski and Potts 2011).

Evolutionary processes and history

In a broader sense, the regional and local clines in *E. globulus* are indicative of the close adaptive response of eucalypts to their environment. In the case of species such as *E. regnans,* which may recruit in mass following wildfire, such adaptation is believed to be driven by strong density dependent selection acting as stands self-thin (Hardner and Potts 1997). While localised adaptive clines also occur in the wide-spread *E. obliqua* (Wilkinson 2008), this species exhibits little genetic differentiation in nuclear molecular markers across its Tasmanian range, indicative of a gene pool well linked by gene flow (Bloomfield *et al.* 2011). There are differences between western, eastern and Tasman Peninsula populations of *E. obliqua* in maternally inherited chloroplast DNA. The chloroplast DNA is only dispersed by seed whereas nuclear markers are dispersed by both seed and pollen. As seed dispersal is limited in most eucalypts, there is much greater gene flow by pollen than seed (e.g. 157 times in the case of *E. obliqua*, Bloomfield *et al.* 2011) and chloroplast DNA normally exhibits much greater spatial structuring than revealed from nuclear markers. In the case of wide-spread *E. obliqua*, the historic isolation between the populations as suggested from the chloroplast DNA appears to have been countered by extensive pollen-mediated gene flow. Similar patterns of differentiation in chloroplast DNA are also evident in *E. regnans*, where unique haplotypes in north-eastern and south-eastern Tasmania suggest the presence of glacial refugia (Nevill *et al.* 2010; Nevill 2010). In this case, while nuclear marker differentiation between populations is also low, there does appear to be a difference between northern and southern populations (Nevill 2010), suggesting an extended period of isolation.

The Tasmanian eucalypt species are from two of the eight major lineages of *Eucalyptus* (13 species from subgenus *Eucalyptus* – the ashes and peppermints; 17 species from subgenus *Symphyomyrtus* – the gums; Table 1) and are restricted to a single taxonomic section within each subgenus. These sections are wide-spread in eastern or south-eastern Australia, and are thought to have evolved over a period of continental-wide drying which commenced c. 25 million years ago (Crisp *et al.* 2004). While the eucalypt lineage is of Gondwanic origin, speciation within the lineages on the island of Tasmania appear to be of relatively recent origin (Steane *et al.* 2002; McKinnon *et al.* 2005; Steane *et al.* 2011). The island clearly contains strongly neo-endemic (recently diverged) species and variants (e.g. *E. risdonii* - Wiltshire *et al.* 1998; Turner *et al.* 2001), and represents a dynamic and actively evolving system (Potts and Jackson 1986; Potts 1990; McKinnon *et al.* 2004a). Marked changes in environment occurring over short distances in response to rapid changes in aspect, altitude, geology and drainage are often associated with rapid transitions in the Tasmanian eucalypt flora (see Jackson 1965; Reid and Potts 1999). These changes include both changes in species composition and local adaptive clines within species (e.g. *E. urnigera* on Mt Wellington - Barber and Jackson 1957, Close *et al.* 2007; *E. gunnii-archeri* - Potts and Reid 1985, Potts 1985; *E. obliqua* - Wilkinson 2008; *E. vernicosa* complex - Potts and Wiltshire 1997; McGowen *et al.* 2001; *E. globulus* - Foster *et al.* 2007). The climatic perturbations of the Pleistocene glacial cycles would have been superimposed on this complex mosaic and no doubt elicited major spatial shifts in the distribution of species and genetic diversity on the island (Jackson 1999; McKinnon *et al.* 2004a). The south-east of the island around

Storm Bay is believed to have been a major refuge for eucalypt forest during glacial periods and endemic eucalypt taxa are concentrated in the south-east of the island. Rising tree-lines at the end of the Last Glacial would mean that many contemporary sub-alpine eucalypt forests are less than 10, 000 years old, and there is evidence for a rapid expansion of forest in Tasmania during the early Holocene. It is thus likely that many contemporary sub-alpine eucalypt forests in the central regions of the island have occupied the areas in which they currently occur for less than 12,000 years. Accordingly the patterns of species distribution and the patterns of genetic variation in these regions would be relatively recent in evolutionary time. Up-slope migration is likely to explain the many small populations of sub-alpine eucalypt taxa or their genetic remnants isolated on hill-tops and plateau in the south-east (e.g. forms with affinity to *E. coccifera* residing in *E. pulchella* populations on hill tops in the eastern Tasmania – Shaw *et al.* 1984). In addition, to the formation and removal of barriers between populations within the island, the Pleistocene glacial periods resulted in the formation and breaking of the land-bridge between Tasmania and the mainland, and would have resulted in periods of isolation and reciprocal invasion associated with the rising and lowering of sea-level respectively. There is chloroplast DNA evidence for a western seed migration route linking the Otway Ranges, King Island and Western Tasmania for several of the species studied (e.g. *E. globulus* - Freeman *et al.* 2001; the peppermint species - McKinnon *et al.* 1999; *E. viminalis* and *E. ovata* – Marthick 2005). In the case of *E. globulus* there is also evidence for a seed migration route between eastern Gippsland and the Furneaux Group of islands off the northern-east coast of Tasmania, but an historic barrier to seed migration between the Furneaux Group and northern Tasmania (Freeman *et al.* 2001). However, this barrier does not appear to be evident for pollen-mediated gene flow (McKinnon *et al.* 2005; Yeoh *et al.* 2012).

Many of the recognised Tasmanian species form complexes of closely related taxa which are effectively nodes in a continuum of variation which appears to reflect a dynamic evolutionary interplay between adaptive radiation and convergence, drift and hybridisation as populations have, and continue to respond to changing environments and distributions. Such complexes are most evident at the series level where exact taxonomic classification of intermediates and atypical variants and populations is often difficult. Examples of such complexes include the peppermints (Subg. *Eucalyptus*, series *Radiatae*), alpine white gums (Subg. *Symphyomyrtus*, series *Orbiculares*), white gums (Subg. *Symphyomyrtus*, series *Viminales*) and yellow gums (Subg. *Symphyomyrtus*, series *Semiunicolores*). Contemporary hybridisation (F_1's (first generation hybrid) and hybrid swarms) and intergration amongst the Tasmanian eucalypts in the wild is well documented (Potts and Reid. 1988; Williams and Potts 1996; Reid and Potts 1999). Even hybridisation and gene exchange between taxa classified into different taxonomic series appears to have occurred. There are examples of trees with intermediate bark between *E. regnans* (Subg. *Eucalyptus*, ser. *Regnantes*) and *E. obliqua* (ser. *Eucalyptus*) in the wet forests of southern Tasmania, as well as Victoria that are believed to be hybrids (Ashton 1981). There are even cases where hybridisation is not visually apparent but revealed only by molecular studies (e.g. *E. cordata* x *E. globulus*- McKinnon *et al.* 2004b, McKinnon *et al.* 2010). Indeed, chloroplast DNA sharing amongst many of the *Symphyomyrtus* eucalypts when they co-occur in south-eastern Tasmania is thought to be due to extensive hybridisation amongst these species in a south-eastern glacial refugium (McKinnon *et al.* 2001; McKinnon *et al.* 2004a). Similar, cryptic hybridisation also appears to be occurring amongst the ash species (*E. regnans*, *E. obliqua* and E. *delegatensis* – Nevill 2010) and amongst the alpine white gums (ser. *Orbiculares*) when species co-occur on the Central Plateau (Hudson 2007; Matthews 2010). Hybridisation and gene exchange (reticulate evolution) within the subgenera thus appears to have been an integral part of the evolutionary history of the Tasmanian eucalypts and is likely an important process for future evolution of the island's eucalypt flora.

Gene-flow from plantations

The last two decades have seen a major expansion of eucalypt plantations in Australia mainly for pulpwood production. This expansion has seen the establishment of a 207,000 hectare estate of *E. nitens* (subg. *Symphyomytrus*, ser. *Globulares*) on the island (Gavran and Parsons 2011). *E. nitens* is native to mainland Australia and is grown for pulpwood and solid-wood production. The other main plantation eucalypt species grown on the island is *E. globulus*, which is mainly grown for pulpwood production. It is native to the island although mainland races are currently favoured for pulpwood plantations in Australia (Jones *et al.* 2006). Both these plantation species can potentially hybridise with local eucalypt species or populations respectively from the subgenus *Symphyomyrtus*, with the exception that *E. nitens* cannot pollinate *E. globulus* due to the large differences in flower size (Potts *et al.* 2003). *E. nitens*, for example, will not hybridise with *E. obliqua*, *E. regnans* and *E. delegatensis*, but will with species such as *E. perriniana* (Barbour *et al.* 2010) and *E. ovata* (Barbour *et al.* 2005a). In specific situations proximity of a proposed reserve to a plantation may need considering, particularly in the case of rare *Symphyomyrtus* eucalypt species (Barbour *et al.* 2010). *E. nitens* will not hybridise with *E. obliqua*, *E. regnans* and *E. delegatensis* because they are from the subgenus *Eucalyptus*, and *E. nitens* will not successfully pollinated *E. globulus* due to the large differences in flower size (Potts *et al.* 2003). In a study of hybridisation with *E. ovata* with distance from *E. nitens* plantations, it has been shown that the rate drops markedly by 200 – 300 m from the plantation edge (Barbour *et al.* 2005b) and there is selection against the hybrids which would reduce their capacity to establish and reach reproductive maturity in the wild (Barbour *et al.* 2006). There are many other barriers to such hybridisation with the Tasmanian native eucalypts, including flowering time differences, which are being used by the Forest Practices Authority to guide risk assessment (Roberts *et al.* 2009).

Approach

General strategy

Point distributional records were used as a means of quantifying the distribution of the island's eucalypt species (and atypical populations and hybrids) and to provide a data set to:

(i) assess the number of records and proportion of records in formal and informal reserves over all of the island, as well as in each IBRA bioregion separately;
(ii) assess the change in this distribution of records through the inclusion of the area within the proposed reserves; and
(iii) identify species, atypical populations and hybrids occurring in each reserve.

The proposed reserves with records of a target eucalypt species were then screened to identify those which may have noteworthy values for the species from a genetic and evolutionary perspective. These values included whether the proposed reserve: contained geographically or ecologically marginal populations; would increase the target eucalypt species representation overall, or in specific IBRA bioregions or local areas where the records suggest a eucalypt species may be under-represented in reserves; or a species was involved in natural hybridisation.

Distribution records

In the timeframe available, it was only possible to collate records from the Tasmanian Government's Natural Values Atlas (NVA, downloaded 15 December 2011), new records from the Tasmanian Herbarium which had not been integrated into the NVA since 2005 (download January 2012), records compiled from the data based used by Williams and Potts (1996) and miscellaneous records from the University of Tasmania. The new herbarium data was screened for location accuracy and nomenclature. Similarly any nomenclature changes which had occurred (e.g. new determinations) to the Tasmanian Herbarium (HO) data previously uploaded into NVA were reviewed and integrated into the data set. Changes to the grid references were made where it was possible to allocate historic records to specific known populations, as in the case of rare species (e.g. *E. morrisbyi* or *E. cordata*) or from location information given in other record fields. As a large component of the data compiled by Williams and Potts (1996) was already on the NVA, only specific components of this data set (38,566 records) were used in order to minimise record duplication. This included the numerous literature sources which had been screened for location information. The compiled database comprising

113,059 records was further screened for obvious location errors or inaccuracies, focusing on rare species and also the range limits of wide-spread species by spatial plotting of records with Google Earth©. Where obviously incorrect or dubious records were detected these were tagged and removed. Nevertheless, the cited accuracy of the retained records varied markedly from 3m to more than 100km or unknown, with the older records usually the less accurate. These less accurate records were retained to obtain the historic and geographic spread of sampling across the island when the location of the record was relatively clear from notes fields or where there was no obvious inconsistency in their position with respect to the known distribution of the species. The dataset was thus reduced to 106,183 records when the more obvious location and taxonomic errors and uncertainties were excluded. It is assumed that any errors in record location are random with respect to land-tenure and IBRA bioregion (Interim Biogeographic Regionalisation of Australia - the scientific framework that is used to develop the National Reserve System) in the analysis presented.

Two levels of taxa identification were used in analyses. The first level was the finer break-down of the affinity of the records into species (e.g. *E. johnstonii*, *E. vernicosa* etc), intergrades between recognised species (e.g. *E. subcrenulata – vernicosa*), subspecies (e.g. *E. gunnii* subsp. *divaricata*), those difficult to assign to one or other species based on the data available (e.g. *E. brookeriana – ovata*), falling outside the norm for a species but having affinities to a given taxon (e.g. *E.* aff. *subcrenulata*) and those given as putative hybrids with (e.g. *E. barberi* x *cordata*) or without (e.g. *E. barberi* x) putative parentage indicated. This more detailed level of classification was used to screen each proposed reserve for biodiversity values (species, hybrids, intergrades etc). The second level of classification was restricted to the species level. When only one subspecies has been reported for Tasmania the full subspecies name is used. Where multiple subspecies have been described for Tasmania, their records were combined as in cases (e.g. *E. gunnii*) it was not possible to allocate all records (particularly historic records) to specific subspecies. Where possible, intergrades were allocated to the species to which they were considered to be closest. In cases where species identification was unclear the original observer’s allocation was used or if unclear the record was left unassigned. All hybrid records or records of unclear affinities were left unassigned to a given species. This second level of classification was used to determine the number of species per 10 x 10 km grid cell, as well as to tabulate the reservation status of each species.

To minimise the effect of duplicate records or oversampling in specific locations (e.g. for species where specific population studies have been undertaken), the compiled data set comprising 106,183 records was reduced to a single record every 100 x 100m for each of the first level classification units (species, subspecies, intergrades, hybrids etc). Priority was given to retaining new high accuracy data followed by the records from the original NVA download. This culling to one record every 100 x 100m resulted in a dataset of 71,433 records. Following the preparation of this data set, records from Forestry Tasmania's giant tree database was provided and added. This data included positional information for their giant trees (>85 m tall or > 280m^3 volume; see http://www.gianttrees.com.au/) amounting to 134 records, plus additional tall trees that were assessed during the process of searching for giant trees. In total this additional data amounted to a total of 499 records of tall *E. regnans*, *E. obliqua*, *E. delegatensis*, *E. globulus* and *E. viminalis*.

This data set of 71,932 records (hereafter referred to as the 'compiled dataset') was then categorised for each species/subspecies (G. Williamson) using GIS layers of the current and proposed land tenure (see Table 2), and their occurrence and number of records in each proposed reserve determined. In the case of *E. globulus*, where the species distribution in Tasmania has been classified into a hierarchy of genetically-defined races and sub-races (Dutkowski and Potts 1999), new shape-files were drawn and used to allocate records into sub-races and the current and proposed land-tenure tabulation repeated at an infra-specific level.

Table 2. Land tenure classes into which records were allocated.

A1 - Dedicated formal reserve
A2 - Informal reserve on public land
A3 - Other public land
FR - Private conservation reserve
IR – Indigenous reserve
P2 - Informal reserve on public land proposed for reservation
P3 - Other public land proposed for reservation
PZ - Unattributed areas proposed for reservation
ZZ - Not attributed (freehold land plus any areas not attributed above)

Bias in compiled records

It is important to recognise that numerous factors which will bias extrapolation of the record data compiled to the species as a whole. Firstly, there is a clear uneven spatial distribution of eucalypt records across Tasmania which may be due to various factors (e.g. differences in accessibility, areas where intensive botanical survey took place, etc). There is a paucity of records from the central and south-west region (Fig. 1), consistent with that observed for non-eucalypt records from the same region (G. Jordan, this report). Most of this area comprises the WHA and reduced sampling intensity no doubt reflects reduced access and human activity in this region. However, this paucity of eucalypt records is also due to an increase in non-eucalypt vegetation (button grass plains, rainforest and alpine areas). Secondly, the tendency to collect records in accessible areas and potentially within these areas from places subject to human activities such as forestry may bias the distribution of records. This bias would result in the record data underestimating the overall proportion of the species gene pool in reserves. Similarly, if historic records have been included from areas which have now been cleared or converted to plantation this would again act to under estimate the current reservation status of the extant gene pool. Thirdly, there is a strong bias within most regions for a concentration of records in reserves or public land and there is an under representation of records relative to the land surface on freehold and other land (tenure category ZZ). This bias towards reserves and public land is most evident in the IBRA bioregions of Ben Lomond, Flinders, King, Tasmanian Northern Midlands, Tasmanian Northern Slopes and Tasmania South East where there are between 3 and 5 times more records per unit area on public land and reserved areas compared to freehold (ZZ). The intensity of records in the proposed reserve area is more similar to that in current reserved and public land. The impact of this bias will depend upon the relative proportion of the freehold estate with eucalypt forest. The changes in the observed reservation status of the records associated with the proposed reserves, is thus mainly relevant to the change in the reservation of the species across reserves and public land.

There are other sources of distributional data which would be valuable to consolidate and utilise in the future, and help increase records from remote areas and freehold land. Indeed a future focus should the consolidation of records from the World Heritage Area, other formal reserve surveys, long-term and repeat measures monitoring projects, field survey notebooks and Forest Practices Plans.

TASVEG communities

As a secondary means of obtaining an insight into the level of gene pool reservation and avoiding some of the bias associated with the compiled records, the hectares of TASVEG mapping communities (Harris and Kitchener 2005) dominated by a target species (e.g. "*Eucalyptus amygdalina* forest and woodland on sandstone" - DAS) were also determined across land tenures where appropriate. This simply involved summing the number of hectares of each TASVEG community defined by the target eucalypt species for each IBRA bioregion and determining the proportion in formal and informal reserves (e.g. for *E. amygdalina* the number of hectares in the TASVEG communities – DAC, DAD, DAI, DAM, DAS and DAZ was summed; for *E. regnans* this involved just a single community WRE). Where two eucalypt species was used to define the TASVEG community, the contribution of hectares to the species sum was halved as indicated in Table 4. The TASVEG community allocation to various land tenure classes was obtained from the analysis of the Tasmanian Reserve Estate June 2011 which had used the adjusted TASVEG Version 2 (provided by L. Gilfedder). This allowed the partition of the TASVEG communities in to the hectares classified as forming part of the Tasmanian Reserve Estate (total informal and informal reserves) as well as the National Reserve Estate (perpetual formal reserves). Reserves in the IBRA bioregions showing TASVEG communities dominated by the focal wide-spread species that were either under-represented or listed under the Tasmanian Nature Conservation Act 2002 (*E. amygdalina* – TASVEG community DAS, DAZ; *E. brookeriana* – WBR; *E. globulus* – DGL, DVC; *E. viminalis* – DVC, DVF, WVI) were identified where warranted. TASVEG mapping communities was also used to minimise the risk that a species presence may be missed within a proposed reserve and provide additional confirmation of a presence. Two measures of the presence of a species in a proposed reserve was thus compiled, the first based on the presence of a point record and the second based on the presence of a point record or a TASVEG community defined by the target species. The use of the TASVEG communities again is only an approximation to the reservation status of the species as a whole for numerous reasons including: the target species varying in density within the community; and also occur in communities defined by other target species.

Results

Distribution of the eucalypt species

For each of the Tasmanian eucalypt species, 10 x10 m grid cell occupancy is shown in Table 1 and the spread of records across the IBRA bioregions is given in Table 4. The perspective on the overall distributions of species has changed little since the Williams and Potts (1996) review. The re-assembly and screening of data records, coupled with the new discoveries over the last 15 years has seen an average increase in the known range of the Tasmanian eucalypt species by five 10 x 10km grid cells (Table 1). Minor contractions can be explained by a change in grid system from AGD66 to GDA94 over this period and different centring of the cells, coupled with the re-assessment of records in terms of location accuracy and taxonomic affinities. The major increases in the estimated grid cell occupancy occurred in *E. radiata* subsp. *radiata* (71% over the Williams and Potts 1996 figure), *E. risdonii* (100%), *E. sieberi* (32%), *E. brookeriana* (45%), *E. barberi* (29%), *E. rodwayi* (18%), *E. subcrenulata* (16%), *E. johnstonii* (17%), *E. urnigera* (21%), and *E. morrisbyi* (50%). New populations of several of the endemics have been discovered since 1996 (e.g. *E. subcrenulata* – Crystal Hill and *E. urnigera* – Wielangta Hill). However, in the case of E. cordata, population discovery has been countered by recent accurate mapping of known populations allowing more precise allocation of historic records. The estimates of grid cell occupancy have been remarkably consistent of some species (e.g. *E. obliqua*, *E. globulus*). Both analyses show that *E. viminalis, E. obliqua* and *E. ovata* are the most wide-spread species on the island followed by *E. delegatensis* subsp. *tasmaniensis, E. globulus* subsp. *globulus* then *E. dalrympleana* subsp. *dalrympleana. Eucalyptus perriniana* and the endemic *E. morrisbyi* are the rarest of the species on the island.

The number of species with records is highest in the Tasmanian South East (25 species) and Tasmanian Southern Ranges (23 species) IBRA bioregions (Table 3). Similarly, the number of eucalypt species recorded in a 10 x 10 km grid cell is higher in the east of the island. This trend also matches an increase the number of eucalypt records in the east (Fig. 1), which is also evident in all NVA flora records in general (see G. Jordan report). While increased sampling intensity would lead to greater species detection, this would not to explain the observed differences between northern and south-eastern Tasmania (Fig. 1). This trend for increasing species richness in the east of the island, particularly in the south-east, is also evident from the earlier mapping of eucalypt species distributions by Jackson (1965) and is thought to partly reflect the presence of a Glacial refuge for eucalypt forest in the south-east of the island (McKinnon et al. 2004a). This south-eastern trend is mainly due to a concentration of endemic eucalypt taxa in the east and south-east of the island (e.g. *E. barberi, E. cordata, E. johnstonii, E. morrisbyi, E. pulchella, E. risdonii, E. tenuiramis* and *E. urniger*a – see Williams and Potts 1996). Other factors such as environmental heterogeneity no doubt also affect diversity and those proposed reserves encompassing large altitudinal transitions for example are also expected to have higher species diversity. Nevertheless, after accounting for area, the proposed reserves with recorded presences of the most eucalypt species tend to be in the east of the island (Figure 2). Based on both records and the presence of a TASVEG mapping communities defined by a target eucalypt species, the proposed reserves near Wielangta (**29**), Little Swanport (**45, 39**) and St Marys (**123**) appear to have the highest richness of eucalypt species. Other proposed reserves which similarly appear to stand out using records alone or records coupled with the TASVEG information are (in order of decreasing reserve area): **208, 39, 68, 76, 14, 117, 122, 204, 40, 215** and **214**.

Reservation levels

Of the 70,333 compiled records assessed at the species level, 32% were in perpetual formal reserves and 43% occurred in either formal or informal reserves (Table 1). Very similar estimates were obtained from the analysis based on species representation in TASVEG communities (35% and 43% respectively).

At the species level, the percentage of compiled records falling in reserves (formal or informal) was lowest for more widely distributed species than rare species, and ranged from 31% for *E. regnans, E. ovata* and *E. pauciflora* to greater than 90% for the rare *E. perriniana* (91%), the alpine shrub *E. vernicosa* (93%), and small sub-alpine tree *E. archeri* (93%). The number of compiled records in reserves for the rare endemic *E. morrisbyi* (50%) underestimates the overall level of reservation of the species as only a few scattered trees of this species occur outside the two main formal reserves in which it occurs. In contrast, the level of reservation of *E. perriniana* is probably overestimated as one of the three populations of this species is unreserved. Only 38% of the records of the newly described *E. nebulos*a occur in reserves. A notable deficit of reserved records (15%) occurs for the threatened subspecies *E. gunnii* subsp. *divaricata*. The most wide-spread of the species *E. obliqua* and *E. viminalis* had 37 % and 42% of records in reserves, although it should be noted that these lowland species would have large areas of their distribution in regions with a paucity of records from freehold land.

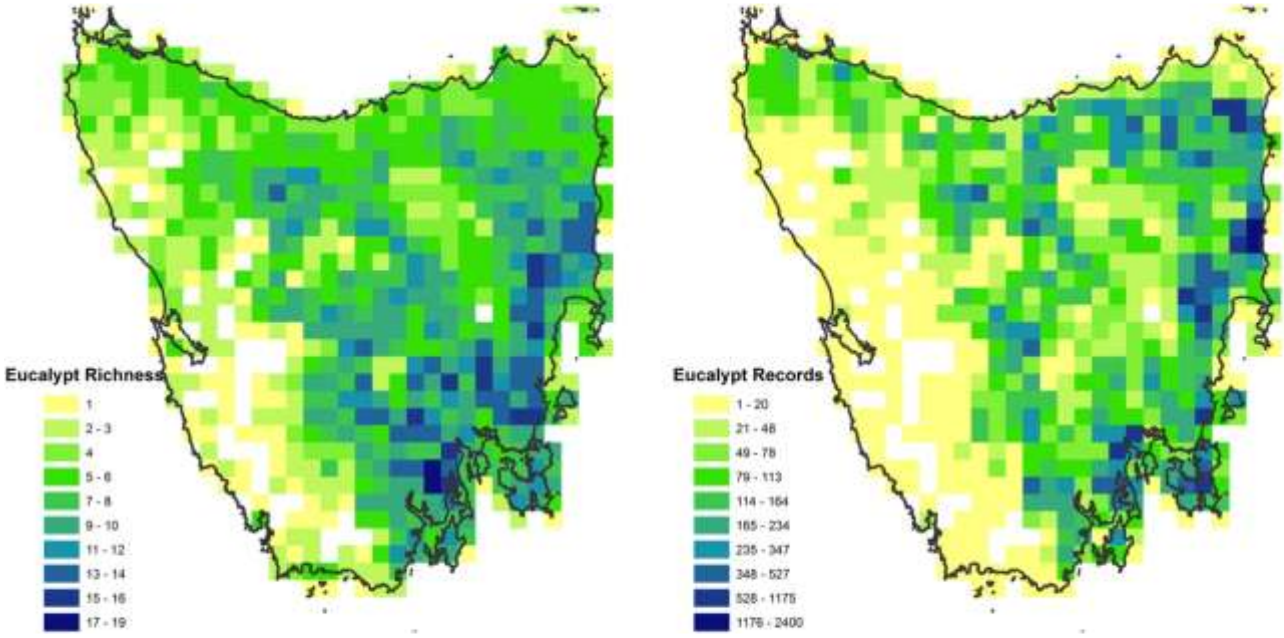

Figure 1. Geographic distribution of the number of eucalypt species (richness) in 10 x 10 km grid cells (left). The number of total eucalypt records per 10 x 10 km grid cell is shown on the right - note the very low numbers of records in most of western Tasmania.

The percentage of the total number of hectares of TASVEG communities defined by the target eucalypt species that were in reserves is also shown in Table 1. There was reasonable consistency between the compiled record and TASVEG community estimates of reservation levels in many cases. For example, virtually identical estimates were obtained using point records and the TASVEG community dominated by the target species for *E. regnans* (31% vs 29% TASVEG - WRE), *E. obliqua* (37% vs 34%), *E. pauciflora* subsp. *pauciflora* (31% vs 29%), *E. ovata* subsp. *ovata* (31% vs 28%), and *E. perriniana* (91% vs 100%). There was deviation in other cases, which could be due to a multitude of factors including the target species occurring in other TASVEG community types. However even where consistency did occur, there were still many records of the target species which occurred in areas outside of the relevant mapped TASVEG communities (e.g. *E. regnans* – WRE) and *visa versa*.

The level of compiled records falling in formal reserves was the least for *E. pauciflora* subsp. *pauciflora* (13%), *E. radiata* subsp. *radiata* (15%) and *E. regnans* (17%). A similar representation is evident from the TASVEG communities for *E. pauciflora* subsp. *pauciflora* (19%) and *E. regnans* (15%). When viewed in terms of their mapped TASVEG communities, *E. dalrympleana* subsp. *dalrympleana* (13%), *E. viminalis* (13%) and *E. rodwayi* (11%) have low representation in formal reserves, although this was less evident in the record data (Table 1). The percentage of records or hectares of their TASVEG communities falling into reserves was very similar for species such as *E. regnans*, *E. obliqua* and *E. ovata* var. *ovata* for formal and informal (plus formal) categories of reservation. The species showing markedly more mapped communities in reserves than did the compiled records in a relative sense were *E. nitida*, *E. pauciflora*, *E. gunnii* and *E. cordata*. In the case of *E. nitida* this is explicable by its wide-spread occurrence in the south-west, in the WHA, where there was a paucity of records overall. There are many species under-represented in reserved mapped TASVEG units compared with reserved records, which could be due to their greater presence in reserves as members of other communities than as their defined community type. Such species are *E. brookeriana*, *E. rodwayi*, *E. viminalis*, *E. dalrympleana* and *E. globulus*.

The distribution of compiled records of each species across the IBRA bioregions is given in Table 3 as well as the percentage in reserves in each bioregion. This information was used to help identify bioregions where species, particularly those of the more wide-spread species, were rare or least reserved. For example, the Tasmanian Northern Midlands bioregion had the lowest percentage of records of *E. obliqua* (16% and a very low representation), *E. ovata subsp. ovata* (11%) and *E. pauciflora subsp. pauciflora* (2%) in reserves (Table 3). In the case of *E. pauciflora*, this trend was also evident in the TASVEG community estimate (12%). *Eucalyptus regnans* was relatively rare in the Flinders and King bioregions and few of the compiled records in this bioregion were in reserves. A notable discrepancy between the *E. regnans* records and TASVEG community in reserves occurred in the Tasmanian West bioregion. This was mainly due to TASVEG mapping of several patches of *E. regnans* (WRE) in the WHA, yet there are no electronic records for *E. regnans* in these more remote western regions which would constitute the south-western margins of the species distribution if validated.

Impact of proposed reserves

If fully implemented, the proposed reserve system would increase the overall percentage of compiled eucalypt records that were in reserves from 44% to 54% and those in formal reserves from 32% to 45% (Table 4). It is important to note that these data refer to the records in the compiled dataset and given the biases noted in the distribution of records cannot be extrapolated to the species or the eucalypt flora as a whole. The main impact of the proposed reserves is to increase the percentage of compiled records in formal reserves for common, wide-spread species such as *E. obliqua* (18%), *E. delegatensis* (21%) as well as species of intermediate spread such as *E. regnans* (24%), *E. johnstonii* (32%) and *E. sieberi* (22%) (Table 4). Some of the species with the least percentage of records in formal reserves such as *E. ovata* var. *ovata* (20%), *E. pauciflora* var. *pauciflora* (13%), and *E. radiata* subp. *radiata* (15%) only marginally benefit from the proposed reserves. In contrast there will be a marked increase in the number of formally reserved records in species such as *E. regnans* (17% to 41%), *E. nebulosa* (25% to 100%), *E. johnstonii* (40% to 72%) and *E. sieberi* (38% to 60%). The proposed reserves result in little or no change in the proportion of compiled records in formal reserves for the listed rare or threatened taxa *E. barberi* (50% to 52%), *E. morrisbyi* (no change), *E, perriniana* (no change) and *E. risdonii* (no change). While only small, the gain for the threatened *E. gunnii* subsp. *divaricata* (10 to 17%) is noteworthy given the low percentage of compiled records in reserves.

Commentary on the notable values of the proposed reserves from a eucalypt phylogenetic and genetic perspective, are given specifically for *E. globulus subsp. globulus* in Table 5, and on a species by species basis in Table 6. A summary of otable contributions of proposed ENGO forest reserves for the maintenance of eucalypt phylogenetic and genetic diversity is presented in Table 7. Several proposed reserves in both the north and south of the island contain relatively large areas of *E. regnans* forest and also include giant trees **13**, **35**, **82**, and **258**; as do several smaller proposed reserves (**166**, **197**). A proposed reserve on the west coast (**81**) would complete the reservation of the small, disjunct populations of *E. globulus* on the west coast of Tasmania, another (**127**) would include an inland disjunct population in the NE of Tasmanian, and components of **2** include the most southern, race of *E. globulus*. One proposed reserve (**198**) will increase the reservation level of the recently described rare endemic *E. nebulosa* (serpentine peppermint), others would result in the formal reservation of a key geographically outlying population of the endemic *E. aff. subcrenulata* (**258**), as well as geographical or ecologically marginal populations of the endemics *E. archeri* (**208**) and *E. gunnii* (**212**, **123** and possibly **45**). An atypical population of *E. barberi* and an area of natural hybridisation between *E. barberi* and another rare endemic, *E. cordata* subsp. *cordata* would be included in **29**. There are few other opportunities to enhance the reservation of *E. cordata* subsp. *cordata* within the proposed reserve system.

Indicative maps of the distribution of some of the notable values of the proposed ENGO reserves were prepared by the Independent Verification Group and are included in Appendix 1.

Table 3. The percentage of eucalypt records and TASVEG hectares in reserves (informal plus formal) by IBRA region and species/subspecies. Where a zero is listed the value is a positive small number, real zeros are blank. Continued next page.

	IBRA Bioregion																	
	Ben Lomond		Flinders		King		Tasmanian Central Highlands		Tasmanian Northern Midlands		Tasmanian Northern Slopes		Tasmanian South East		Tasmanian Southern Ranges		Tasmanian West	
EUCALYPT SPECIES	% reserved	% of all Tas records	% reserved	% of all Tas records	% reserved	% of all Tas records	% reserved	% of all Tas records	% reserved	% of all Tas records	% reserved	% of all Tas records	% reserved	% of all Tas records	% reserved	% of all Tas records	% reserved	% of all Tas records
E. amygdalina	28	25	33	11	50	0	53	2	30	7	48	16	63	37	43	3	95	0
*(DAC DAD DAI DAM DAS DAZ (DSC*0.5)) TASVEG*	28	24	40	20	12	0	48	1	25	15	32	11	37	30	38	1	100	0
E. archeri	92	29					93	71										
E. barberi													69	100				
(DBA) TASVEG													82	32	100	29	100	34
E. brookeriana	45	21	0	0	43	26			100	0	43	1	55	40	40	3	80	8
(WBR) TASVEG	16	2			31	92	100	0			17	1	38	2	100	4	44	1
E. coccifera							78	53	0	0	69	2	71	13	84	31	100	1
(DCO) TASVEG							87	79	100	0	100	2	94	2	96	17	100	1
E. cordata													34	54	63	46		
(DCR) TASVEG													100	64	93	37		
E. dalrympleana subsp. dalrympleana	28	10	100	0	0	0	35	16	49	2	53	6	48	41	25	24	100	0
*((DDP*0.5) WDA) TASVEG*	21	25					25	16			59	24	5	4	30	31	100	0
E. delegatensis subsp. tasmaniensis	40	16	0	0	33	0	56	20	43	1	42	12	63	31	30	20	77	2
(DDE WDB WDL WDR WDU) TASVEG	30	16					41	32	26	1	44	7	25	17	45	24	86	4
E. globulus subsp. globulus	54	2	29	2									46	80	25	14	95	1
(DGL WGK WGL) TASVEG	35	1	26	2			0	0					25	94	21	3		
E. gunnii	70	2					39	82			32	2	71	4	80	9	83	1
(DGW) TASVEG	18	2					87	88			100	4			97	6	100	0
E. johnstonii													70	15	50	80	29	5
E. morrisbyi													50	100				
(DMO) TASVEG													76	100				
E. nebulosa																	38	100
E. nitida			43	1	34	27	68	5			56	12	67	0	57	19	81	35
(DNF DNI WNL WNR WNU) TASVEG			57	3	40	6	90	6			65	2			92	12	91	71
E. obliqua	24	24	26	4	23	9	56	1	16	0	44	18	53	24	32	17	49	2
*(DOB (DSC*0.5) WOB WOL WOR WOU) TASVEG*	29	11	39	2	18	11	46	1	15	0	32	21	34	15	35	29	64	11
E. ovata var. ovata	23	15	33	9	20	5	36	1	11	8	35	13	37	43	31	5	74	1
(DOV DOW) TASVEG	16	18	50	8	35	8	61	0	20	8	19	27	25	23	70	3	70	4
E. pauciflora subsp. pauciflora	23	6	39	2			30	19	20	18	53	4	30	34	41	17	100	0
*((DDP*0.5) DPD DPO)TASVEG*	18	4	56	0			29	43	12	2	74	0	17	21	41	30	100	0
E. perriniana													86	48	96	52		
(DPE) TASVEG													100	100				
E. pulchella	13	0	0	0					50	0			51	91	51	8		
(DPU) TASVEG	3	0									0	0	35	94	19	6		
E. radiata subsp. radiata							70	9			68	90					100	1
E. regnans	24	48	7	0	15	0	74	0	0	0	41	5	24	8	29	36	12	2
(WRE) TASVEG	29	40	10	0	0	0	80	0			36	3	30	6	28	50	100	0
E. risdonii													41	100				
(DRI) TASVEG													36	100				
E. rodwayi	43	12	14	1			25	23	24	4	33	6	44	37	49	16	100	0
(DRO) TASVEG	25	12	0	0			14	42	43	4	47	1	12	25	38	15		
E. rubida	22	6					45	3	0	2	0	0	49	76	62	13		
E. sieberi	38	44	27	32					83	2			87	22				
(DSG) TASVEG	34	64	21	30					64	2			76	3				
E. subcrenulata	100	0					85	34			94	9			71	51	80	6
(WSU) TASVEG	31	0					99	53			99	8	100	0	83	35	100	3
E. tenuiramis	78	1											60	94	46	5	100	1
(DTD DTG DTO) TASVEG							0	0					34	96	17	4	100	1
E. urnigera							25	24	0	0			88	42	90	34		
E. vernicosa							94	9							95	21	93	70
E. viminalis	28	19	29	7	24	1	51	2	29	7	38	13	53	48	33	3	50	0
*((DVC*0.5) DVF DVG DVS WVI) TASVEG*	15	13	31	2	84	1	56	1	15	25	26	5	13	53	14	1	8	0
No. Species		19		14		9		19		15		16		25		23		20

Table 3 (cont.). The percentage of eucalypt records and TASVEG hectares in reserves by IBRA bioregion and species/subspecies. TASVEG hectares were calculated by summing across the communities defined by the eucalypt species and could only be estimated for a subset of the data.

	IBRA Bioregion																	
	Ben Lomond		Flinders		King		Tasmanian Central Highlands		Tasmanian Northern Midlands		Tasmanian Northern Slopes		Tasmanian South East		Tasmanian Southern Ranges		Tasmanian West	
EUCALYPT SPECIES	% reserved	% of all Tas records	% reserved	% of all Tas records	% reserved	% of all Tas records	% reserved	% of all Tas records	% reserved	% of all Tas records	% reserved	% of all Tas records	% reserved	% of all Tas records	% reserved	% of all Tas records	% reserved	% of all Tas records
SUBSPECIES																		
E. cordata* subsp. *cordata		0		0		0		0		0		0	37	92	33	8		0
E. cordata* subsp. *quadrangulosa		0		0		0		0		0		0	18	9	69	91		0
E. gunnii* subsp. *divaricata		0		0		0	16	100		0		0		0		0		0
E. viminalis* subsp. *hentyensis		0		0		0		0		0		0		0		0	50	100

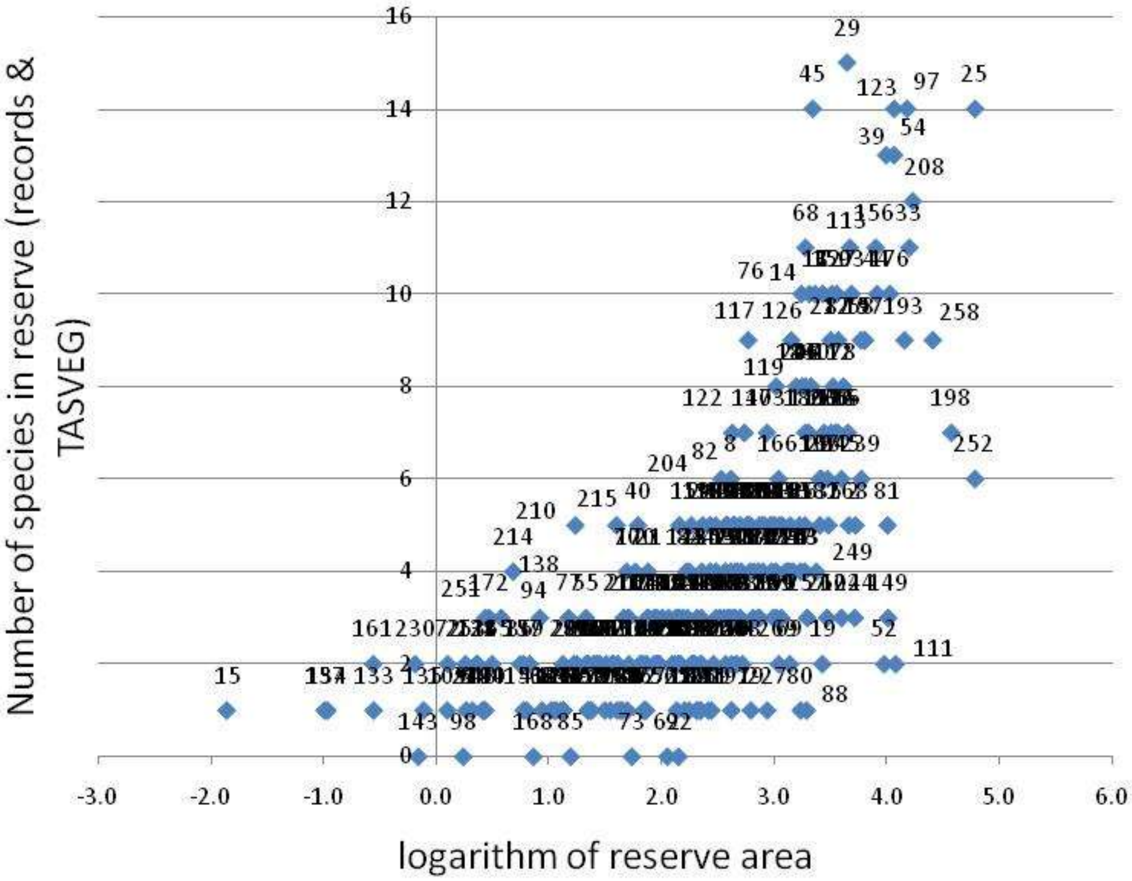

Figure 2. Plot of the number of species present in each proposed reserve versus the logarithm of reserve area (ha) where species presence has been predicted from the record data supplemented with information from the presence of a TASVEG community defined by the focal species. The number of of eucalypt records per reserve also increases with reserve area.

Table 4. The conservations status, total number of records assessed, percentage of records in (i) areas of informal reserve proposed for reservation (P2), (ii) in the whole area proposed for reservation (P2, P3, PZ), (iii) currently in formal reserves (A1), (iv) would be in formal reserves if all proposed reserves were accepted (A1, P2, P3, PZ), (v) currently in formal and informal reserves (A1, A2, FR, IR, P2), and (vi) would be in formal or informal reserves if all proposed reserves were accepted (A1, A2, FR, IR, P2, P3, PZ). These categories effectively describe the change in record status in the National Reserve System (iii to iv; Australia's network of protected areas) and the Tasmanian Reserve Estate (v to vi).

Species	Status	Extent (numberof 10 x 10 km grid cells occupied)	Total number of records	% in areas of informal reserve proposed for reservation (P2)	% in all area proposed for reservation (P2, P3, PZ)	% currently in formal reserves (A1)	% in formal reserves including the proposed reserves (A1, P2, P3, PZ)	% currently in formal or informal reserves (A1, A2, FR, IR, P2)	% in formal or informal reserves including proposed reserves (A1, A2, FR, IR, P2, P3, PZ)
Eucalyptus amygdalina		421	10954	2	9	35	44	46	53
Eucalyptus archeri	endemic	18	173	8	14	85	99	92	99
Eucalyptus barberi	endemic, rare	22	266	0	2	50	52	69	71
Eucalyptus brookeriana		118	536	1	11	40	51	51	61
Eucalyptus coccifera	endemic	127	942	5	12	70	81	79	86
Eucalyptus cordata	endemic	24	302	0	1	36	37	47	48
Eucalyptus dalrympleana subsp. dalrympleana		203	2172	2	10	27	37	39	47
Eucalyptus delegatensis subsp. tasmaniensis		341	7940	5	21	38	59	49	65
Eucalyptus globulus subsp. globulus		221	4483	1	6	31	37	43	49
Eucalyptus gunnii	endemic	96	1084	3	11	35	46	45	53
Eucalyptus johnstonii		55	288	7	32	40	72	52	77
Eucalyptus morrisbyi	endemic, endangered	3	16	0	0	50	50	50	50
Eucalyptus nebulosa	endemic	3	8	13	75	25	100	38	100
Eucalyptus nitida	endemic	293	1377	7	16	49	65	60	69
Eucalyptus obliqua		433	14793	3	18	26	44	37	52
Eucalyptus ovata var. ovata		426	3080	1	5	20	24	31	35
Eucalyptus pauciflora subsp. pauciflora		178	1531	3	6	13	19	31	34
Eucalyptus perriniana	rare	4	44	0	0	91	91	91	91
Eucalyptus pulchella	endemic	126	1701	0	4	34	38	51	55
Eucalyptus radiata subsp. radiata	rare	12	107	6	6	15	21	68	68
Eucalyptus regnans		170	4089	5	24	17	41	31	50
Eucalyptus risdonii	endemic, rare	8	380	0	0	28	28	41	41
Eucalyptus rodwayi	endemic	159	793	4	7	25	33	38	41
Eucalyptus rubida		90	412	0	1	36	37	48	49
Eucalyptus sieberi		49	1306	3	22	38	60	46	65
Eucalyptus subcrenulata	endemic	72	358	6	14	71	85	78	87
Eucalyptus tenuiramis	endemic	133	1776	0	3	49	52	60	63
Eucalyptus urnigera	endemic	35	373	2	3	66	69	73	75
Eucalyptus vernicosa	endemic	68	193	1	3	92	95	93	95
Eucalyptus viminalis		441	8856	2	8	30	38	42	49
all species			**70333**	**3**	**13**	**32**	**45**	**44**	**54**
Subspecies alone									
Eucalyptus cordata subsp. cordata	endemic		82	0	1	22	23	37	38
Eucalyptus cordata subsp. quadrangulosa	endemic		116	0	0	61	61	65	65
Eucalyptus gunnii subsp. divaricata	endemic, endangered		290	3	7	10	17	16	19
Eucalyptus viminalis subsp. hentyensis	endemic		26	0	4	50	54	50	54

Table 5. The total number of records, and percentage of records in reserves (classes A1, A2, FR, IR, P2) and in other areas within the proposed reserves (classes P3 and PZ) of the 10 Tasmanian sub-races of *E. globulus* from 8 races. Sub-races follow Dutkowski and Potts (1999).

Table 4

E. globulus subrace	Total records	% records in areas of informal reserve proposed for reservation (P2)	% records in all area proposed for reservation (P2, P3, PZ)	% records currently in formal reserves (A1)	% records in formal reserves including the proposed reserves (A1, P2, P3, PZ)	% records currently in formal or informal reserves (A1, A2, FR, IR, P2)	% records in formal or informal reserves including proposed reserves (A1, A2, FR, IR, P2, P3, PZ)	Proposed reserves with most value for the *E. globulus* gene pool
Dromedary	49	0	0	10	10	12	12	No impact
Inland_NETas	106	2	7	3	9	22	26	**127**: includes an inland disjunct population of *E. globulus* at Pepper Hill. The race/subrace to which this population belongs has relatively few records in reserves
King Island	NA							
NE Tasmania	1134	3	7	54	61	64	68	**93**, **129** and **150**: contain 39, 27 and 8 ha respectively of vulnerable TASVEG community DGL
Port Davey	17	0	0	100	100	100	100	No impact
Recherche Bay	43	40	70	23	93	65	95	**2**: most southerly population of *E. globulus* is in this area. This small race is genetically different from *E. globulus* further north and has some genetic affinities with populations from western Tasmania
SE Tasmania	2176	2	6	27	33	40	44	**22**: contains 79 ha of vulnerable TASVEG community DGL; the 5% increase in reservation would require multiple reserves in this subrace (e.g. multiple records are in **29**, **39** and **45**)
St Helens	34	0	9	74	82	74	82	Little impact
S Tasmania	447	3	19	9	28	19	35	**3**, **5** and specific localities within **25** would increase the reservation status. **25**: would also include some of the most inland records of *E. globulus* in Tasmania
Tasman Peninsula	445	0	6	15	21	27	32	Increased proportion of records in reserves would be achieved with **8** (includes 6 ha of vulnerable TASVEG community DGL), **12** and **17** (has records but no TASVEG community mapped)
W Tasmania	26	42	50	46	96	92	100	**81**: would increase the reservation status of one of the three small, disjunct populations of E. globulus known on the west coast of Tasmania (near Little Henty River) and mean all three were formally reserved. These populations represent a molecular lineage which includes King Island and is differentiated from the more common eastern Tasmanian lineage of E. globulus as well as mainland lineages. These populations are no doubt the remnants of a more continuous past distribution along the west coast of Tasmania. (see article in http://www.crcforestry.com.au/view/index.aspx?id=69920)

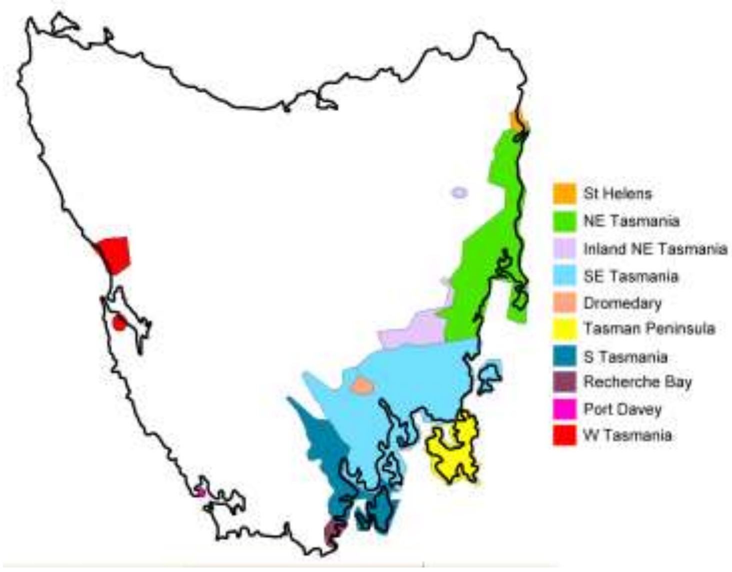

Figure 3. Distribution of the geographic races/sub-races of *E. globulus* subsp. *globulus* (the Tasmanian blue gum) modified from Dutkowski and Potts (1999).

Footnote: This hierarchy of races and sub-races was developed to summarise the continuous quantitative genetic variation which exist within the *E. globulus* gene pool in Tasmania and on the mainland. The Tasmanian component of the gene-pool encompasses 10 sub-races which have been grouped into western (Western Tasmania, Port Davey – also links with King Island which is not shown) and eastern molecular lineages (Steane *et al.* 2006). The Furneaux Island *E. globulus* has closest affinities to the eastern lineage. The small race at Dromedary was initially recognised because of the abnormal seedling morphology and growth which appeared indicative of local hybridisation. Subsequent molecular studies suggest it is part of the broader SE Tasmanian race in which it is embedded.

Table 6. Notable reserves for each of the Tasmanian eucalypt species. The table shows the number of 10 x 10km cells in which the species has been recorded, the percentage of records in formal reserves (class A1) and the percentage of records in all areas proposed for reservation (reserve classes P2, P3 and PZ).

Species/subspecies	extent (# of 10x10km cells)	% in formal reserves	% proposed for reservation	Distribution	Endemism and conservation status	Comments	Notable reserves
Eucalyptus amygdalina	421	35	9	widespread	Endemic	Wide-spread species integrading with *E. nitens* to the west and *E. pulchella* to the east; DAS and DAZ are threatened *E. amygdalina* define communities. Outyling records are probably associated with integration with E. nitida, but there does appear to be an under representation of records in the King IBRA.	Notable reserves for this species are based on increasing representation in vulnerable TASVEG community types (Eucalyptus amygdalina forest and woodland on sandstone or Eucalyptus amygdalina inland forest and woodland on Cainozoic deposits) are **17**, **39**, **65**, **87**, **97** (both communities), **113**, **127**, **136**, **140**, **141**, **142**, **148**, **151**, **188**, **196**, **239**
Eucalyptus archeri	18	85	14	regional, several disjunct populations	Endemic	Sub-alpine endemic, well reserved.	**208:** will include two isolated populations of *E. archeri* in the far NE of the species range on Ben Nevis and Mt Saddleback consolidating the reservation of this sub-alpine endemic
Eucalyptus barberi	22	50	2	regional, series of small disjunct populations	Endemic, listed as rare on schedules of the Tasmanian Threatened Species Protection Act 1995	Seedling trials have shown that the northern and southern populations of this species are genetically differentiated, with the transition occurring at about the level of Swansea (McEntee et al. 1994). Populations of the southern form are less well reserved and their is an atypical 3 fruited (normally 7) variant in the far south of the species range.	**29:** most southerly part of the *E. barberi* distribution. An atypical 3 fruited variant of *E. barberi* extends onto slopes surrounding Ponybottom Creek. The reserve includes a unique area of hybridisation between endemics *E. barberi* and *E. cordata*. **39:** includes a high density of records for the southern form of the endemic *E. barberi* in the northern parts of the proposed reserve
Eucalyptus brookeriana	118	40	11	widespread but in specific habitats		Closely related to E. ovata and it is often difficult to differentiate between west coast forms of E. ovata and E. brookeriana. Records of both taxa occur same for even the same locality and where affinities are unclear they have been identified as E. brookeriana - ovata and then assigned to the taxa of recorded affinities . Any occurence in Flinders and Central Highlands significant and also at the base of the Western Tiers which links NE and NW distributions, Endangered community WBR.	WBR in **249** 30ha, **123** 15ha **150** 11ha **265** 7ha; **29** has records, E. brookeriana is poorly reserved in this area which is near the southern limit of its distribution on the east coast edge; **39** and **45** contain records spacing reserved populations evenly down the east coast
Eucalyptus coccifera	127	70	12	locally common	Endemic		**78**: may include the Alma Tier peppermint *E. coccifera - tenuiramis* which has yet to be formally recognised but is poorly reserved (would need ground truthing). **29**: includes records which may represent genetic remnants of *E. coccifera* following up-slope migration from the Last Glacial (eg Middle Peak - Shaw et al 1984, coccifera - pulchella); **17** & **14** as with **29** but may involve introgression with *E. tenuiramis*)

Table 6. Notable reserves for each of the Tasmanian eucalypt species. Continued.

Species/subspecies	extent (# of 10x10km cells)	% in formal reserves	% proposed for reservation	Distribution	Endemism and conservation status	Comments	Notable reserves
Eucalyptus cordata	24	36	1		Endemic		
Eucalyptus cordata subsp. cordata		22	1	rare,disjunct populations of varying size	Endemic		**29**: Only proposed reserve with records of the endemic *E. cordata* . The proposed reserve includes multiple records for subsp. *cordata* suggesting several patches within the proposed reserve. One of these on a ridge near Poneybottom Creek is involved in hybridisation with E. barberi. Studies have also shown evidence of cryptic hybridisation between *E. cordata* and *E. globulus* at this site (McKinnon et al. 2004; 2010). Searches for the population corresponding to the record near the summit of Wielangta Hill have not been fruitful but a small patch of eucalypt of unclear affinity (E. aff. *rubida /dalrympleana*) has been located which may explain the record and is just as significant.
Eucalyptus cordata subsp. quadrangulosa		61	0	rare, disjunct populations	Endemic		No impact
Eucalyptus dalrympleana subsp. dalrympleana	203	27	10	widespread in sub-alpine areas in the north and east		informally recognised as an endemic subspecies (subsp. 'Tasmania') in Nicholle 2006	
Eucalyptus delegatensis subsp. tasmaniensis	341	38	21	widespread		Well represented in reserves; Discrepancy between South-east records and TASVEG % in reserves; priority for TASVEG communities of lower % reservation DDE WDB - DDE 29% WDB 33% WDL 75% WDR 86% WNU 64%; any occurrence of E. delegatenis in Flinders or King regions would also have priority as the species is rare in these IBRA regions. No proposed reserves were found with records or TASVEG communities in these regions . The western limit of the species is well reserved by the WHA. The NE and SE geographic extremes occur in putative glacial refugia.	Eastern limits and representation in putative glacial refugia would be enhanced in the SE by **5**, **14** (or **12**), **17** and **29**. Proposed reserves **237** or **258** would enhance the % reservation of *E. delegatensis* in the far NE of the species range
Eucalyptus globulus subsp. globulus	221	31	6	regionally widespread in east but several small disjunct populations in the west coastal areas		The four taxa in the E. globulus complex are variably treated as species or subspecies as there is extensive integradation between them. Recent molecular studies have indicated subsp. pseudoglobulus is porly defined and part of an widely distributed gene pool extending across southern Victoria (Gippsland to the Otway Ranges)	**127, 93, 129, 150, 2, 22, 3, 5, 25** and **81**: see Table 4 for details

Table 6. Notable reserves for each of the Tasmanian eucalypt species. Continued.

Species/subspecies	extent (# of 10x10km cells)	% in formal reserves	% proposed for reservation	Distribution	Endemism and conservation status	Comments	Notable reserves
Eucalyptus globulus subsp. pseudoglobulus				rare, small populations on N Flinders and Rodondo Island	Listed as rare on schedules of the Tasmanian Threatened Species Protection Act 1995	The three-fruited form found on norther Flinders Island and Rodondo Island in Bass Strait with morphological affinities to mainlanland populations. Three-fruited forms of the west coast of Tasmanian have sometimes been assigned to subsp. pseudoglobulus but molecular studies have clearly shown these populations form a distinct western lineage which includes King Island and links populations in the Otway Ranges and eastern Tasmania.	NA
Eucalyptus gunnii	96	35	11	broad geographic range but restricted to specific habitats	Endemic	E. gunnii mainly occurs at higher altitude central parts of the island but there are several disjunct populations in the north east, east and south east of the species range. Populations at Snow Hill (eastern Tiers) and Mt Victoria are already reserved but there are several other key populations which would be included in the proposed reserves. A key low altitude disjunct population at the SE limits of the species range at Esperence Plains is not formally reserved.	**212:** includes a key disjunct population in the NE at the base of Mt Arthur at the lower altitudinal limit of the species range; **123:** includes the lowest altitudinal occurence of the species in a disjunct population at the eastern limit of the range of this normally centrally distributed species (Horseshoe Marsh); **45:** includes an single outlying record of E. gunnii which is validated would be an important more southerly disjunct population at the eastern limits of the species range; **25:** includes records in an area of the south-east where there are few populations of E. gunnii; **198:** includes a record which if validated would be near the low altitudinal and north-western limit of E. gunnii. The Populations in the NW of the E. gunnii distribution have been referred to as the NW form of gunnii (potts and Reid 1985). **97:** a central population which includes many records of the E. gunnii, including several around Great Lake classified as the threatened subsp. divariacata. This proposed reserve is likely to inlclude the type location for E. gunnii collected by Ronald Gunn.
Eucalyptus gunnii subsp. divaricata		10	7	localised and rare	Endemic, listed as endangered on schedules of the Tasmanian Threatened Species Protection Act 1995 and the Commonwealth Environment Protection and Biodiversity Conservation Act 1999	The most frost resistant form of E. gunnii (cider gum) which is threatened due to extensive death of mature trees since the early 1990's. Clinally linked with E. gunnii and integrades into E. archeri in the north of its range. Poor reservation status.	**74:** includes many records classified as the threatened subsp. divaricata
Eucalyptus gunnii subsp. gunnii				regionally common, disjunct populations	Endemic		The low altitude disjunct populations referred to under E. gunnii (see above) would classify as belonging to subsp. gunnii

Table 6. Notable reserves for each of the Tasmanian eucalypt species. Continued.

Species/subspecies	extent (# of 10x10km cells)	% in formal reserves	% proposed for reservation	Distribution	Endemism and conservation status	Comments	Notable reserves
Eucalyptus johnstonii	55	40	32	regional	Endemic	Records of E. johnstonii are included in the TASVEG mapping unit for E. subcenulata in SE Tasmania(WSU).	**25:** significantly increases the number of reserved records of the endemic E. johnstonii in SE Tasmania, particularly along its western limit, where in cases it clinally integrades with E. subcrenulata at higher altitudes (McGowen et al. 2001) in the WHA. This reserve includes 2290ha - WSU, which would include records classified as E. subcenulta and E. johnstonii and encompass populations of the forest tree form of this species complex. Populations at the southeastern limit of the geographic range are also included in reserves: **3** includes a population at Tylers Hill where there are historic records of three-way hybridisation between E. johnstonii, E urnigera and E. globulus, (recent searches have failed to *E. johnstonnii* or *E. urnigera* in this area but have located hybrids). **5** and **14** would expand the reservation of outlying populations at the geographic margins of the species range on Bruny Island and the Tasman Peninsula respectively
Eucalyptus morrisbyi	3	50	0	rare, know from three main localities, 4th may be an historic planting	Endemic, listed as endangered on schedules of the Tasmanian Threatened Species Protection Act 1995 and the Commonwealth Environment Protection and Biodiversity Conservation Act 1999	The two main populations of this species are reserved (c. 95% of indiviuals of the species). The smaller reserved population is in decline but has been established in two ex situ plantings/seed orchards and seed has been collected from one and lodged with the Millenium Seed Bank.	No impact
Eucalyptus nebulosa	3	25	75	rare, 2 localities known	Endemic	restricted to serpentine out crops, although not all serpentine outcrops in this area have E. nebulosa. Affinities to E. nitida require clarification.	**198**: records of the newly described serpentine specialist *E. nebulosa* occur in two disjunct locations in this proposed reserve
Eucalyptus nitida	293	49	16	widespread	Endemic	E. ambigua DC. now has priority over E. nitida Hook.f. as the formal taxonomic name but most works still refer to E. nitida at the moment. Intergrades with E. amygdalina and some outlying populations may have closer affinities to this species. Populations on Furneaux island have been reported as intermediate between E. nitida and a mainland peppermint. Discrepancy between records and TASVEG in IBRA SE Tasmania region partly due to unclear affinities of some of the few records of E. nitida in this area wrt E. amygdalina (eg coastal forms).	***25:*** *Leptospermum scrub / canopy E. nitida 52.96 ha R;* ***44:*** *Eucalyptus nitida over rainforest 5.99ha V*

Table 6. Notable reserves for each of the Tasmanian eucalypt species. Continued.

Species/subspecies	extent (# of 10x10km cells)	% in formal reserves	% proposed for reservation	Distribution	Endemism and conservation status	Comments	Notable reserves
Eucalyptus obliqua	433	26	18	widespread		There is an under-representation of records and TASVEG units with E. obliqua in IBRA regions: King and Northern Midlands but there are few opportunities to change this with the exception of 78, 97 which records suggest may contain small areas of E. obliqua. All giant trees of E. obliqua appear to be in formal reserves	**78, 97**
Eucalyptus ovata var. ovata	426	20	5	widespread	Large areas of original range have been cleared for agriculture; DOV threatened 26% DOW 48%; up overall reservation representation where possible with priorities on the Ben Lomond and Northern Midlands and DOV		DOV Ben Lomond **258** 54ha; **262** 16ha; **264** 37ha; other area **169** - 23ha, **180** - 27ha, **186** - 95ha, **188**- 32 ha, RECORDS in **29**, **39**, **46**, **169**, **218**, **232**
Eucalyptus pauciflora subsp. pauciflora	178	13	6	Regional		Significant areas of original range have probably been cleared for agriculture and highest reservation priority would be in the dry low altitude landscapes; Species appears to have lowest reservation status in Northern Midlands, Ben Lomond and South-Eastern IBRA regions; There is also a benefit to increase reserved populations in the Tasmanian Northern Slopes and Flinders bioregions as the records suggests that the species is relatively rare in these regions.	Ben Lomond **117** - minimal, **118** - 35ha DPO; **119** - 123ha DDP; **127** - 3ha DPO; **137** 10ha DDP;**173** - 33ha DDP 6ha DPO; **208** - 65ha DDP; South-east - **46** - 358ha DPD; Northern Slopes 115: The most suitable proposed reserve in Northern Slopes bioregion but only has 1 record and no TASVEG listed (records are nearby, would need ground truthing), No suitable proposed reserves were identified in the Flinders bioregion.
Eucalyptus perriniana	4	91	0	rare, 3 disjunct populations known	Listed as rare on schedules of the Tasmanian Threatened Species Protection Act 1995		No impact

Table 6. Notable reserves for each of the Tasmanian eucalypt species. Continued.

Species/subspecies	extent (# of 10x10km cells)	% in formal reserves	% proposed for reservation	Distribution	Endemism and conservation status	Comments	Notable reserves
Eucalyptus pulchella	126	34	4	regionally common	Endemic	Medium distribution, common in the SE, types intermediate between E. puchella and amygdalina are widespread to the north and east of its distribution; c. 50% of records in reserves in the 3 IBRA regions within which it occurs; populations of interest for hybridisation with E. coccifera on hills in the SE, also hybridisation reported on Snug Plains (formal reserve)	No key reserves identified
Eucalyptus radiata subsp. radiata	12	15	6	local, several outlying records available	Listed as rare on schedules of the Tasmanian Threatened Species Protection Act 1995	One outlying low atitude record in Wilmot River area is unreserved	**122**, **132**, **140** this will mainly involve upgrade of reservation status.
Eucalyptus regnans	170	17	24	regional and confined to specific habitats		There are very few records and TASVEG mapping units with E. regnans (WER), in IBRA regions: Flinders and King and thus stands in these regions would be ecological/geographic outliers for the species. Ther are few opportunities to change this with the proposed reserves. The distribution and reservation representation of this species in the Western IBRA and WHA region requires clarification as no point records were available for several TASVEG mapped WRE forest in several remote areas which would consitute the south western limits of the species distribution.	**20 & 30:** close to the western inland limit of the species in this region and main source of records for the Western IBRA bioregion. While no WRE is mapped here, this is WOR and point records suggest that E. regnans is occurring with E. obliqua in this area. Thesignificance of this occurence will partly depend upon validation of mapped WRE further in the WHA. **13**: 1,293 ha of WRE 3 giant E. regnans trees occur on the NE edge of the proposed reserve and there is a cluster of giant trees in this general area; **25**: 5,028ha of WRE, plus 500 E. obliqua and 221 E. regnans records in this large reserve, includes 6+ giant E. regnans trees. **35**: 801 ha WRE, 1 E. delegatensis and 4 E. regnans giant trees. **82**: includes records of one of the two small disjunct populations at the northern limits of the southern distribution of E. regnans on the east coast. Its significance will depend upon whether E. regnans occurs in the adjacent Cygnet River Forest Reserve (currently no records) . **39**: 314ha of WRE, would increase reservation of a mid-east coast disjunct occurence of E. regnans (but only 1 record). **5**: would enlarge the reservation of E. regnans records on Bruny Island which is on the SE fridge of the species distribution. **14** and **17** would increase the reservation of E. regnans on the Tasman and Forestier Peninsula which may have been a SE refugial area for the species.
Eucalyptus risdonii	8	28	0	rare, localised	Endemic, listed as rare on schedules of the Tasmanian Threatened Species Protection Act 1995	Outlying population near New Norfolk requires field validation	No impact

Table 6. Notable reserves for each of the Tasmanian eucalypt species. Continued.

Species/subspecies	extent (# of 10x10km cells)	% in formal reserves	% proposed for reservation	Distribution	Endemism and conservation status	Comments	Notable reserves
Eucalyptus rodwayi	159	25	7	relatively widespread but localised populations	Endemic	Eucalyptus rodwayi forest and woodland (DRO relatively 20% reserved in total). Poorly replreseneted in Flinders IBRA region and absent from King. Outlying populations in the south are not reserved (eg near Geeveston and Tasman Peninsula)	**236** and either **195** or **188** would allow reservation in localised areas poorly reserved. DRO is only 20% reserved main increases can be achieved with reserves **54** - 227ha, **66** - 107ha, **113** - 225ha, **208** - 157ha
Eucalyptus rubida subsp. rubida	90	36	1	relatively widespread in the east		Records suggest that E. rubida is not well reserved in the Ben Lomond bioregion. E. rubida is rare in the Northern Midlands bioregion probably due to clearing for agriculture and there are no records in reserves	**123**, **119** and **117:** records suggest that these 3 reserves are likely to contain E. rubida and would increase the reservation of E. rubida in the Ben Lomond bioregion. **97** is immediately adjacent to the Northern Midlands bioregion in the west and records also suggest would contain E. rubida
Eucalyptus sieberi	49	38	22	regionally common in the NE		Good match between record and TASVEG % reservation. Well balanced representataion in each TASVEG community DSG 31% DSO 33%. Focus in Flinders EBRA Bioregion for increased reservation	Increased reservation in the Flinders bioregion could be achieved with **154**: - 631ha of DSO; **164:** - 51ha of DSO; **174** - 278ha of DSO; **175**- 66ha of DSO; **245** - 103ha of DSG at northernextremity of distribution; **258** also includes records at the northern extremity of distribution and transgresss bioregions - 668h of DSG and 13ha of DSO
Eucalyptus subcrenulata	72	71	14	regional, many disjunct populations	Endemic		**258:** key reserve for E. subcrenulata as includes a highly disjunct population with aff. *E. subcrenulata* in the far NE of the island. This is the only know population of the yellow gums that extends into the north east of the island (Ben Lomond bioregion)
Eucalyptus tenuiramis	133	49	3	regional with disjunct populations, probasbly comprised multiple subspecies requiring description	Endemic	This species comprises different forms (northern, Tasman Peninsula and Southern forms) which require description at the subspecies level. The southern form intergrades with E. risdonii near Hobart on the north shore of the Derwent River. Disjunct populations with affinities to E. tenuiramis occur in the WHA and possibly on Cape Barren Island.	**113** - contains outlying records representing the NW edge of the species range in the east of the island (population would need field validation). **45** contains records which may represent the limit to a N/S disjunction in the species and the southern limit of the northern form of this species ; **14** and **17** - contain sizeable populations of the species on the Tasman Peninsula, DTD ha 122 and 20 ha respectively.

Table 6. Notable reserves for each of the Tasmanian eucalypt species. Continued.

Species/subspecies	extent (# of 10x10km cells)	% in formal reserves	% proposed for reservation	Distribution	Endemism and conservation status	Comments	Notable reserves
Eucalyptus urnigera	35	66	3	regional series of disjunct populations	Endemic	Records suggest the nothern populations of this species are the least well reserved. There is little opportunity to change this with the proposed reserves (except possible **97** which has records close by but ground truthing would be required)	Notable reserves are - **29**: includes a small isolated population of the endemic E. urnigera at the geographic margins of the distribution near Wielangta Hill. **25**: there are records of a population near Mt Styx which would be geographically intermediate between the major distributions of the species on Mt Wellington and Mt Field. **3**. There are historic records of a small population on Tylers Hill at the southern limits of the known distribution of the species which is involved in hybridisation with E. globulus and johnstonii (a recent searches have not found this population of E. urnigera). **5**: may include parts of an isolated population for which most records lie in the adjacent Mt Mangana Forest Reserve.
Eucalyptus vernicosa	68	92	3	regional series of disjunct populations	Endemic	Well reserved, proposed reserve have little impact on this alpine shrub form of the yellow gums	No significant impact
Eucalyptus viminalis subsp. hentyensis		50	4	rare, localised distribution	Endemic	included with E. viminalis subsp. viminalis by Nicholle 2011. Molecular studies have suggested that this population is derived from hybridisation between E. viminalis and E. aff. ovata/brookeriana	**59**: Only proposed reserve with a record for the localised E. viminalis subsp. hentyensis but TASVEG communities do not suggest a substantial population. Would require ground truthing.
Eucalyptus viminalis subsp. viminalis	441	30	8	widespread		Intergrades into *E. dalrympleana* at higher altitudes and intermediate forms are common at intermediate altitudes (termed vim/dal).	**123**: would increase reservation in the Northern Midland bioregion where there are relatively few *E. viminalis* records in reserves . Records suggest that increases in the reservation of *E. viminalis* in the Flinders bioregion could be achieved with **245** (37 records but no TASVEG) and **193** (52 records but no TASVEG).

Table 7. Notable contributions of proposed ENGO forest reserves for the maintenance of eucalypt phylogenetic and genetic diversity

Reserve 2: • Most southerly population of *E. globulus* is in this area. This small race is genetically different from *E. globulus* further north and has some genetic affinities with populations in western Tasmania
Reserve 3: • Increase the reservation status of the southern race of *E. globulus*
Reserve 5: • May include parts of an isolated population of the endemic *E. urnigera* for which most records lie in the adjacent Mt Mangana Forest Reserve • Increase the reservation status of the southern race of *E. globulus* • Increase the reservation status *E. regnans* in the Tasmanian South East bioregion on Bruny Island which is the south-eastern fringe of its distribution • Would expand the reservation of outlying populations of the endemic *E. johnstonii – subcrenulata* at the geographic margins of the species range (2 records plus 24ha WSU)
Reserve 8: • Increase the reservation status of the Tasman Peninsula race of the vulnerable *E. globulus* forest DGL (6 ha) • Increasing the representation of *E. ovata* in the endangered TASVEG community DOV (6 ha)
Reserve 13 • Giant tree database (3 individuals) • Increase the reservation status *E. regnans* in the Tasmanian West bioregion (1,293 ha of wet *E. regnans* forest WRE) • Cluster of giant and large trees in this area
Reserve 14: • High levels of species richness of *Eucalyptus* after accounting for area • Sizeable population of the endemic *E. tenuiramis* on Tasman Peninsula (123 ha of *E. tenuiramis forest*) • Increase the reservation status *E. regnans* in the Tasmanian South East bioregion on the Tasman and Forestier Peninsula which may have been southeastern refugia for the species • Includes records of the endemic *E. coccifera* which may represent genetic remnants following upslope migration from Last Glacial and may involve introgression with the endemic *E. tenuiramis* • would expand the reservation of outlying populations of the endemic *E. johnstonii* at the geographic margins of the species range
Reserve 17: • Sizeable population of the endemic *E. tenuiramis* on Tasman Peninsula (20 ha of *E. tenuiramis forest*) • Increase the reservation status of the Tasman Peninsula race of the vulnerable *E. globulus* (needs field verification) • Increasing representation of the endemic *E. amygdalina* in vulnerable TASVEG community DAS (87 ha) • Includes records of the endemic *E. coccifera* which may represent genetic remnants following upslope migration from Last Glacial and may involve introgression with the endemic *E. tenuiramis*

Reserve 20:

- close to western inland limit of range for *E. regnans*
- Increase the reservation status *E. regnans* in the Tasmanian West bioregion

Reserve 22:

- Contains 80 ha of the SE race of the vulnerable *E. globulus* forest DGL

Reserve 25:

- Records of a population of the endemic *E. urnigera* near Mt Styx. This is geographically intermediate between the major distributions on Mt Wellington and Mt Field
- Some of the most inland records of *E. globulus* in Tasmania
- Increase the reservation status of the southern race of *E. globulus*
- Increase the reservation status *E. regnans* in the Tasmanian Southern Ranges bioregion (5,028 ha of wet *E. regnans* forest WRE)
- Giant tree database (6 individuals)
- Includes records in an area of the south-east where there are few populations of the endemic *E. gunnii*
- significantly increases the number of reserved records of the endemic *E. johnstonii* in SE Tasmania, particularly along its western limit, where in cases it clinally integrades with *E. subcrenulata* at higher altitudes

Reserve 29:

- Amongst the higher levels of species richness of *Eucalyptus* in Tasmania
- most southerly part of the rare endemic *E. barberi* distribution.
- Atypical 3-fruited variant of the rare *E. barberi* on slopes surrounding Ponybottom.
- Unique *E. barberi/E. cordata* hybrid.
- Records of poorly reserved *E. brookeriana* near the southern limit of east coast range.
- Includes records of endemic *E. coccifera* which may represent genetic remnants following upslope migration from last Glacial (eg Middle Peak)
- Small isolated population of endemic *E. urnigera* at geographic margins of distribution near Wielangta Hill

Reserve 35:

- Giant tree database (5 individuals)
- Increase the reservation status *E. regnans* in the Tasmanian Southern Ranges bioregion (801 ha of wet *E. regnans* forest WRE)

Reserve 39:

- High level of species richness of *Eucalyptus* for Tasmania
- high levels of species richness of Eucalyptus in Tasmania after accounting for area
- high density of records of southern form of the rare endemic *E. barberi*
- Increase the reservation status *E. regnans* in the Tasmanian South East bioregion (314 ha of wet *E. regnans* forest WRE)(mid-east coast disjunct occurrence)
- Increasing representation of *E. amygdalina* in vulnerable TASVEG community DAS (318 ha)

Reserve 40:

- High levels of species richness of *Eucalyptus* after accounting for area
- High density of records of southern form of the rare endemic *E. barberi*

Reserve 45:

- Amongst the higher levels of species richness of *Eucalyptus* in Tasmania
- May include geographical or ecologically marginal populations of the endemic *E. gunnii* (needs field verification)
- Occurrence may represent the limit of a north-south disjunction of the endemic *E.*

tenuiramis
Reserve 46: • Increase bioregional reservation of *E. pauciflora* in South East Bioregion (358 ha of *E. pauciflora* DPD forest)
Reserve 54: • Increase bioregional reservation in Flinders Bioregion of *E. rubida* (227 ha of *E. rubida* forest)
Reserve 59: • Only proposed reserve for the endemic *E. viminalis* subsp. *hentyensis* (needs field verification), a localised west coast population of *E. viminalis* that has recently been described as a separate subspecies
Reserve 65: • Increasing representation of *E. amygdalina* in vulnerable TASVEG community DAS (13 ha)
Reserve 66: • Increase bioregional reservation in Flinders Bioregion of *E. rubida* (107 ha of *E. rubida* forest)
Reserve 68: • high levels of species richness of *Eucalyptus* after accounting for area
Reserve 74: • Includes many records classified as the threatened endemic *E. gunnii* subsp. *divaricata*
Reserve 76: • high levels of species richness of *Eucalyptus* after accounting for area
Reserve 78: • may include undescribed Alma Tier peppermint (endemic *E. coccifera-tenuramis*), poorly-reserved. • Increase bioregional reservation in Northern Midlands Bioregion of *E. obliqua*
Reserve 81: • Increase the reservation status of the western subrace of *E. globulus* • Contains one of three small disjunct populations of *E. globulus* on the Wes*t Coast (nea*r Little Henty River). They represent molecular line*ages which i*ncludes King Island and is differentiated from the more common eastern lineage and the mainland lineages • complete the reservation of the small, disjunct populations of *E. globulus* on the wes*t* coast of Tasmania
Reserve 82: • • One of two small disjunct populations at the northern limits of the southern distribution of *E. regnans* on the east coast
Reserve 87: • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAS (35.5 ha)
Reserve 93: • Contains 39 ha of the NE race of the vulnerable *E. globulus* forest DGL
Reserve 97: • Likely to contain *E. rubida* (needs field verification), rare in Northern Midlands bioregion and would increase its bioregional reservation • Increase bioregional reservation in Northern Midlands Bioregion of *E. obliqua* • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG

communities DAS (74 ha) and DAZ (57 ha)
Reserve 113: • North-west edge of range of *E. tenuiramis* in eastern Tas (needs field verification) • Increase bioregional reservation in Flinders Bioregion of *E. rubida* (225 ha of *E. rubida* forest) • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAS (48 ha)
Reserve 114: • Increasing representation of *E. viminalis* in endangered TASVEG community WVI (9 ha)
Reserve 115: • The most suitable proposed reserve to secure bioregional reservation of *E. pauciflora* in Northern Slopes Bioregion (needs field verification) • Increasing representation of *E. viminalis* in endangered TASVEG community WVI (12.5 ha) in Northern Slopes BioregionIncreasing the representation of *E. ovata* in the endangered TASVEG community DOV (9.5 ha) in Northern Slopes Bioregion
Reserve 116: • Increasing representation of *E. viminalis* in endangered TASVEG community WVI (24 ha)
Reserve 117: • High levels of species richness of *Eucalyptus* after accounting for area • Increase bioregional reservation of *E. rubida* in Ben Lomond (needs field verification) • Increase bioregional reservation of *E. pauciflora* in Ben Lomond (minimal)
Reserve 118: • Increase bioregional reservation of *E. pauciflora* in Ben Lomond (35 ha of *E. pauciflora* DPO forest)
Reserve 119: • Increase bioregional reservation of *E. rubida* in Ben Lomond (needs field verification) • Increase bioregional reservation of *E. pauciflora* in Ben Lomond (123 ha of *E. pauciflora* DPP forest) • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAS (69 ha)
Reserve 122: • High levels of species richness of *Eucalyptus* after accounting for area • Increase reservation of *E. radiata* ssp. *radiata*
Reserve 123: • Amongst the highest levels of species richness of *Eucalyptus* in Tasmania • Increase bioregional reservation of *E. rubida* in Ben Lomond (needs field verification) • Increase bioregional reservation level of *E. viminalis* subsp. *viminalis* in Northern Midlands bioregion • Includes the lowest altitudinal occurence of the endemic *E. gunnii* in a disjunct population at the eastern limit of the range of this normally centrally distributed species (Horseshoe Marsh) • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAS (26 ha) • Increasing representation of *E. brookeriana* in vulnerable TASVEG community WBR

(15 ha)
Reserve 127: • Increase bioregional reservation of *E. pauciflora* in Ben Lomond (3 ha of *E. pauciflora* DPO forest) • Inland disjunct population of *E. globulus* at Pepper Hill. The race/subrace has relatively few records in reserves. • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAZ (258 ha)
Reserve 129: • Contains 27 ha of the NE race of the vulnerable *E. globulus* forest DGL
Reserve 132: • Increase reservation of *E. radiata* ssp. *radiata*
Reserve 136: • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAS (25 ha)
Reserve 137: • Increase bioregional reservation of *E. pauciflora* in Ben Lomond (10 ha of *E. pauciflora* DDP forest)
Reserve 140: • Increase reservation of *E. radiata* ssp. *radiata* • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAS (106 ha)
Reserve 141: • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAS (25 ha)
Reserve 142: • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAS (70 ha)
Reserve 148: • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAS (3 ha)
Reserve 150: • Contains 8 ha of the NE race of the vulnerable *E. globulus* forest DGL • Increasing representation of *E. brookeriana* in vulnerable TASVEG community WBR (11 ha)
Reserve 151: • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAS (28 ha)
Reserve 154: • Increase bioregional reservation level of *E. sieberi* in Flinders bioregion (630 ha of *E. sieberi* forest)
Reserve 164: • Increase bioregional reservation level of *E. sieberi* in Flinders bioregion (51 ha of *E. sieberi* forest)
Reserve 166: • Giant tree
Reserve169 • Increasing the representation of *E. ovata* in the endangered TASVEG community DOV (23 ha)
Reserve 173:

• Increase bioregional reservation of *E. pauciflora* in Ben Lomond (33 ha of *E. pauciflora* DDP forest plus 6 ha DPO)
Reserve 174: • Increase bioregional reservation level of *E. sieberi* in Flinders bioregion (278 ha of *E. sieberi* forest)
Reserve 175: • Increase bioregional reservation level of *E. sieberi* in Flinders bioregion (66 ha of *E. sieberi* forest)
Reserve 180: • Increasing the representation of *E. ovata* in the endangered TASVEG community DOV (27 ha)
Reserve 186: • Increasing the representation of *E. ovata* in the endangered TASVEG community DOV (95 ha) • Increasing representation of *E. viminalis* in endangered TASVEG community WVI (18 ha)
Reserve 188: • Increase bioregional reservation in Flinders Bioregion of endemic *E. amygdalina* forest • Increasing the representation of *E. ovata* in the endangered TASVEG community DOV (32 ha) • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAS (46 ha)
Reserve 193: • Increase bioregional reservation level of *E. viminalis* subsp. *viminalis* in Northern Midlands bioregion • Increasing the representation of *E. ovata* in the endangered TASVEG community DOV (22 ha) • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAS (5 ha)
Reserve 195: • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAZ (92 ha) • Increasing the representation of *E. ovata* in the endangered TASVEG community DOV (12 ha)
Reserve 196: • Increasing representation of endemic *E. amygdalina* in vulnerable TASVEG community DAS (122 ha)
Reserve 197 : • Giant tree *E. regnans*
Reserve 198 : • Increase reservation level of recently described newly described endemic *E. nebulosa*

Reserve 208: • High levels of species richness of *Eucalyptus* after accounting for area • Increase bioregional reservation in Flinders Bioregion of *E. rubida* (157 ha of *E. rubida* forest) • Increase bioregional reservation of *E. pauciflora* in Ben Lomond (65 ha of *E. pauciflora* DDP forest) • Geographical or ecologically marginal populations of the endemic *E. archeri* - two isolated populations of *E. archeri* in NE (Ben Nevis & Saddleback), consolidate reservation of subalpine endemic. • Increasing representation of *E. viminalis* in endangered TASVEG community WVI (40 ha)
Reserve 212: • Geographical or ecologically marginal populations of the endemic *E. gunnii* • Increasing the representation of *E. ovata* in the endangered TASVEG community DOV (14 ha) • Increasing representation of *E. viminalis* in endangered TASVEG community WVI (7.5 ha)
Reserve 214: • High levels of species richness of *Eucalyptus* in Tasmania after accounting for area
Reserve 215: • High levels of species richness of *Eucalyptus* in Tasmania after accounting for area
Reserve 236: • Increase bioregional reservation of the endemic *E. rodwayi* in Flinders Bioregion
Reserve 239: • Increasing representation of *E. amygdalina* in vulnerable TASVEG communities DAS (22 ha) and DAZ (16.5 ha)
Reserve 245: • Increase bioregional reservation level of *E. sieberi* in Flinders bioregion (668 ha of *E. sieberi* forest on granite and 13ha of *E. sieberi* forest on other substrates) • Increase bioregional reservation level of *E. viminalis* subsp. *viminalis* in Northern Midlands bioregion • Northern extremity for *E. sieberi* forest on granite (103 ha)
Reserve 249 • Increasing representation of *E. brookeriana* in vulnerable TASVEG community WBR (30 ha)
Reserve 258 • Giant tree • Formal reservation of a key geographically outlying & disjunct population of the endemic *E. aff. subcrenulata.* Only known population in the north-east of the State • Increasing the representation of *E. ovata* in the endangered TASVEG community DOV (54 ha) • Includes records at the northern extremity of distribution of *E. sieberi* • Increasing representation of *E. viminalis* in endangered TASVEG community WVI (140 ha)
Reserve 262 • Increasing the representation of *E. ovata* in the endangered TASVEG community DOV (15.5 ha)
Reserve 264 • Increasing the representation of *E. ovata* in the endangered TASVEG community DOV (37 ha)

Reserve 265

- Increasing representation of *E. brookeriana* in vulnerable TASVEG community WBR (7 ha)

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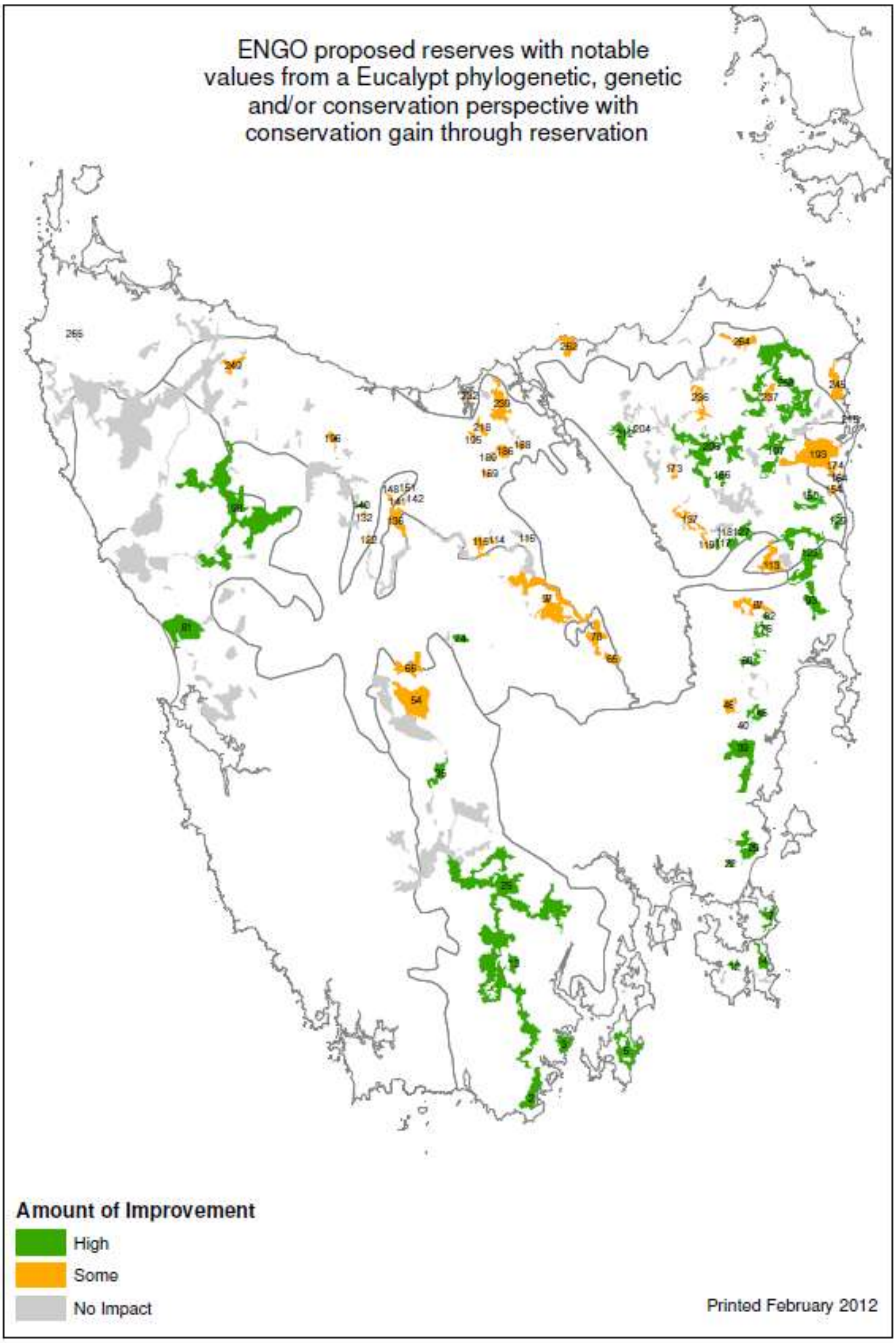
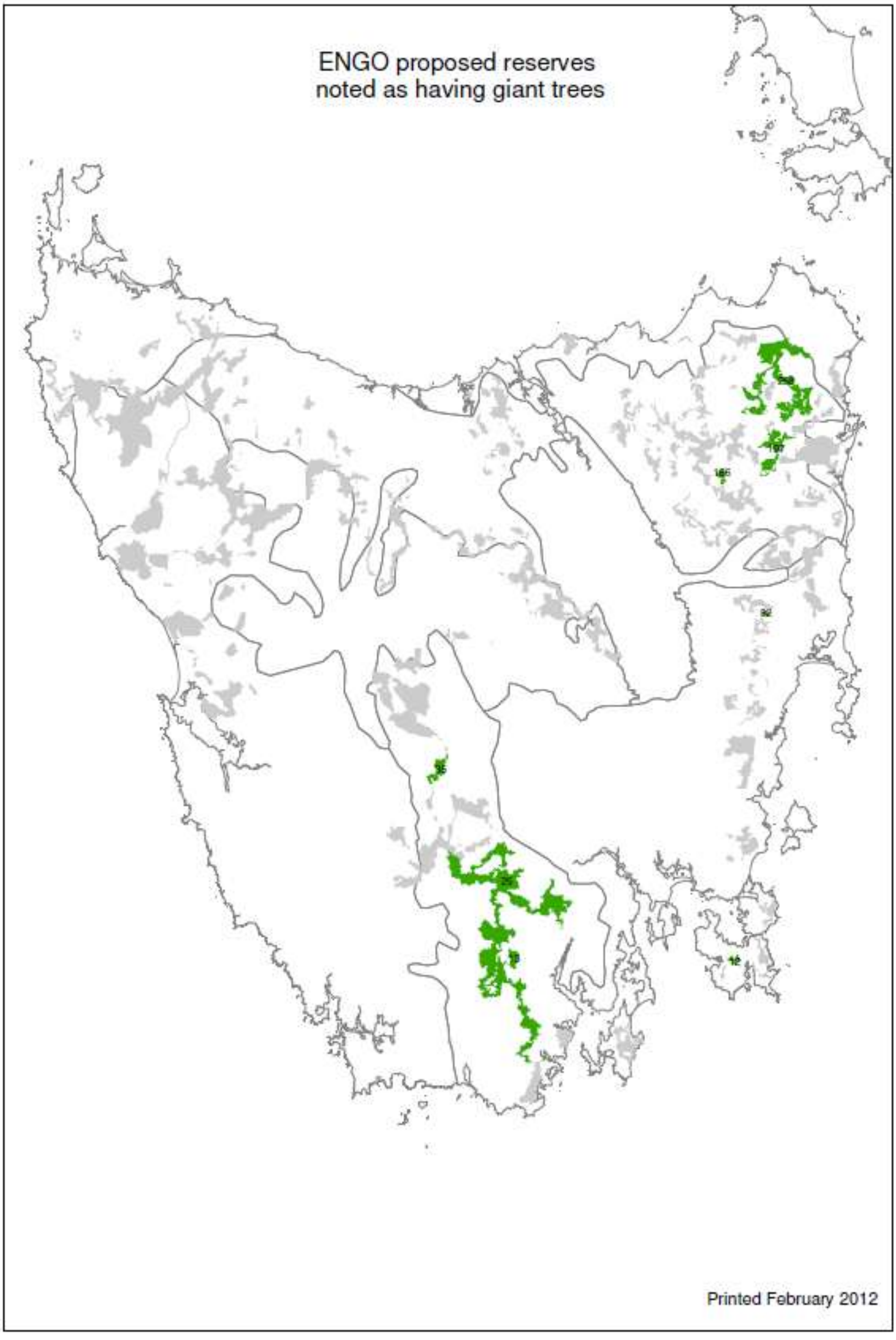
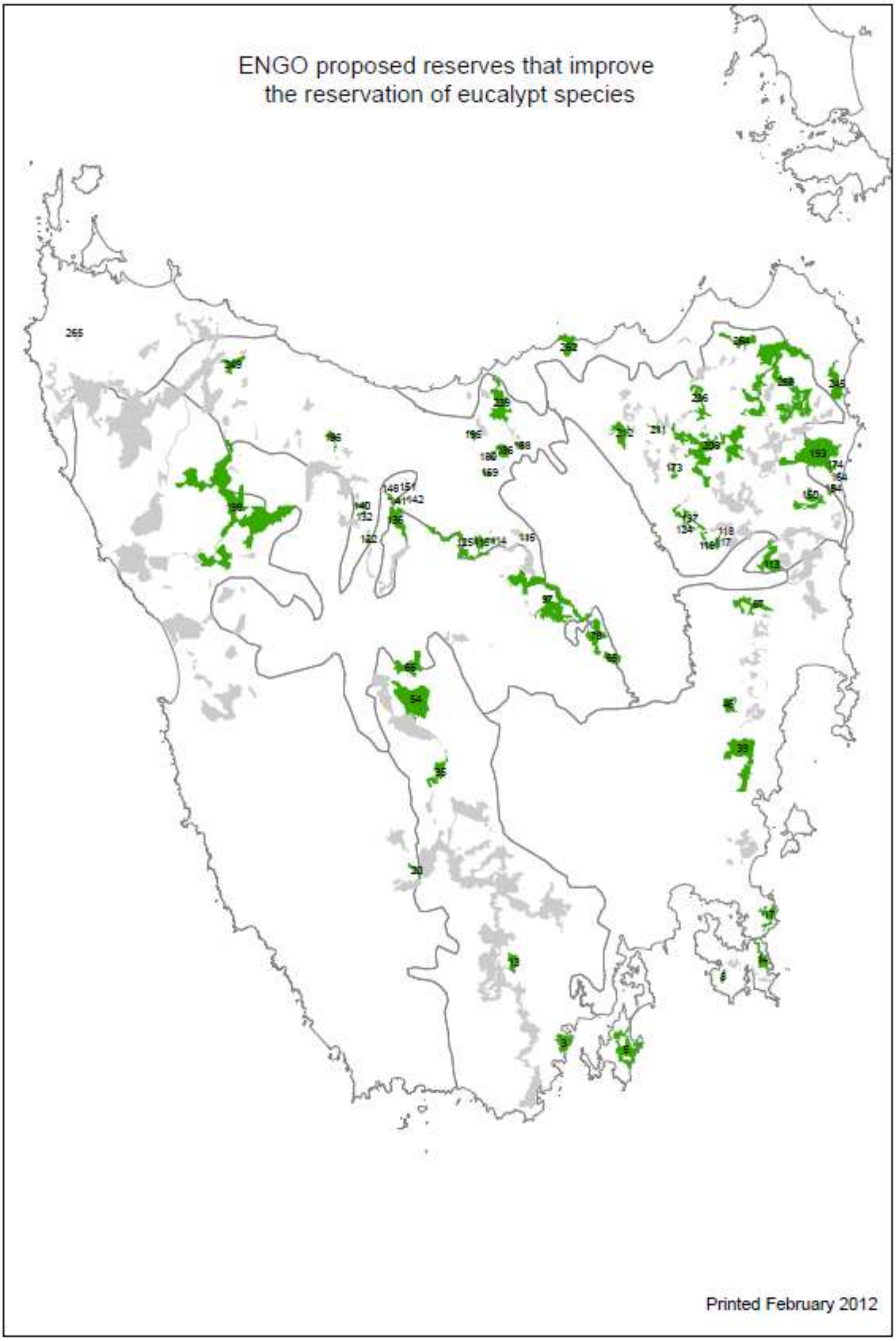
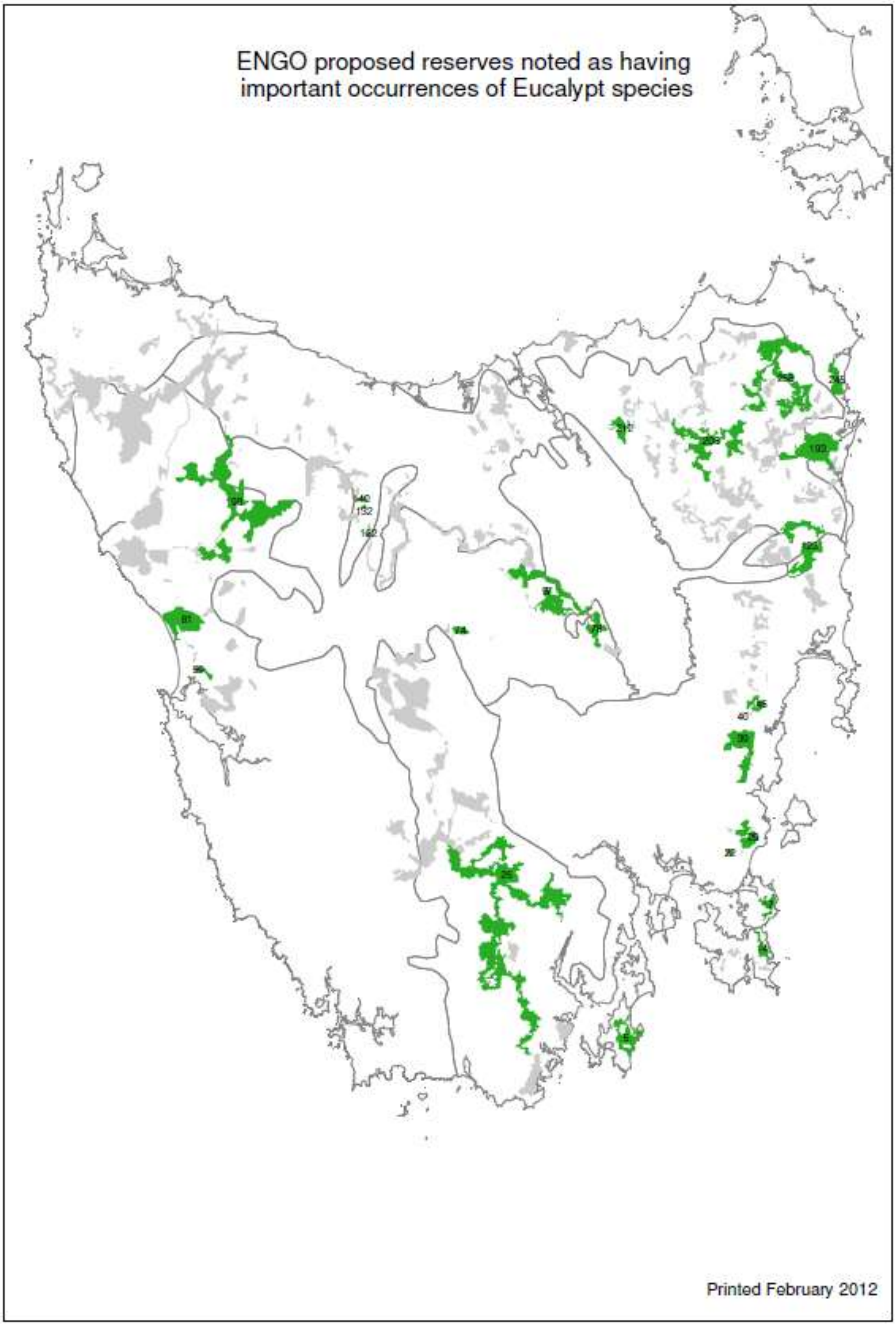
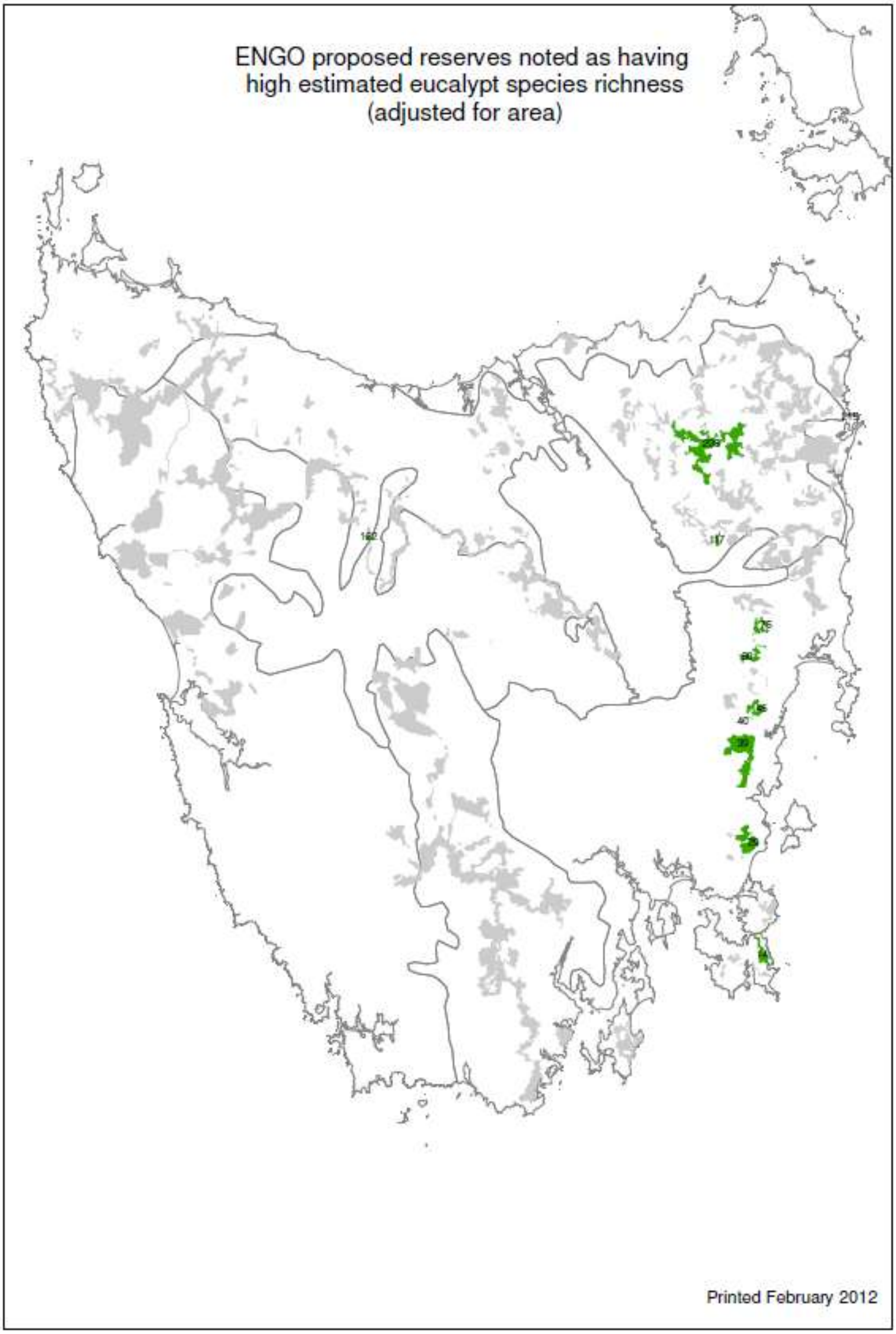
Appendix 1. Indicative maps of the distribution of some of the notable values of the proposed ENGO reserves prepared by the Independent Verification Group.




ENGO proposed reserves
noted as having giant trees
Printed February 2012


ENGO proposed reserves that improve
the reservation of eucalypt species
Printed February 2012


ENGO proposed reserves noted as having
important occurrences of Eucalypt species
Printed February 2012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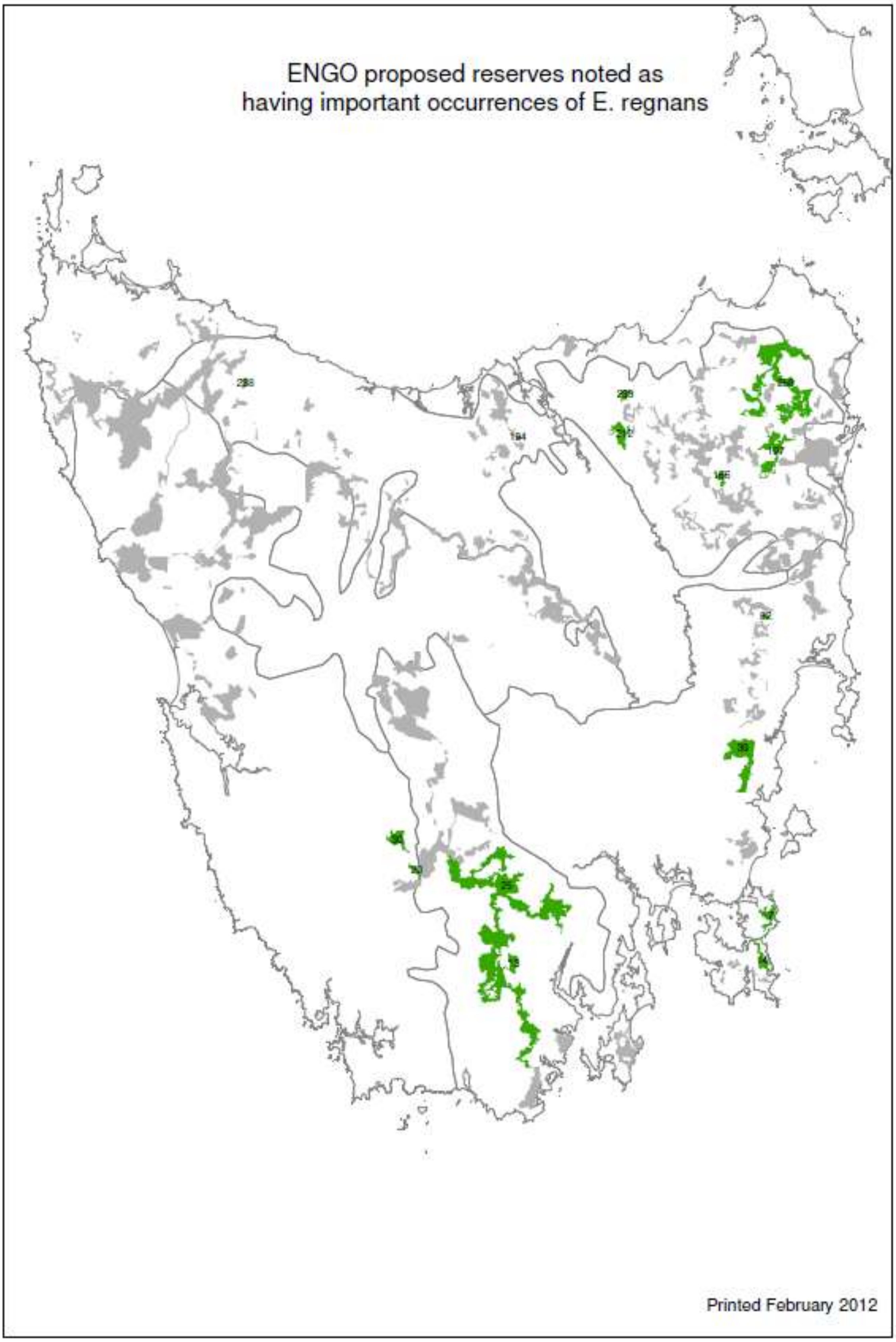
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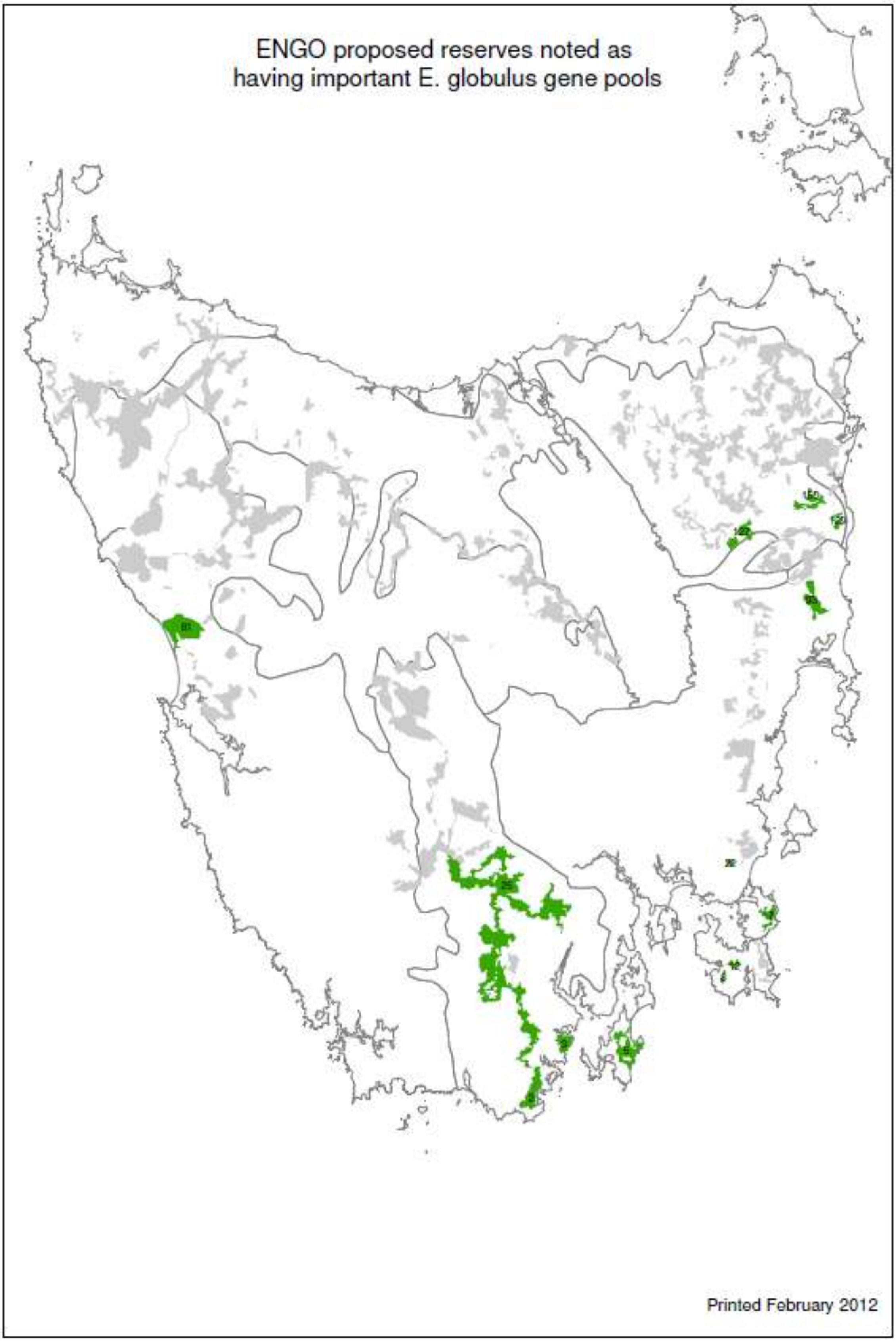
having important occurrences of E. regnans
Printed February 2012


ENGO proposed reserves noted as
having important E. globulus gene pools
Printed February 2012