

# The Eucalypts of the Greater Blue Mountains World Heritage Area: distribution, classification and habitats of the species of *Eucalyptus*, *Angophora* and *Corymbia* (family Myrtaceae) recorded in its eight conservation reserves

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**Abstract:** The Greater Blue Mountains World Heritage Area (GBMWH), immediately west of Sydney (33° 53'S; 151° 13'E), on the east coast of Australia was listed as World Heritage for its outstanding natural values, a major component of which is the high number of eucalypt species and eucalypt-dominated communities present, some 13 per cent of all eucalypt species in the world. They grow in a great variety of plant communities, from tall closed forests, through open forests and woodlands, to stunted mallee shrublands.

This paper provides a definitive list of the 96 eucalypts (species of the genera *Eucalyptus*, *Angophora* and *Corymbia* in the family Myrtaceae), that have been recorded there (55 widespread, 41 restricted), together with the distribution of the eucalypts in the eight reserves that make up the GBMWH, and information on the classification and habitat of the different species. The information is based on records held at the National Herbarium of New South Wales and the results of surveys by the NSW Department of Environment, Climate Change and Water (DECCW) over the past 20 years. The majority of species have components of both stress-tolerator and competitor ecological strategies and this has probably been a main contributor to their success. However details of the ecology of the majority of taxa are poorly-known and more research is needed to provide guidance for conservation management in the face of changing climate conditions.

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## Introduction

The Greater Blue Mountains World Heritage Area (GBMWH) immediately west of Sydney (33° 53'S; 151° 13'E), on the east coast of Australia, was inscribed on the World Heritage list in 2000. It covers over one million hectares (1 032 649 ha) and covers eight protected conservation reserves, largely contiguous but partly separated by transport and urban corridors. There are seven national parks as well as the Jenolan Caves Karst Conservation Reserve (2 422 ha). The National Parks are Blue Mountains (247 840 ha in area), Wollemi (499 879 ha), Yengo (153 483 ha), Nattai (47 855 ha), Kanangra-Boyd (65 379 ha), Gardens of Stone (15 150 ha) and Thirlmere Lakes (641 ha) (Figure 1). Approximately 60% of the area is dedicated as wilderness (669 000 ha).

The GBMWH was listed for its outstanding natural universal values:

- As an outstanding example representing significant ongoing ecological and biological processes in the evolution of terrestrial ecosystems and communities of plants and animals; and

- For containing the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

It is not just because of its magnificent scenery, or the distant blue haze that sometimes appears over the rugged landscape. It is the eucalypt forests, more than anything else, that make the area special. The Blue Mountains have been described as a natural laboratory for the study of evolution of eucalypts. In the mountains' diverse plant communities, you can trace the changing nature of the Australian environment – from geological shifts and climate variations, through to the impact of Aboriginal settlement and European colonisation.

The aim of this paper is to provide a definitive list of the GBMWH eucalypts (species of the genera *Eucalyptus*, *Angophora* and *Corymbia* in the family Myrtaceae), together with information on their distribution, classification and habitat which will provide a basis for further research and to assist communication of the important biodiversity values of the area.

*Eucalypts in Australia*

The eucalypts or gum trees are a characteristic Australian group of species (mainly trees but with some small shrublike mallees) belonging in the Myrtaceae family (for ecology of Myrtaceae in the Sydney area – see Myerscough 1998). More than 98% of the 700 or so known eucalypt species are endemic to Australia. Most eucalypts are in the genus *Eucalyptus* but the similarly-looking and closely-related genera *Angophora* and *Corymbia* are also traditionally included as eucalypts in general usage. *Eucalyptus* itself is considered to include two large subgenera, *Eucalyptus* (*Monocalyptus*) and *Symphyomyrtus*, and a number of smaller ones (notably *Eudesmia* in northern Australia)

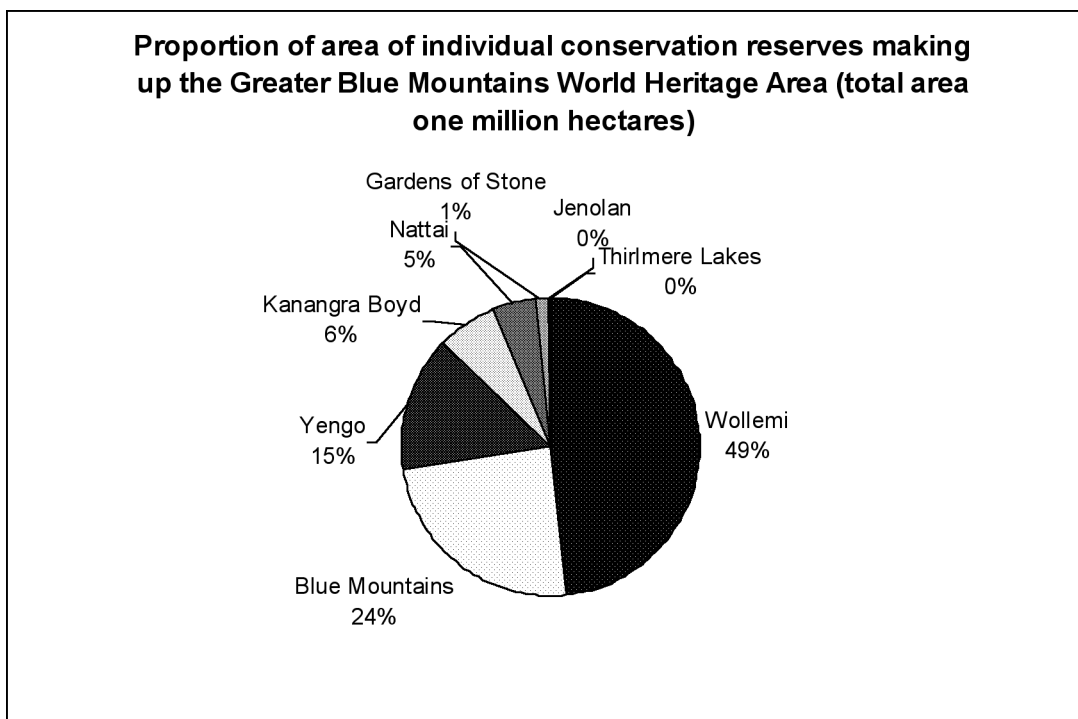
As well as the bud and fruit characteristics which are generally needed for positive identification, a distinctive characteristic of the group is the nature of the bark. Bark types which give their names to broad groups include stringybarks, ironbarks, boxes, bloodwoods, peppermints as well as smooth-barked gums. These bark types are the basis for many of the common names applied to the species though unfortunately they do not necessarily align with the generic or subgeneric groups. Smooth-barked gums for example occurring in most of the major groups e.g. *Angophora costata*, *Corymbia maculata*, *Eucalyptus tereticornis*.

Eucalypts originated between 35 and 50 million years ago, not long after Australia-New Guinea separated from Gondwana, their rise coinciding with an increase in fossil

charcoal deposits (suggesting that fire was a factor even then). However, they remained a minor component of the Tertiary rainforest until about 20 million years ago when the gradual drying of the continent and depletion of soil nutrients led to the development of more open forest types, predominantly *Casuarina* and *Acacia* species. Major redistributions of eucalypt forest occurred in southeastern Australia during the Quaternary, probably in relation to both temperature and aridity changes. According to McKinnon et al (2004), patterns of morphological variation within *Eucalyptus* in Tasmania, in particular intergradation between species, suggest that these redistributions might have enabled divergent species to come into contact and exchange genes through hybridization (reticulate evolution). Similar processes probably occurred in the GBMWhA leading to closely-related groups of species such as the *Eucalyptus*-Green-leaved Ashes.

**The Eucalypts of the Greater Blue Mountains World Heritage Area**

A list of eucalypt species present was included in the GBMWhA nomination in 1998 (Appendix 6.2 in NPWS 1998). This list has now been updated to include newly described species and delete unconfirmed species, and enlarged to provide species occurrence in the individual reserves of the GBMWhA with data from specimen records held at the National Herbarium of New South Wales, together



**Fig. 1.** Proportion of area of individual conservation reserves making up the Greater Blue Mountains World Heritage Area (total area one million hectares)

**Table 1a. Eucalypt species with relatively widespread distributions in the Greater Blue Mountains World Heritage Area showing occurrence in conservation reserves.**

Based on records from the National Herbarium of New South Wales and surveys by the NSW Dept of Environment, Climate Change and Water.

National Parks	Wollemi	Yengo	Gard. of Stone	Blue Mtns	Jenolan Karst Cons Res	Kanang. Boyd	Thirl. Lakes	Nattai
Reserve size (ha)	499879	153483	15150	247840	2422 ha	65379	641	47855
<b>Eucalypt species</b>								
<i>Angophora bakeri</i>	W	Y		B			T	N
<i>Angophora costata</i>	W	Y		B				N
<i>Angophora floribunda</i>	W	Y	G	B		K	T	N
<i>Corymbia eximia</i>	W	Y		B			T	
<i>Corymbia gummifera</i>	W	Y		B		K	T	N
<i>Eucalyptus agglomerata</i>	W	Y		B		K	T	N
<i>Eucalyptus albens</i>	W		G	B				N
<i>Eucalyptus amplifolia</i> subsp. <i>amplifolia</i>	W	Y		B				
<i>Eucalyptus bicostata</i>	W			B	J			
<i>Eucalyptus blakelyi</i>	W		G	B				
<i>Eucalyptus blaxlandii</i>	W		G	B	J	K		N
<i>Eucalyptus bosistoana</i>				B		K		N
<i>Eucalyptus bridgesiana</i>	W			B				
<i>Eucalyptus consideriana</i>	W			B				
<i>Eucalyptus crebra</i>	W	Y	G	B		K		N
<i>Eucalyptus cypellocarpa</i>	W		G	B	J	K		N
<i>Eucalyptus dalrympleana</i> subsp. <i>dalrympleana</i>	W		G	B	J	K		
<i>Eucalyptus deanei</i>	W	Y		B		K		N
<i>Eucalyptus dives</i>	W		G	B	J	K		
<i>Eucalyptus elata</i>				B		K		N
<i>Eucalyptus eugenioides</i>	W	Y	G	B	J	K		N
<i>Eucalyptus fastigata</i>	W		G	B	J	K		
<i>Eucalyptus fibrosa</i>	W	Y	G	B		K		N
<i>Eucalyptus globoidea</i>	W			B				N
<i>Eucalyptus macrorhyncha</i>	W		G	B				
<i>Eucalyptus mannifera</i> subsp. <i>gullickii</i>	W		G	B		K		
<i>Eucalyptus mannifera</i> subsp. <i>mannifera</i>			G	B		K		
<i>Eucalyptus melliodora</i>	W	Y	G	B	J	K		N
<i>Eucalyptus moluccana</i>	W	Y	G	B				N
<i>Eucalyptus multicaulis</i>	W		G	B				
<i>Eucalyptus notabilis</i>		Y		B				
<i>Eucalyptus obliqua</i>				B		K		
<i>Eucalyptus oreades</i>	W		G	B				N
<i>Eucalyptus ovata</i>				B		K		N
<i>Eucalyptus paniculata</i> subsp. <i>paniculata</i>	W	Y		B				
<i>Eucalyptus parramattensis</i> subsp. <i>parramattensis</i>	W	Y	G				T	N
<i>Eucalyptus pauciflora</i>					J	K		
<i>Eucalyptus pilularis</i>		Y		B				
<i>Eucalyptus piperita</i>	W	Y	G	B		K	T	N
<i>Eucalyptus polyanthemos</i> subsp. <i>polyanthemos</i>	W		G					
<i>Eucalyptus praecox</i>	W		G					
<i>Eucalyptus punctata</i>	W	Y	G	B	J	K	T	N
<i>Eucalyptus radiata</i> subsp. <i>radiata</i>	W		G	B	J	K		N
<i>Eucalyptus resinifera</i> subsp. <i>resinifera</i>	W			B			T	
<i>Eucalyptus rossii</i>	W		G	B				
<i>Eucalyptus saligna</i>	W	Y						
<i>Eucalyptus sclerophylla</i>	W	Y	G	B		K		N
<i>Eucalyptus sideroxylon</i>	W			B		K		N
<i>Eucalyptus sieberi</i>	W		G	B	J	K	T	N
<i>Eucalyptus smithii</i>				B		K		
<i>Eucalyptus sparsifolia</i>	W	Y	G	B	J	K		N
<i>Eucalyptus stricta</i>	W			B		K		
<i>Eucalyptus tenella</i>	W		G					
<i>Eucalyptus tereticornis</i>	W	Y	G	B		K		N
<i>Eucalyptus viminalis</i>	W		G	B	J	K		N

**Table 1b. Eucalypt species with relatively restricted distributions in the Greater Blue Mountains World Heritage Area showing occurrence in conservation reserves, comments on the overall distribution, and formal and informal conservation listings.** Conservation listings TSC=NSW *TSC* Act, EPBC=Commonwealth *EPBC* Act; \*=IUCN (proposed by Bell 2008). Notes on overall distribution are from PlantNet and Fairley and Moore (2000).

Eucalypt species	GBMWhA reserves	Why uncommon in the GBMWhA	Cons. listing-statutory	Cons. listing ROTAP, IUCN
<i>Angophora euryphylla</i>	Yengo, Wollemi	Restricted distribution – sandstone outcrops between the Central Coast and Putty.		
<i>Angophora hispida</i>	Yengo, Wollemi	Widespread on shallow soils on Hawkesbury sandstone plateaus near the coast. Uncommon in the GBMWhA.		
<i>Corymbia maculata</i>	Wollemi	Widespread on moderately fertile soils on drier parts of the coastal plain and escarpment from Queensland to Victoria. Its preferred combination of soil fertility and climate is limited in the GBMWhA.		
<i>Corymbia trachyphloia</i> subsp. <i>amphistomatica</i>	Wollemi	Widespread along the western slopes north from Denman. Suitable climatic conditions only occur in the far north of the GBMWhA.		
<i>Eucalyptus aenea</i>	Wollemi	Restricted distribution – sandstone ridges around northern Wollemi NP, Goulburn River NP and Manobolai NR		2RC-, VU D2*
<i>Eucalyptus aggregata</i>	Blue Mtns	Occurs on cold alluvial flats from Wallerawang to Victoria. Suitable climatic and drainage conditions are limited in the GBMWhA.	Vulnerable (TSC)	
<i>Eucalyptus apiculata</i>	Blue Mtns, Nattai	Restricted distribution – scattered populations on skeletal soils between Linden and Berrima		3RC
<i>Eucalyptus baeuerlenii</i>	Blue Mtns	Restricted distribution – scattered populations at Wentworth Falls, Budawang Range, Wadbilliga NP.		3RCa
<i>Eucalyptus baueriana</i>	Wollemi	Alluvial soils along streams from Putty south to Victoria. Suitable fertile alluvial soils are limited within the GBMWhA.		
<i>Eucalyptus bensonii</i>	Wollemi	A species endemic to the GBMWhA, only found on the Wollemi and Hunter Ranges.		2RCa VU D2*
<i>Eucalyptus benthamii</i>	Blue Mtns, Nattai	Restricted distribution – alluvial soils in the lower Hawkesbury-Nepean catchment	Vulnerable (TSC) Vulnerable (EPBC)	2VCi
<i>Eucalyptus beyeriana</i>	Wollemi	Locally frequent in drier areas between Narrabri and Nowra. Suitable soil and climatic conditions are limited in the GBMWhA.		
<i>Eucalyptus burgessiana</i>	Wollemi, Blue Mtns, Nattai	A species endemic to the GBMWhA, with scattered populations on skeletal soils at lower elevations.		2RCa VU D2 *
<i>Eucalyptus caleyi</i> subsp. <i>caleyi</i>	Wollemi	Widespread along the western slopes north from about the Goulburn River into Queensland. Suitable climatic conditions only occur in the far north of the GBMWhA.		
<i>Eucalyptus camphora</i> subsp. <i>camphora</i>	Wollemi, Blue Mtns	On open swampy flats from Nullo Mountain to the Megalong Valley. Suitable swampy alluvial soils are limited within the GBMWhA.		
<i>Eucalyptus cannonii</i>	Wollemi, Gardens of Stone	Restricted distribution – Bylong to the upper Wolgan Valley on moderately fertile soils. Suitably fertile soils within its limited distribution are uncommon in the GBMWhA.	Vulnerable (TSC) Vulnerable (EPBC)	2RCa LC *
<i>Eucalyptus capitellata</i>	Yengo	Locally frequent on sandy soils on coastal foothills between Karuah and Nerriga. Uncommon in the GBMWhA.		
<i>Eucalyptus conica</i>	Wollemi	Widespread along the western slopes from Wagga Wagga to Queensland. Its preferred combination of a dry climate and fertile soils only occurs in very limited parts of northern Wollemi.		
<i>Eucalyptus corticosa</i>	Wollemi	Restricted distribution – upper Cudgegong River on sandstone ridges.	Vulnerable (TSC)	2VC-VU D2 *
<i>Eucalyptus cunninghamii</i>	Blue Mtns, Kanangra Boyd, Nattai	A species endemic to the GBMWhA, with localised populations on skeletal soils in the upper Blue Mountains and Wanganderry Tableland.		2RCa

<i>Eucalyptus dawsonii</i>	Wollemi	Locally frequent on the western slopes and Hunter valley between Wellington and Singleton. The suitable combination of climate and soil fertility only occurs on escarpment footslopes in northern Wollemi.	Vulnerable Ecological Community (TSC)	
<i>Eucalyptus dendromorpha</i>	Blue Mtns	Restricted distribution – scattered populations from Mt Tomah to the Budawang Range.		
<i>Eucalyptus dwyeri</i>	Wollemi	Widespread on shallow soils along the western slopes from Victoria to Queensland. Suitable climatic conditions only occur in the far north of the GBMWhA.		
<i>Eucalyptus fergusonii</i> subsp. <i>dorsiventralis</i>	Yengo, Wollemi	Restricted distribution – Lake Macquarie and northern Yengo NP to Mountain Lagoon		3RCa LC *
<i>Eucalyptus fracta</i>	Yengo	Restricted distribution – sandstone ranges between the Hunter valley and northern Yengo NP	Vulnerable (TSC)	2V
<i>Eucalyptus hypostomatica</i>	Yengo, Wollemi, Blue Mtns, Nattai	Localised distribution – the lower Hunter Valley to Kangaroo Valley		3RC- LC *
<i>Eucalyptus laevopinea</i>	Wollemi	Widespread on the tablelands from Mt Coricudgy to Queensland. A species typical of the Northern Tablelands with a disjunct population south of the Hunter valley		
<i>Eucalyptus laophila</i>	Wollemi, Gardens of Stone	Restricted distribution – skeletal soils from Newnes Plateau to Nullo Mountain		
<i>Eucalyptus ligustrina</i>	Gardens of Stone, Blue Mtns	Disjunct populations on sandy soils between the Gibraltar Range and Deua NP		
<i>Eucalyptus macarthurii</i>	Kanangra Boyd	Restricted distribution – cold flats on the Southern Highlands, with an outlying occurrence on the Boyd Plateau	Vulnerable (TSC)	
<i>Eucalyptus michaeliana</i>	Yengo	Highly disjunct distribution – Broke to St Albans, Enmore to Wollomombi and in Queensland.		3RCa
<i>Eucalyptus moorei</i>	Blue Mtns, Kanangra Boyd	Disjunct occurrences on sandy soils in the Gibraltar Range, Blue Mountains & the Budawang Range		
<i>Eucalyptus muelleriana</i>	Blue Mtns	Widespread along the coast and escarpment from Bindook Highlands to Victoria. It reaches its northern limit in the GBMWhA.		
<i>Eucalyptus nubila</i>	Wollemi, Gardens of Stone	On sandy soils along the western slopes north from about Capertee to Queensland. Suitable climatic and soil conditions are limited within the GBMWhA.		
<i>Eucalyptus prominula</i>	Yengo, Wollemi	Restricted distribution – skeletal soils from the Watagans to Colo Heights		2RC- LC *
<i>Eucalyptus quadrangulata</i>	Blue Mtns, Kanangra Boyd	Disjunct occurrences along the escarpment – Bundanoon to the Bindook Highlands, Barrington Tops to Dorrigo		
<i>Eucalyptus ralla</i>	Blue Mtns	Restricted distribution – sandstone soils from Lake Burragorang to Yalwal Plateau		
<i>Eucalyptus rubida</i> subsp. <i>rubida</i>	Kanangra Boyd	Widespread on cold flats south from Sofala to Victoria. Sufficiently cold conditions are limited in the GBMWhA.		
<i>Eucalyptus scias</i> subsp. <i>scias</i>	Wollemi	Central Coast to northern Sydney, Colo Heights area; mainly occurs on hilly parts of the coastal plain, uncommon in the GBMWhA.		
<i>Eucalyptus squamosa</i>	Yengo, Wollemi	On sandstone from Cessnock to near Picton. Uncommon in the GBMWhA because it mainly occurs on plateaus nearer the coast.		
<i>Eucalyptus stellulata</i>	Blue Mtns, Kanangra Boyd	Widespread on cold flats at higher altitudes from the McPherson Range to Victoria. Sufficiently cold conditions are rare in the GBMWhA.		
<b>Potential additional species</b>				
<i>Eucalyptus copulans</i>	Not recorded in GBMWhA reserves	Highly localised at Wentworth Falls (but only recorded just outside the GBMWhA reserve boundary)	Endangered (TSC)	2E
<i>Eucalyptus expressa</i> ms. (also known as <i>Eucalyptus</i> sp. aff. <i>eugenioides</i> (Bees Nest Ridge)	Yengo, Wollemi	Restricted distribution – sheltered gullies in northern Wollemi and Yengo. Awaiting formal description before inclusion in the GBMWhA list.		3KC DD *
<i>Eucalyptus gregsoniana</i>	Not recorded in GBMWhA reserves	Sporadic and scattered, in mallee heath on sandy soils of limited drainage in elevated areas; Wadbilliga to Newnes Plateau (on margin of GBMWhA).		3RCa
<i>Eucalyptus</i> sp. Howes Swamp Creek (Doherty 26)	Wollemi	Awaiting formal description before inclusion in the GBMWhA list.	Endangered (TSC) Endangered (EPBC)	2ECi CR D1*
<i>Eucalyptus nobilis</i>	Wollemi	Reported near Mount Coricudgy (Stephen Bell pers. com. 2010). Still to be confirmed.		

with records of recent surveys by the New South Wales Department of Environment, Climate Change and Water (DECCW) and its predecessors over the past 20 years. Since the inscription of the GBMWH in 2000, vegetation surveys have been undertaken in the Jenolan Karst Conservation Reserve, Nattai, Thirlmere Lakes, Yengo, Gardens of Stone and much of Blue Mountains National Park. The survey of Wollemi NP is currently in progress, and surveys are in the planning stage for Kanangra Boyd NP and the Grose Valley. A number of eucalypts not known from the GBMWH at the time of its inscription have now been confirmed. Nomenclature and authorities follow PlantNet, the website for the National Herbarium of NSW. (Note: the term *species* (rather than *taxa*) is used in this paper in the broadest sense and includes subspecific taxa).

98 recognised eucalypt taxa (mostly species of *Eucalyptus* but including five *Angophora* and four *Corymbia* species) have been recorded in the eight reserves of the GBMWH (Tables 1a and 1b). The species range in size from large forest trees over 30 m in height (e.g. *Eucalyptus deanei*, *Eucalyptus saligna*), through spreading woodland trees (e.g. *Eucalyptus sclerophylla*) to small multistemmed mallees, some less than 1 m in height in heathland (*Eucalyptus cunninghamii*). More than half of the species (58) (Table 1a) are regarded as widespread in the GBMWH i.e. recorded from two or more reserves (e.g. *Eucalyptus punctata*), but others recorded from only one reserve (42 species) (Table 1b) (e.g. *Eucalyptus bauerlenii*), may be relatively to very restricted, although the great disparity in size of the reserves (Figure 1) makes this a very rough measure. The restricted eucalypts are either widespread species with habitat requirements that are of limited extent within the GBMWH or species that have a naturally restricted distribution. The former are usually more typical of drier, colder or more coastal environments.

#### *Clarification of the list of eucalypts in the original GBMWH nomination*

90 eucalypts were included in the List of Eucalypts in the GBMWH nomination (Appendix 6.2 in NPWS 1998). However, two of those (*Eucalyptus siderophloia* & *Eucalyptus umbra*) have not been subsequently confirmed as occurring within the GBMWH. *Eucalyptus siderophloia* is found on moderately fertile soils on the coastal plain but the nearest records to the GBMWH are east of Yengo National Park. *Eucalyptus umbra* has also been recorded near Yengo National Park. While records for both species are close to Yengo NP, no confirmed GBMWH records have been found.

*Eucalyptus rudderi* was included in the nomination because it was formerly considered to occur from Taree to near the Shoalhaven River (eg Brooker & Kleinig 1983). Johnson and Hill (1990) separated *Eucalyptus hypostomatica* from *Eucalyptus rudderi* on the basis of the former's broad-lanceolate to ovate, hypostomatic adult leaves. This meant that *Eucalyptus rudderi* is now confined to the Taree-Karuah

district on the mid north coast of NSW. Hence, *Eucalyptus rudderi* has been replaced by *Eucalyptus hypostomatica* in the current list.

The original nomination included an undescribed taxon, *Eucalyptus* sp. aff. *dalrympleana*, which has not been included in the current list because there is insufficient information to attribute it to any newly described or undescribed species.

Subspecies names were not attributed to *Eucalyptus radiata* and *Eucalyptus mannifera* in the nomination. We have listed *Eucalyptus radiata* subsp. *radiata* as it is the only subspecies occurring in the GBMWH. The reference to *Eucalyptus mannifera* could have been to either of *Eucalyptus mannifera* subsp. *gullickii* or *Eucalyptus mannifera* subsp. *mannifera*. However, it was probably the former because this taxon is more widespread in the Blue Mountains.

The current list remains subject to change as further survey and exploration bring to light new occurrences of species, and perhaps even new species. Bell (2008) in his list of rare or threatened plants of Wollemi NP, includes two species that were not formally described at that time. *Eucalyptus* sp. aff. *eugenioides* (Bees Nest Ridge) is a stringybark found in sheltered gullies in northern Wollemi and Yengo NPs (to be named *Eucalyptus expressa* – Bell, Klaphake & Nicolle, in prep). *Eucalyptus* sp. Howes Swamp Creek (Doherty 26) is only known from one small stand growing on alluvium in the Mellong Swamps (and is listed as Endangered under the EPBC and TSC Acts). As neither taxon has been formally described (2010) they are included in Table 1b as *potential additional species*.

A small population of mallee-like red gums currently attributed to *Eucalyptus dealbata* has been recorded near the Martindale Trail in northern Wollemi NP (Bell 2001). Confirmation of the identity of these specimens is required because this population would represent a considerable range extension and it occurs on infertile soils on Narrabeen Sandstone, which is an unusual substrate for this species. This taxon has not been included in Table 1b.

Further change is also likely to result from ongoing systematic and ecological research into the relationships between species. For example recent work on the scribbly gum group (Pfeil & Henwood 2004) indicates that this group is best treated as 3 taxa rather than the current 5. If accepted and applied to the GBMWH list this would probably mean replacing *Eucalyptus racemosa*, *Eucalyptus rossii* and *Eucalyptus sclerophylla* with *Eucalyptus racemosa* subsp. *racemosa* and *Eucalyptus racemosa* subsp. *rossii*.

#### *Rare or threatened species*

Two thirds of the species have a number of populations in at least two of the eight GBMWH reserves indicating many species are relatively widespread and well-conserved in the region (Table 1a).

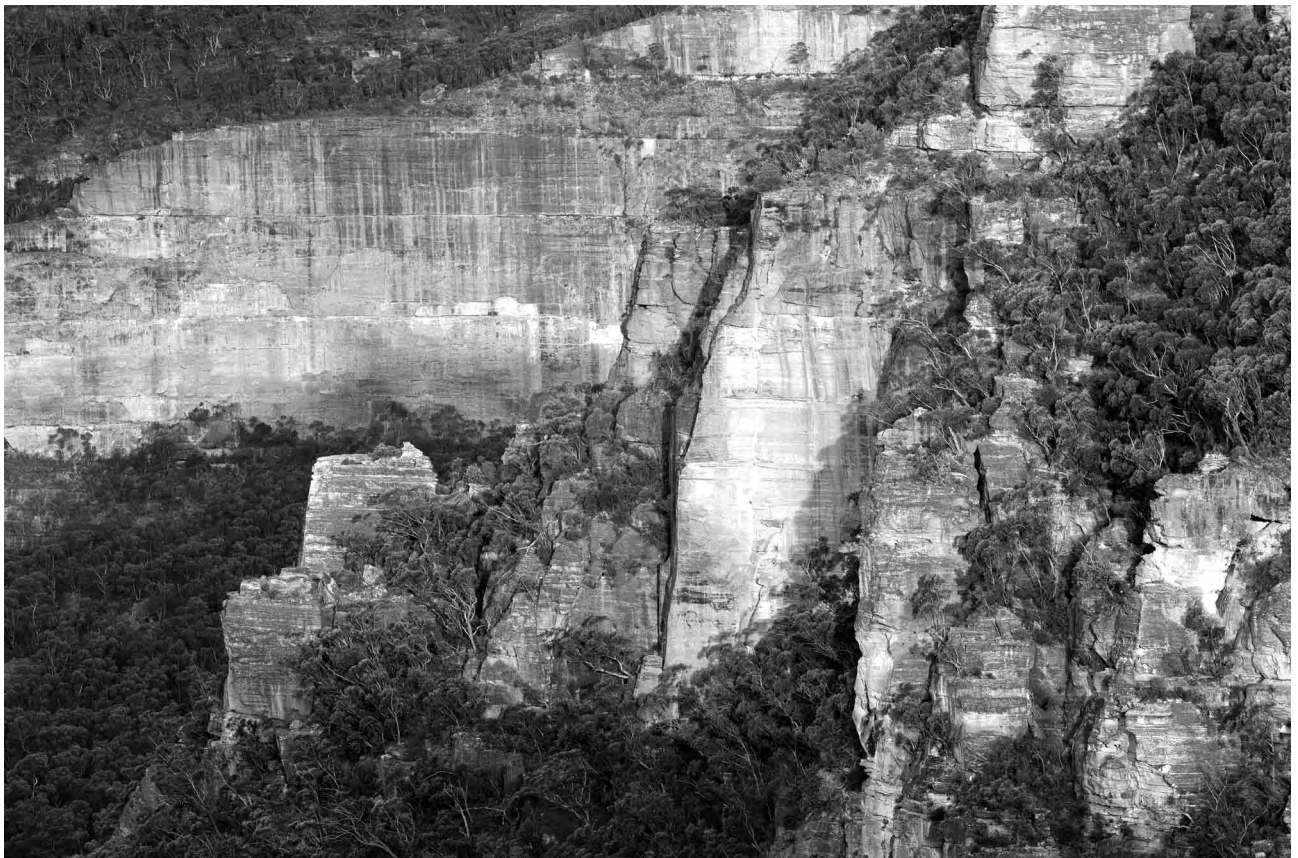
Of those limited to one national park (Table 1b), some are at the edge of a much wider distribution beyond the GBMWA. (e.g. *Eucalyptus dwyeri*, *Eucalyptus muelleriana*). Others are very restricted. Some such as *Eucalyptus bensonii*, *Eucalyptus baeuerlenii*, and *Eucalyptus laophila* are very restricted but have most or all of their distribution protected within the GBMWA. Others (e.g. *Eucalyptus hypostomatica*, *Eucalyptus michaeliana*) have reasonably large populations within the GBMWA. Six of the rare eucalypts are mallees with three being endemic to the GBMWA (*Eucalyptus bensonii*, *Eucalyptus burgessiana*, *Eucalyptus cunninghamii*).

Other restricted species are less well protected. Six are listed as vulnerable under the NSW *Threatened Species Conservation Act* (TSC Act) a low proportion (6%) compared with listings for other parts of NSW as the extensive area of the GBMWA has provided conservation security for most species. Two of these species are also listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation* (EPBC) Act. Due to their small population sizes, the primary threat to *Eucalyptus fracta* and *Eucalyptus corticosa* are risks from chance stochastic events. *Eucalyptus aggregata*, *Eucalyptus cannonii* and

*Eucalyptus macarthurii* primarily occur on agricultural lands with modified pastures. They are threatened by lack of regeneration and are poorly represented in conservation reserves. *Eucalyptus benthamii* is threatened by increased nutrients, frequent burning and weed invasion in its habitat of alluvial flats. Much of its habitat has been cleared for agriculture or submerged beneath the waters of Lake Burrangrang (Benson 1985).

*Eucalyptus dawsonii* is a community dominant in the Vulnerable Ecological Community *Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion* that occurs below the escarpment in northern Wollemi NP near Jerrys Plains. This community is threatened by clearing, emerging weeds and frequent burning (Peake 2006).

A further ten eucalypts have been recognised as rare on the list of Rare or Threatened Australian Plants (ROTAP, Briggs & Leigh 1996). These eucalypts typically have a highly restricted or disjunct distribution, but are subject to a lower level of threat. A good example is *Eucalyptus baeuerlenii*, which has a very restricted distribution on cliff ledges at Wentworth Falls–Leura, but is within the GBMWA and is being managed for conservation.



**Fig. 2.** Many eucalypt species grow in the dissected sandstone landscapes of the Blue Mountains and Wollemi areas where habitats range from moist sheltered gullies to exposed ridges and cliffines.

**Table 2. Classification of eucalypts of the Greater Blue Mountains World Heritage Area showing subgeneric groups and lower groups in *Eucalyptus* (after Hill 2002) with provisional notes on generalised group ecology.**

<b>Genus</b>	<b>Generalised group ecology</b>
<b><i>Angophora</i></b>	
<i>Angophora costata</i>	Large or small trees on range of soils and rainfall, flower Summer, seeds shed at maturity, prolific seedling recruitment
<i>Angophora floribunda</i>	
<i>Angophora euryphylla</i>	
<i>Angophora bakeri</i>	
<i>Angophora hispida</i>	
<b><i>Corymbia</i></b>	
<i>Corymbia maculata</i>	Trees on range of soils and rainfall, mature seeds retained on tree
<i>Corymbia gummifera</i>	
<i>Corymbia eximia</i>	
<i>Corymbia trachyphloia</i> subsp. <i>amphistomatica</i>	
<b><i>Eucalyptus</i></b>	
<b><i>Symphomyrtus</i> – <i>Adnataria</i></b>	
<i>Eucalyptus aenea</i>	Mostly woodland or forest trees, mostly Ironbarks or boxes; generally lower rainfall areas, medium nutrient soils clays or clay-influenced sandstones; Flower Winter–Spring, seed shed at maturity; recruitment respond to seasonal conditions; long-lived, slow-growing
<i>Eucalyptus albens</i>	
<i>Eucalyptus baueriana</i>	
<i>Eucalyptus beyeriana</i>	
<i>Eucalyptus bosistoana</i>	
<i>Eucalyptus caleyi</i> subsp. <i>caleyi</i>	
<i>Eucalyptus crebra</i>	
<i>Eucalyptus dawsonii</i>	
<i>Eucalyptus fergusonii</i> subsp. <i>dorsiventralis</i>	
<i>Eucalyptus fibrosa</i>	
<i>Eucalyptus hypostomatica</i>	
<i>Eucalyptus melliodora</i>	
<i>Eucalyptus moluccana</i>	
<i>Eucalyptus nubila</i>	
<i>Eucalyptus paniculata</i> subsp. <i>paniculata</i>	
<i>Eucalyptus sideroxylon</i>	
<i>Eucalyptus conica</i>	
<i>Eucalyptus fracta</i>	
<i>Eucalyptus polyanthemus</i> subsp. <i>polyanthemus</i>	
<b><i>Eucalyptus</i></b>	
<b><i>Symphomyrtus</i> – <i>Bisectaria</i></b>	
<i>Eucalyptus squamosa</i>	Tree or mallee on low nutrient soil, flowers Winter, seed retained for up to a year. Only GBMWH representative of a group of mainly Western Australian mallees.
<b><i>Eucalyptus</i></b>	
<b><i>Symphomyrtus</i> – <i>Exsertaria</i></b>	
<i>Eucalyptus amplifolia</i> subsp. <i>amplifolia</i>	‘Redgum’ group; Trees on a range of soil and rainfall conditions; flower Spring or Summer, seed retained for up to a year, recruitment episodic, quick growing
<i>Eucalyptus blakelyi</i>	
<i>Eucalyptus dwyeri</i>	
<i>Eucalyptus michaeliana</i>	
<i>Eucalyptus parramattensis</i> subsp. <i>parramattensis</i>	
<i>Eucalyptus tereticornis</i>	
<b><i>Eucalyptus</i></b>	
<b><i>Symphomyrtus</i> – <i>Maidenaria</i></b>	
<i>Eucalyptus aggregata</i>	‘Mountain Gums’ on medium or low–medium nutrient soils, often montane or cooler Tablelands sites, often with higher rainfall, riparian or periodic swamp requirements; Flowering in all seasons depending on individual species, seeds retained for a year or shed at maturity depending on season. Fire response species-specific, some strongly epicormic, others weakly epicormic and relatively fire-sensitive.
<i>Eucalyptus baeuerlenii</i>	
<i>Eucalyptus benthamii</i>	
<i>Eucalyptus bicostata</i>	
<i>Eucalyptus bridgesiana</i>	
<i>Eucalyptus camphora</i> subsp. <i>camphora</i>	
<i>Eucalyptus cypellocarpa</i>	
<i>Eucalyptus dalrympleana</i> subsp. <i>dalrympleana</i>	
<i>Eucalyptus mannifera</i> subsp. <i>gullickii</i>	
<i>Eucalyptus mannifera</i> subsp. <i>mannifera</i>	
<i>Eucalyptus ovata</i>	
<i>Eucalyptus quadrangulata</i>	
<i>Eucalyptus rubida</i> subsp. <i>rubida</i>	
<i>Eucalyptus smithii</i>	
<i>Eucalyptus viminalis</i>	
<i>Eucalyptus macarthurii</i>	
<i>Eucalyptus praecox</i>	
<i>Eucalyptus corticosa</i>	



<b>Genus</b>	<b>Generalised group ecology</b>
<b><i>Eucalyptus</i></b> <b><i>Symphyomyrtus</i> – <i>Transversaria</i></b> <i>Eucalyptus deanei</i> <i>Eucalyptus notabilis</i> <i>Eucalyptus punctata</i> <i>Eucalyptus resinifera</i> subsp. <i>resinifera</i> <i>Eucalyptus scias</i> subsp. <i>scias</i> <i>Eucalyptus saligna</i>	‘Coastal Blue Gums’, quick-growing forest trees, on medium – high nutrient soils, coastal, low elevation sites; mostly Summer flowering with mature seeds shed sporadically after the next Summer. Generally vigorous seedling recruitment.
<b><i>Eucalyptus</i></b> <b><i>Eucalyptus</i> – <i>Blue-leaved ashes A</i></b> <i>Eucalyptus oreades</i> <i>Eucalyptus pauciflora</i> <i>Eucalyptus piperita</i>	Woodland or forest trees, often community dominants, on low – high nutrient soils, flowering Summer, seeds retained in capsules for up to a year, fire response variable, strong epicormic or resprouting to killed ( <i>E. oreades</i> ). Seedling recruitment vigorous, not fire dependent, often colonisers of disturbed sites.
<b><i>Eucalyptus</i></b> <b><i>Eucalyptus</i> – <i>Blue-leaved ashes B</i></b> <i>Eucalyptus consideniiana</i> <i>Eucalyptus multicaulis</i> <i>Eucalyptus rossii</i> <i>Eucalyptus sclerophylla</i> <i>Eucalyptus sieberi</i>	Mainly woodland trees, often community dominants, on low nutrient soils; flowering Spring/Summer, seeds retained in capsules for up to a year; fire response strong epicormic or lignotuberous resprouting. Seedling recruitment sporadic.
<b><i>Eucalyptus</i></b> <b><i>Eucalyptus</i> – <i>Black sallies</i></b> <i>Eucalyptus moorei</i> <i>Eucalyptus stellulata</i>	Mallees or small trees, low to medium nutrient soils at high elevation, flowering Autumn
<b><i>Eucalyptus</i></b> <b><i>Eucalyptus</i> – <i>Green-leaved ashes</i></b> <i>Eucalyptus apiculata</i> <i>Eucalyptus burgessiana</i> <i>Eucalyptus cunninghamii</i> <i>Eucalyptus dendromorpha</i> <i>Eucalyptus fastigata</i> <i>Eucalyptus laophila</i> <i>Eucalyptus obliqua</i> <i>Eucalyptus stricta</i>	Mainly long-lived mallees, on low-nutrient sandy soils, flowering Summer, with seed retained in capsules for about a year, vigorous lignotuberous regrowth after fire, seedlings rarely reported. <i>Eucalyptus fastigata</i> , large tree on high nutrient soils is exception.
<b><i>Eucalyptus</i></b> <b><i>Eucalyptus</i> – <i>Peppermints</i></b> <i>Eucalyptus dives</i> <i>Eucalyptus elata</i> <i>Eucalyptus pilularis</i> <i>Eucalyptus radiata</i> subsp. <i>radiata</i>	Trees, on range of soils, flower Spring, seeds shed or retained, juvenile recruitment generally conspicuous, fire response strong to weak epicormic growth
<b><i>Eucalyptus</i></b> <b><i>Eucalyptus</i> – <i>Stringybarks</i></b> <i>Eucalyptus agglomerata</i> <i>Eucalyptus bensonii</i> <i>Eucalyptus blaxlandii</i> <i>Eucalyptus cannonii</i> <i>Eucalyptus capitellata</i> <i>Eucalyptus eugenioides</i> <i>Eucalyptus globoidea</i> <i>Eucalyptus laevopinea</i> <i>Eucalyptus ligustrina</i> <i>Eucalyptus macrorhyncha</i> <i>Eucalyptus muelleriana</i> <i>Eucalyptus prominula</i> <i>Eucalyptus ralla</i> <i>Eucalyptus sparsifolia</i> <i>Eucalyptus tenella</i>	A large group of trees, small trees and mallees often with populations intergrading with nearby stringybark species; mostly on low nutrient soils, but some on medium and high nutrient soils, over a wide range of rainfall, though all in well-drained sites. Flower mainly Autumn–Winter, sporadically. Seed retained for up to a year, seedling recruitment sporadic.

### *Significant species just outside the GBMWhA*

An endangered species *Eucalyptus copulans* now persists as only two individuals in suburban Wentworth Falls within a kilometre of the boundary of the GBMWhA. Because of the clearing for urban development it is now too late to determine its original distribution, but it was evidently very restricted and indicates the vulnerability to human impacts of species with very restricted occurrences.

*Eucalyptus gregsoniana* which has a ROTAP code of 3RCa occurs on Newnes Plateau in close proximity to the GBMWhA. It typically occurs above 1100m elevation and may be present in the higher parts of the catchments of the Wollangambe River, the Wolgan River or Carne Creek.

### *Classification of GBMWhA eucalypt species*

The genus *Eucalyptus* was described in 1792 from specimens of *Eucalyptus obliqua* from Tasmania. However specimens of *Angophora costata* and *Corymbia gummifera* were collected by Joseph Banks and Daniel Solander at Botany Bay in 1770 and named by Joseph Gaertner in 1788 as *Metrosideros costata* and *Metrosideros gummifera* respectively. The first eucalypt collections from the GBMWhA were probably made by the botanist George Caley who explored Thirlmere Lakes in 1802 and the lower Blue Mountains reaching as far as Mount Banks in 1804.

Description of the 700 or so eucalypts has involved many prominent Australian botanists including Ferdinand Mueller, Joseph Maiden and William Blakely. In 1971 Pryor and Johnson (1971) proposed a classification dividing the group into a number of subgenera; subsequent research has supported the various subgeneric groupings, but raised questions over their relative ranks. For the eucalypts of the GBMWhA three genera are currently recognised, *Angophora*, *Corymbia* (raised to generic rank by Hill & Johnson 1995) and *Eucalyptus*, which itself includes two major subgenera *Eucalyptus (Monocalyptus)* and *Symphyomyrtus*. Further subdivision of these subgenera into the formal and informal groups (following Hill 2002) is given in Table 2.

### *Ecological strategies*

While many of the subgeneric groups align with groups based on bark characters that have been traditionally used in field identification and forestry work particularly, e.g. stringybarks, boxes, ironbarks, others cut across several groups e.g. smooth-barked gums. However it is considered that further insights into the identification and ecology of the individual species might be gained from consideration of common attributes relevant to the groups. With this in mind, general ecological features that appear to be characteristic of particular groups, including soil nutrient conditions, habitat, flowering and fruiting timing and fire responses have been listed using data sourced from Benson & McDougall (1998) together with our general field observations on the species. Eucalypts have evolved to occupy

a very wide range of habitats and some groups including *Angophora*, *Corymbia* and *Symphyomyrtus*–*Adnataria* include species with a very wide range of ecologies. In the GBMWhA eucalypts are only absent from rainforest and swamp sites. Competition for light at the seedling recruitment stage probably keeps them out of rainforest, as there are many eucalypts that grow on the high nutrient soils that are generally associated with rainforest. Most eucalypts need well-drained soils and are killed by extended waterlogging. However some species in *Symphyomyrtus*–*Maidenaria* do cope with some waterlogging (*Eucalyptus camphora*, *Eucalyptus aggregata*, *Eucalyptus ovata*) and could allow evolution of future swamp species.

In terms of Grime's (2001) CSR triangle of ecological strategies COMPETITORS — STRESS — TOLERATORS — RUDERALS, groups such as the *Eucalyptus*–Green-leaved ashes and *Symphyomyrtus*–*Adnataria* are very strong stress-tolerators, while *Symphyomyrtus*–*Transversaria* are strong competitors. The majority of species have components of both strategies however and this has probably contributed to their success. Ruderal strategy characteristics (short-life, quick growth, colonisers) show in a couple of species from different subgroups (*Eucalyptus oreades*, *Eucalyptus elata*) but are unusual. These strategies may provide some pictures of past dynamic changes. For example the stress-tolerator capacity of the *Eucalyptus*–Green-leaved ashes and their geographical distribution on ridges particularly in the upper Blue Mountains suggest they may have been able to survive in that area during the cold conditions of the Last Glacial Maximum 20 000 years ago, whereas competitor groups such as *Symphyomyrtus*–*Transversaria* may have been able to invade new areas as climate ameliorated 5–10 000 years ago.

### *Habitat and ecological ranges of GBMWhA eucalypts*

Brief notes on the habitats of the individual species (Table 3) have been compiled predominantly from DECCW surveys (NPWS 2003, DEC 2004, DEC 2006, DEC 2006a & DEC 2008). Sources of information for those parts of the GBMWhA where survey is not complete were Bell (1998) for Wollemi National Park, Keith and Benson (1988) and Black (1982) for Kanangra Boyd National Park and Keith and Benson (1988) and Benson (1992) for the Grose valley.

The main landscape characteristic of the GBMWhA is the predominance of sandstone but within this is a considerable variation in local habitat conditions resulting from topographic variation, climate, slope and aspect, and soil fertility. The following factors contribute to the diverse range of habitats present in the GBMWhA.

### *Altitude and climate*

Elevation in the GBMWhA ranges from 20 m elevation near the Nepean River at Glenbrook to 1 330 m elevation at Mt Emperor near Jenolan Caves. The lowest plateau in the GBMWhA is Yengo NP which has extensive areas below

**Table 3. Notes on the habitats of individual Greater Blue Mountains World Heritage Area eucalypt species compiled predominantly from DECCW survey work.**

<b>Eucalypt species</b>	<b>Habitat/distribution</b>
<i>Angophora bakeri</i>	<ul style="list-style-type: none"> <li>• dry, colluvial slopes on Permian sediments below the escarpments of the Wollondilly, Nattai, Little River Valleys and around Lake Burragorang</li> <li>• ridges, upper slopes and lower slopes on sandstone below 400 m in southern Yengo and Wollemi, the Blue Labyrinth &amp; Nattai</li> <li>• low ridges and plains with deep, freely draining sands on the Mellong Plateau</li> </ul>
<i>Angophora costata</i>	<ul style="list-style-type: none"> <li>• sheltered slopes and gullies and more exposed situations on dissected sandstone plateaus across the GBMWH A below 700 m</li> <li>• drier slopes on Permian sediments beneath the escarpment in the Megalong and Kedumba Valleys</li> <li>• larger volcanic diatremes at mid elevations in the Erskine Ranges</li> </ul>
<i>Angophora euryphylla</i>	<ul style="list-style-type: none"> <li>• sandstone outcrops from Mt Yengo area to Martindale Range (localised)</li> </ul>
<i>Angophora floribunda</i>	<ul style="list-style-type: none"> <li>• alluvium along major rivers, larger creeks and gullies on a variety of substrates throughout the GBMWH A</li> <li>• colluvial slopes beneath the escarpment across the GBMWH A</li> <li>• well drained sandy alluvium of the Mellong Swamps area</li> <li>• more limited among rocky pagodas between Dunns Swamp and Newnes Plateau</li> </ul>
<i>Angophora hispida</i>	<ul style="list-style-type: none"> <li>• exposed ridges north of Upper Colo and near Mt Lockyer (localised)</li> </ul>
<i>Corymbia eximia</i>	<ul style="list-style-type: none"> <li>• throughout Yengo on sandstone and sandstone with thin layers of shale, the Blue Labyrinth, the Blue Breaks and in limited parts of south east Wollemi</li> </ul>
<i>Corymbia gummifera</i>	<ul style="list-style-type: none"> <li>• more exposed and sheltered slopes on dissected sandstone plateaus across the GBMWH A below 700 m</li> <li>• drier slopes on Permian sediments beneath the escarpment in the Megalong and Kedumba Valleys, Tonalli Range and around Lake Burragorang</li> </ul>
<i>Corymbia maculata</i>	<ul style="list-style-type: none"> <li>• sandstone ridges and sheltered situations enriched by shale in a small area near Bulga</li> </ul>
<i>Corymbia trachyphloia</i> subsp. <i>amphistomatica</i>	<ul style="list-style-type: none"> <li>• exposed aspects on sandstone in low rainfall areas of northern Wollemi</li> </ul>
<i>Eucalyptus aenea</i>	<ul style="list-style-type: none"> <li>• dry ridges in north western Wollemi (localised)</li> </ul>
<i>Eucalyptus agglomerata</i>	<ul style="list-style-type: none"> <li>• the Bindook Highlands, steep slopes of the Wollondilly Valley and Scotts Main Range</li> <li>• more exposed and sheltered slopes on dissected sandstone plateaus at moderate elevations across the GBMWH A</li> <li>• dry colluvial slopes below the escarpment of the Kedumba, Nattai, Little and Burragorang Valleys</li> </ul>
<i>Eucalyptus aggregata</i>	<ul style="list-style-type: none"> <li>• moist alluvial soils associated with cold air drainage hollows and alluvial bogs at high elevations, Limeburners Flat, Murruin Range</li> </ul>
<i>Eucalyptus albens</i>	<ul style="list-style-type: none"> <li>• basalt caps and diatremes in low rainfall areas in low rainfall areas north of the Hunter Range</li> <li>• Devonian siltstone &amp; limestone on lower slopes and drainage lines in the Capertee Valley</li> <li>• undulating foothills along the Wollondilly River and tributaries</li> </ul>
<i>Eucalyptus amplifolia</i> subsp. <i>amplifolia</i>	<ul style="list-style-type: none"> <li>• alluvial flats along streams and colluvial fans at the headwaters of streams in Big Yango &amp; Wallabadah and Howes Valley area</li> <li>• volcanic diatremes of the Lower Blue Mountains and eastern Wollemi</li> </ul>
<i>Eucalyptus apiculata</i>	<ul style="list-style-type: none"> <li>• rock plates with skeletal sandy soils below 900m, eg Linden, Kings Tableland, Blue Labyrinth, Bonnum Pic</li> </ul>
<i>Eucalyptus bauerlenii</i>	<ul style="list-style-type: none"> <li>• Darwins Walk on Jamison Ck</li> </ul>
<i>Eucalyptus baueriana</i>	<ul style="list-style-type: none"> <li>• alluvial flats along Putty Creek</li> </ul>
<i>Eucalyptus bensonii</i>	<ul style="list-style-type: none"> <li>• skeletal soils along the Wollemi Range between Cyrils Rocks and Gaspers Mtn (very limited)</li> </ul>
<i>Eucalyptus benthamii</i>	<ul style="list-style-type: none"> <li>• alluvial flats in the Kedumba Creek, Reedy Creek, Little and Nattai River catchments</li> </ul>
<i>Eucalyptus beyeriana</i>	<ul style="list-style-type: none"> <li>• ridges and exposed slopes with shallow soils in eastern Wollemi below 400 m and the low rainfall areas of the Goulburn River catchment</li> <li>• basalt caps in low rainfall areas north of Nullo Mountain</li> </ul>
<i>Eucalyptus bicostata</i>	<ul style="list-style-type: none"> <li>• limited – Karst at Jenolan Caves</li> <li>• high altitude &gt;900m basalt caps in high rainfall areas, eg Mt Nullo Mountain, Cedar Creek</li> <li>• sheltered gullies and protected slopes at higher elevations on Gangerang &amp; Murruin Range</li> </ul>

<b>Eucalypt species</b>	<b>Habitat/distribution</b>
<i>Eucalyptus blakelyi</i>	<ul style="list-style-type: none"> <li>• shallow sandy soils in sheltered situations in the low rainfall areas of north west Wollemi</li> <li>• diatremes in low rainfall areas north of Nullo Mountain</li> <li>• undulating topography on the floor of the Capertee &amp; Wolgan Valleys, eg Crown &amp; Barton Creeks</li> </ul>
<i>Eucalyptus blaxlandii</i>	<ul style="list-style-type: none"> <li>• sheltered slopes &amp; ridges on Ordovician, Silurian and Devonian metasediments between 800 and 1000m, Black Range, Jenolan Caves, Gangerang Range to Limeburners trail;</li> <li>• Bindook Highlands and the steep slopes of the Wollondilly Valley</li> <li>• high altitude &gt;900 m basalt caps in high rainfall areas, eg Budthingeroo, Mt Cameron</li> <li>• gullies among rocky pagoda complexes; sheltered slopes and ridges with deeper soils on sandstone</li> <li>• on trachyte at Mt Jellore (limited)</li> </ul>
<i>Eucalyptus bosistoana</i>	<ul style="list-style-type: none"> <li>• Bindook Highlands and the steep slopes of the Wollondilly Valley</li> <li>• occasional on sheltered aspects along the Jenolan, Coxs and Kowmung Rivers and larger tributaries</li> </ul>
<i>Eucalyptus bridgesiana</i>	<ul style="list-style-type: none"> <li>• rocky slopes around Wombeyan Caves (currently outside GBMWhA),</li> <li>• higher altitude diatremes in high rainfall areas above 500 m, eg Box Hole Clearing</li> <li>• sandy soils along creeks around the Cudgegong River (limited)</li> <li>• slopes along Murruin Creek, Jocks Creek and the Wollondilly River</li> <li>• cold air drainage hollows and alluvial bogs at high elevations, Limeburners Flat, Murruin Range</li> </ul>
<i>Eucalyptus burgessiana</i>	<ul style="list-style-type: none"> <li>• rock plates with skeletal soils below 900 m, eg Kedumba Walls, Axehead Mountain, Lacys Tableland, Golden Moon Bluff ridge, the Lower Blue Mountains</li> </ul>
<i>Eucalyptus caleyi</i> subsp. <i>caleyi</i>	<ul style="list-style-type: none"> <li>• ridges and slopes in low rainfall areas in the Goulburn River catchment</li> </ul>
<i>Eucalyptus camphora</i> subsp. <i>camphora</i>	<ul style="list-style-type: none"> <li>• waterlogged soils on the footslopes of the Megalong Valley below Narrow Neck</li> <li>• poorly drained alluvial sands possibly associated with impermeable clays in Never Never &amp; Ganguddy Creeks</li> </ul>
<i>Eucalyptus cannonii</i>	<ul style="list-style-type: none"> <li>• talus slopes below the escarpment and protected gullies between Growee Gulph and the Capertee valley</li> <li>• undulating topography on the floor of the Capertee &amp; Wolgan Valleys, eg Crown &amp; Barton Creeks</li> </ul>
<i>Eucalyptus capitellata</i>	<ul style="list-style-type: none"> <li>• Near the Macdonald River (localised)</li> </ul>
<i>Eucalyptus conica</i>	<ul style="list-style-type: none"> <li>• Fertile soils in north western Wollemi (localised)</li> </ul>
<i>Eucalyptus consideniiana</i>	<ul style="list-style-type: none"> <li>• ridges and exposed slopes in Wollemi south of the Hunter Range below 800 m, and Blue Labyrinth</li> </ul>
<i>Eucalyptus corticosa</i>	<ul style="list-style-type: none"> <li>• shallow sandstone soils on ridges around the Cudgegong River (localised)</li> </ul>
<i>Eucalyptus crebra</i>	<ul style="list-style-type: none"> <li>• dry &amp; sheltered slopes through the Coxs, Jenolan, Kowmung, Nattai, Little and Burragorang valleys</li> <li>• colluvial slopes below the escarpment along Lake Burragorang between the Kedumba and Wollondilly Valleys</li> <li>• upper slopes and undulating ridges along Scotts Main Range and the Bindook Highlands</li> <li>• ridges and protected slopes on sandstone with interbedded layers of shale in Yengo and Wollemi</li> <li>• shale caps and volcanic diatremes of the Lower Blue Mountains and eastern Wollemi, eg The Ironbarks, Euroka, Machins Crater, St Helena Crater</li> <li>• Capertee Valley on Permian sediments</li> </ul>
<i>Eucalyptus cunninghamii</i>	<ul style="list-style-type: none"> <li>• rock plates with skeletal soils on Kings Tableland, plateaus near Jamison valley &amp; upper Grose</li> </ul>
<i>Eucalyptus cypellocarpa</i>	<ul style="list-style-type: none"> <li>• sheltered slopes and gullies at high elevations from Black Range and Jenolan Caves to Murruin Range, Bindook Highlands and steep slopes of the Wollondilly Valley</li> <li>• protected sandstone gullies, sheltered slopes and among rocky pagodas across the GBMWhA</li> <li>• slopes beneath the escarpment in the Megalong, Jamison and Kedumba Valleys, High Gangerangs, Coxs River arm of Lake Burragorang and Newnes Plateau</li> </ul>
<i>Eucalyptus dalrympleana</i> subsp. <i>dalrympleana</i>	<ul style="list-style-type: none"> <li>• moist, sheltered situations at high elevations from Black Range, Jenolan Caves and Boyd Plateau to Murruin Range and the Bindook Highlands</li> <li>• ridges and sheltered slopes on and around Newnes Plateau</li> </ul>
<i>Eucalyptus dawsonii</i>	<ul style="list-style-type: none"> <li>• talus slopes below the escarpment in low rainfall areas between Growee Gulph and Jerrys Plains</li> </ul>
<i>Eucalyptus deanei</i>	<ul style="list-style-type: none"> <li>• deeper colluvial soils on Permian sediments on protected escarpment midslopes and benches from the Kedumba &amp; Jamison Valleys to the Nattai &amp; Burragorang Valleys</li> <li>• deep, protected gullies and sheltered slopes on sandstone and Silurian and Devonian metasediments in higher rainfall areas of GBMWhA</li> <li>• volcanic diatremes of the lower Blue Mountains</li> </ul>
<i>Eucalyptus dendromorpha</i>	<ul style="list-style-type: none"> <li>• localised on higher elevation sandstone plateaus e.g., Kings tableland, Wentworth Falls, Narrowneck, Govetts Leap and Mt Banks</li> </ul>
<i>Eucalyptus dives</i>	<ul style="list-style-type: none"> <li>• exposed sites above 900m at Jenolan Caves, undulating terrain the Boyd Plateau</li> <li>• poorly drained headwaters of creeks on the Newnes Plateau</li> </ul>

- Eucalyptus dwyeri*  
*Eucalyptus elata*
- exposed aspects in low rainfall areas of northern Wollemi
  - sheltered situations on Murrui Range, Bindook Highlands and steep slopes of the Wollondilly Valley
  - escarpment footslopes on Permian sediments in Burrarorang, Nattai, Megalong and Kedumba Valleys
  - sheltered positions on sandstone across the Nattai and Wanganderry Tablelands;
  - alluvial flats along major streams in the Little and Nattai River catchments
- Eucalyptus eugenioides*
- dry & sheltered sites through the Coxs, Jenolan, Kowmung, Nattai, Little and Burrarorang catchments
  - colluvial slopes below the escarpment on both sides of Lake Burrarorang between the Megalong and Wollondilly Valleys
  - upper slopes and undulating ridges along Scotts Main Range and the Bindook Highlands and steep protected slopes of the Wollondilly Valley
  - residual shale caps and interbanded shale soils on sandstone ridges of the Lower Blue Mountains
  - localised colluvial fans in gullies and diatremes in Big Yango, Wallabadah, Werong Creek & Devils Hole area
- Eucalyptus fastigata*
- sheltered locations at the high elevations from Black Range, Jenolan Caves & Boyd Plateau to Murrui Range and the Bindook Highlands
  - gullies & sheltered slopes below escarpment on Newnes Plateau
  - high altitude basalt caps (limited), eg Budthingeroo
- Eucalyptus fergusonii* subsp.  
*dorsiventralis*  
*Eucalyptus fibrosa*
- enriched soils on gentle slopes, ridges and benches in central and northern Yengo and eastern Wollemi
  - colluvial slopes below the escarpment along Lake Burrarorang between the Kedumba and Wollondilly Valleys, and below Newnes Plateau
  - ridges and slopes on sandstone or soils enriched by shale in Yengo, Wollemi, the Blue Breaks and Nattai
  - slopes of the Jenolan, Coxs and Kowmung Rivers and Scotts Main Range
  - shale caps on ridges of the Lower Blue Mountains, eg The Ironbarks
  - ridges and upper slopes within the Capertee valley on Permian sediments
- Eucalyptus fracta*  
*Eucalyptus globoidea*
- Sentry Box Point near Milbrodale (localised)
  - sandstone ridges enriched with shale bands and exposed upper slopes of the Blue Breaks, southern Blue Labyrinth, Nattai, Wanganderry and Burrarorang Tablelands
  - higher shale caps in south east Wollemi, Blue Labyrinth & Nattai, eg Culoul Range, Wattle Ridge
  - upper slopes and crests along southern Scotts Main Range and the Bindook Highlands
- Eucalyptus hypostomatica*
- slopes and benches below escarpment in the Burrarorang and Nattai Valleys
  - mid to lower south and east facing slopes on Narrabeen sediments across central and northern Yengo
  - scattered occurrences on sheltered sites in the tributaries of the Coxs & Kowmung Rivers
- Eucalyptus laevopinea*  
*Eucalyptus laophila*  
*Eucalyptus ligustrina*  
*Eucalyptus macarthurii*  
*Eucalyptus macrorhyncha*
- high altitude >900m basalt caps in high rainfall areas, eg Mt Coricudgy, Nullo Mtn
  - between sandstone pagodas in western Wollemi at elevations < 800 m
  - localised on rock plates with skeletal sandy soils below 900m, eg Kedumba Walls, Kings Tableland, Capertee valley
  - Boyd Plateau (localised)
  - Permian talus slopes below the escarpment in higher elevation areas between Growee Gulph and the Capertee valley
  - exposed ridges and slopes with skeletal soils on Ordovician metasediments west of Pantoneys Crown
  - slopes along Murrui Range, Jocks Creek and the Wollondilly River
- Eucalyptus mannifera* subsp.  
*gullickii*  
*Eucalyptus mannifera* subsp.  
*mannifera*  
*Eucalyptus melliodora*
- poorly drained headwaters of creeks on sandstone on the Bindook Highlands, Narrow Neck Ti-Willa and Newnes Plateaus, eg Deanes & Rocky Creek
  - low relief situations in the upper Cudgegong catchment
  - moderately sheltered, rocky positions on metasediments on slopes between 800 and 1000m, Gangerang Range to Limeburners trail
  - foothills and slopes on Bindook Porphyry in the Burrarorang Valley between Joorilands and Murrui Range
  - slopes on Devonian sediments in the Jenolan, Coxs and Kowmung Rivers and Scotts Main Range
  - localised diatremes, eg Werong Creek, Devils Hole
  - hills of the Capertee & Wolgan Valleys, eg Crown & Barton Creeks (limited)
- Eucalyptus michaeliana*
- mid to lower south and east facing slopes on Narrabeen sediments across central and northern Yengo

Eucalypt species	Habitat/distribution
<i>Eucalyptus moluccana</i>	<ul style="list-style-type: none"> <li>• undulating hills and escarpment footslopes on Permian sediments and on Bindook Porphyry along the Wollondilly River and tributaries and the lower Nattai &amp; Kedumba Valleys</li> <li>• mid to lower protected slopes on Narrabeen sediments and shale capped ridges in central and northern Yengo</li> <li>• basalt caps diatremes in low rainfall areas of Yengo and Wollemi, eg Mounts Wareng and Yengo, Sandy Camp, Kerrabee/Woodlands Trig</li> <li>• steep, dry escarpment slopes on Permian sediments above the floor of the Hunter Valley in Yengo and Wollemi</li> <li>• on limestone around Crown Creek, Capertee Valley</li> <li>• rainshadow areas in the Coxs &amp; Kowmung catchments</li> </ul>
<i>Eucalyptus moorei</i>	<ul style="list-style-type: none"> <li>• skeletal sandy soils at elevations greater than 700m, eg Kanangra Walls, Narrow Neck, Ti Willa Plateau, Gangerang Plateau</li> </ul>
<i>Eucalyptus muelleriana</i>	<ul style="list-style-type: none"> <li>• moderately deep soils on the Bindook Highlands, eg Bullnigang Heights, Tomat Creek to Nyanga Mountain</li> </ul>
<i>Eucalyptus multicaulis</i>	<ul style="list-style-type: none"> <li>• rock plates with skeletal sandy soils below 900m, eg Kings Tableland, western Wollemi</li> </ul>
<i>Eucalyptus notabilis</i>	<ul style="list-style-type: none"> <li>• interbanded and residual shale soils on sandstone ridges of the Blue Labyrinth and Blue Breaks</li> </ul>
<i>Eucalyptus nubila</i>	<ul style="list-style-type: none"> <li>• ridges and slopes in low rainfall areas in the Goulburn River catchment (limited)</li> <li>• hills near Watch House Creek (limited)</li> </ul>
<i>Eucalyptus obliqua</i>	<ul style="list-style-type: none"> <li>• moist, sheltered slopes and gullies of the high elevations from Black Range, to Murrui Range to the Bindook Highlands</li> </ul>
<i>Eucalyptus oreades</i>	<ul style="list-style-type: none"> <li>• sheltered slopes and gullies between Kings Tableland and Newnes Plateau, often above escarpment cliffs</li> <li>• sheltered positions on the Nattai and Wanganderry Tablelands</li> </ul>
<i>Eucalyptus ovata</i>	<ul style="list-style-type: none"> <li>• tableland soaks associated with swamps the Bindook Highlands, eg Tomat, Random, Back and Colong Swamp</li> <li>• along gently sloping drainage lines on the of the Boyd Plateau and at upper Martins Creek</li> </ul>
<i>Eucalyptus paniculata</i> subsp. <i>paniculata</i>	<ul style="list-style-type: none"> <li>• residual shale caps on ridges of the Lower Blue Mountains and south east Wollemi, eg The Ironbarks, Culoul Range</li> </ul>
<i>Eucalyptus parramattensis</i> subsp. <i>parramattensis</i>	<ul style="list-style-type: none"> <li>• better-drained and permanently wet sites on deep sands in the Garland Valley and Mellong Swamps area</li> <li>• sandy drainage flats adjoining the eastern side of Thirlmere Lakes (limited)</li> <li>• colluvial soils along the larger creeks of the western Capertee valley (limited)</li> </ul>
<i>Eucalyptus pauciflora</i>	<ul style="list-style-type: none"> <li>• on undulating terrain or in cold hollows on granite on the Boyd Plateau and around Jenolan Caves</li> <li>• cold air drainage hollows, alluvial bogs and rock plates at high elevations on the Loombah Plateau, Bindook Highlands, Murrui Range and Mt Fatigue trail</li> </ul>
<i>Eucalyptus pilularis</i>	<ul style="list-style-type: none"> <li>• enriched sandstones between the Warragamba River and Erskine Creek</li> <li>• shale influenced ridges, slopes and gullies of the Oakdale Plateau, eg Green Hill, Waterfall Creek, Pumpkin Hill (limited)</li> </ul>
<i>Eucalyptus piperita</i>	<ul style="list-style-type: none"> <li>• slopes, gullies and ridges with deeper soils on sandstones across much of the GBMWA, except the low rainfall northern areas</li> <li>• residual Permian outcrops on Scotts Main Range; colluvial slopes below escarpment of the Tonalli Range, southern Blue Labyrinth and Newnes Plateau</li> <li>• rocky soil on residual plateaus or ridges, High Gangerangs to Black Range</li> </ul>
<i>Eucalyptus polyanthemos</i> subsp. <i>polyanthemos</i>	<ul style="list-style-type: none"> <li>• talus slopes below the escarpment in the Wolgan and Capertee valleys</li> </ul>
<i>Eucalyptus praecox</i>	<ul style="list-style-type: none"> <li>• north of Rowans Hole (limited), Dunns Swamp</li> </ul>
<i>Eucalyptus prominula</i>	<ul style="list-style-type: none"> <li>• dry rocky exposed ridges and upper slopes on sandstone south of the Old Settlers Trail in Yengo, and eastern Wollemi</li> </ul>
<i>Eucalyptus punctata</i>	<ul style="list-style-type: none"> <li>• possibly the most frequently recorded and widespread Eucalypt of the GBMWA, occurring on a variety of substrates, in wetter and dry areas and in all but the coldest sites</li> <li>• occurs on ridges, slopes, gullies and talus on sandstone, Silurian and Devonian metasediments, Bindook Porphyry, Permian sediments, volcanic breccia, shale, granite, alluvium and colluvium.</li> </ul>
<i>Eucalyptus quadrangulata</i>	<ul style="list-style-type: none"> <li>• between Yerranderie and the Bindook Highlands (limited)</li> <li>• scattered occurrences on sheltered sites in tributaries of the Coxs &amp; Kowmung Rivers</li> </ul>
<i>Eucalyptus radiata</i> subsp. <i>radiata</i>	<ul style="list-style-type: none"> <li>• sheltered situations at high elevations from Black Range, Jenolan Caves and Boyd Plateau to Murrui Range to the Bindook Highlands on a variety of substrates</li> <li>• small sheltered drainage lines on sandstone above southern escarpment from Katoomba to Wentworth Falls and Newnes Plateau</li> <li>• sheltered slopes beneath the escarpments in the Megalong and Kedumba Valleys</li> <li>• high altitude &gt;900m basalt caps in high rainfall areas</li> </ul>
<i>Eucalyptus ralla</i>	<ul style="list-style-type: none"> <li>• dry colluvial slopes below the escarpment on both sides of Lake Burragorang between the Kedumba and Wollondilly Valley</li> </ul>
<i>Eucalyptus resinifera</i> subsp. <i>resinifera</i>	<ul style="list-style-type: none"> <li>• higher ridgelines with shale caps in south east Wollemi, eg Culoul Range (limited)</li> <li>• broad flat to gently sloping sites on plateaus north of Oakdale, southern Blue Labyrinth and Blue Breaks</li> </ul>

- Eucalyptus rossii*
- below 800 m on ridges with shallow soils on Ordovician metasediments in western Wollemi and the Capertee valley
  - talus slopes below escarpment of Newnes Plateau and Donkey Mountain
  - sheltered slopes and valleys among rocky pagodas
- Eucalyptus rubida* subsp. *rubida*
- Eucalyptus saligna*
- on undulating terrain or in cold hollows on granite on the Boyd Plateau
  - protected gullies and sheltered lower slopes on Narrabeen sediments mainly in northern Yengo
  - colluvial fans at the headwaters of gullies in Big Yango & Wallabadah area
  - sheltered gullies and lower slopes in eastern Wollemi, usually on soils enriched by shale or basalt, eg Culoul Range
- Eucalyptus scias* subsp. *scias*
- Eucalyptus sclerophylla*
- Culoul Range (localised)
  - ridgetops and exposed slopes on sandstone plateaus above 600m, eg Narrow Neck, Tonalli Mountain, Lacys, Nattai and Wanganderry Tableland,
  - lower elevation and higher rainfall areas of the south-eastern corner of Yengo
  - Permian outcrops on Scotts Main Range and on footslopes around the edge of the Megalong & Burragorang Valleys
  - better-drained and wetter sites on deep sands in the Garland Valley and Mellong Swamps area
- Eucalyptus sideroxylon*
- ridges and slopes in low rainfall areas in the Goulburn River catchment
  - exposed dry slopes along the Coxs, Jenolan and lower Kowmung River valleys below 550 m
- Eucalyptus sieberi*
- high elevation plateaus, ridges and slopes between 800 and 950m, Bindook Highlands, north from Little Wombeyan Creek, Kanangra area, Boyd Plateau, High Gangerang, Black & Moorara Range, Jenolan Caves
  - rocky areas, ridgetops and exposed slopes on sandstone, south from the Capertee valley
  - residual Permian outcrops on Scotts Main Range
  - slopes of the Nattai and Wanganderry Tablelands
- Eucalyptus smithii*
- Eucalyptus sparsifolia*
- sheltered and more exposed sites from Bindook Highlands to Black Range
  - slopes, gullies and ridges on sandstone and enriched shale soils across the GBMWSHA mostly below 800 m
  - Permian outcrops on Scotts Main Range and on talus slopes below escarpment of Newnes Plateau and Donkey Mountain
  - skeletal, often rocky soil on residual plateaus or ridges, High Gangerangs, Black Range and Jenolan Caves
  - footslopes around the edge of the Megalong & Jamison Valleys on Permian sediments
  - better-drained sites on deep sands in the Garland Valley and Mellong Swamps area
  - Bindook Highlands and northern fall of the Wollondilly Gorge
  - slopes along the Coxs, Jenolan and lower Kowmung River valleys
- Eucalyptus squamosa*
- Eucalyptus stellulata*
- exposed sites in the lower elevation and higher rainfall areas of the south-eastern Yengo and north of Upper Colo in south east Wollemi
  - cold air drainage hollows and alluvial bogs at high elevations, Boyd Plateau, Limeburners Flat, Murruin Range, Tomat, Random, Back, Colong and Bent Hook Swamps
- Eucalyptus stricta*
- rock plates with skeletal sandy soils at higher elevations, eg Kanangra Walls, Narrow Neck, Ti Willa Plateau, Gangerang Plateau, Kedumba Walls, Axehead Mountain, Loombah Plateau, along the Murruin Range and Mt Fatigue trail
- Eucalyptus tenella*
- along the divide between the Growee & Cudgegong catchment, eg Heffrons Gap
  - broad valley floors, ridges and upper slopes within the Capertee valley
- Eucalyptus tereticornis*
- sheltered & dryer slopes on Devonian sediments in the Jenolan, Coxs and Kowmung Rivers, their larger tributaries and along Scotts Main Range
  - deeper colluvial soils below escarpment on protected aspects in the the Coxs River arm of Lake Burragorang, the Kedumba, Burragorang, Nattai and Little River Valleys;
  - slopes & undulating foothills of the Wollondilly River & tributaries on Bindook Porphyry
  - volcanic diatremes of the lower Blue Mountains and south east Wollemi below 400 m, eg Euroka, Machins Crater, Saint Helena Crater
  - moist sandy alluvium in the Mellong Swamps area, and footslopes and alluvial flats along broader streams around Howes Valley and along the Nattai & Little Rivers
  - basalt caps, shale capped ridges and enriched mid slopes in north-western Yengo and north east Wollemi, eg Mounts Wareng and Yengo
- Eucalyptus viminalis*
- Bindook Highlands and protected slopes of the Wollondilly Valley
  - on gentle slopes across the Boyd Plateau on granite, especially around eastern & northern plateau rim
  - high altitude basalt caps and diatremes in high rainfall areas, eg Budthingeroo
  - sheltered sites at high elevations from Jenolan Caves & the Black Range to Murruin Range
  - freely drained alluvial soils along drainage lines on the Mellong sandmass and sheltered streams
  - along larger streams and among rocky pagodas between Dunns Swamp and Newnes Plateau

300 m elevation. The remainder of the GBMWhA is usually higher than 400 m elevation, other than the larger incised valleys such as the Coxs and Grose Rivers. Only a relatively small part of the GBMWhA is above 1 000 m elevation, mainly around Mount Werong, the Boyd Plateau and Narrow Neck Peninsula. A notable feature of the GBMWhA is the high level of vertical relief between the plateaus and incised valleys, which reaches a peak of about 900 m in the south west of the area.

As the altitude increases, the climate becomes colder and wetter. Frost, fog and some snow can occur in the Upper Mountains, where conditions are generally colder and harsher. Species restricted to the coldest areas include *Eucalyptus pauciflora* and *Eucalyptus laevopinea* on the high peaks, and *Eucalyptus rubida*, *Eucalyptus stellulata* and *Eucalyptus aggregata* on flats subject to cold air drainage. The climate is much warmer in the lower eastern and northern areas; those species typically found at lower elevations such as *Angophora costata* and *Corymbia eximia* usually have a widespread distribution within the GBMWhA.

#### Rainfall

Annual rainfall over most of the GBMWhA is moderate (800–1200 mm pa) but increases with elevation to 1400

mm in the central Blue Mountains (Katoomba to Newnes Plateau) and in Kanangra – Boyd NP. Rainfall progressively decreases north of Newnes Plateau and is lowest in the northwest of the GBMWhA, in northern Wollemi. Jerrys Plains near the northern boundary of Wollemi NP has an annual rainfall 640 mm, which is probably representative of this part of the World Heritage area. Taxa that are more widespread on the NSW Western Slopes such as *Corymbia trachyphloia* subsp. *amphistomatica*, *Eucalyptus dawsonii* and *Eucalyptus beyeriana* only occur in this part of the GBMWhA.

#### Rock types

The oldest rocks of the GBMWhA are of Siluro-Devonian age and are mainly found in the southern Blue Mountains. Tectonic plate movements and volcanic intrusions have caused considerable deformation to them. Deposition of the Sydney Basin sediments commenced in the early Permian with marine sediments and coal deposits which outcrop below the major escarpments. The sandstones that are so extensive across the region were deposited next, as river sediments in late Permian to mid Triassic. More fertile shales were occasionally deposited above these sandstones. The most recent phase were the basalt flows of the Miocene, which remain as caps on a number of mountains.



Fig. 3. Smooth straight trunks of *Eucalyptus deanei* in Blue Gum Forest in Blue Mountains National Park



Through the processes of weathering, rock breaks down into soil – some rocks create more fertile, higher nutrient soils than others. The sandstones break down into low nutrient soils which hold little moisture. There are many eucalypts typical of low nutrient sandstones including *Angophora bakeri*, *Angophora hispida*, *Corymbia gummifera*, and many of the subgenus *Eucalyptus* such as the *Eucalyptus*–Green-leaved ashes and *Eucalyptus* Blue-leaved ashes B. The quartzites typical of the rugged valley of the mid Coxs River produce low nutrient soils, where *Eucalyptus sieberi* and *Eucalyptus punctata* commonly occur. The Permian coal measures, shale and volcanic rocks such as basalt and porphyry form a brown, loamy soil which is high in nutrients and retains more moisture. Distinctively different plant communities occur on these soils, dominated by tall eucalypts such as *Eucalyptus deanei*, *Eucalyptus fastigata* or *Eucalyptus muelleriana*. Localised areas of basalt may have *Eucalyptus saligna* or *Eucalyptus viminalis* in higher rainfall areas or *Eucalyptus albens* and *Eucalyptus moluccana* in drier areas. Rainforests are largely restricted to the higher nutrient soils in the highest rainfall areas.

#### Drainage

The often steep topography in the sandstone areas generally allows water to run off rapidly but where there are layers of impervious rock, such as claystone or ironstone, waterlogged conditions may occur allowing swamp communities to develop. Most eucalypt species are sensitive to waterlogged conditions and they rarely occur in poorly-drained sites. An exception is *Eucalyptus camphora* found in swamps in the Rylstone area. Species in alluvial habitats may recruit in temporarily wet sites after floods e.g. *Eucalyptus benthamii*, *Eucalyptus elata*.

#### Aspect

The aspect of the slope determines how much sunlight it gets, and which winds it is more exposed to. In general, north-facing slopes are drier and hotter, supporting a different suite of smaller eucalypts than south-facing slopes. Exposed sites associated with cliff-lines in the upper mountains may frequently have the mallees e.g. *Eucalyptus cunninghamii*, *Eucalyptus stricta*, though these sites are also influenced by drainage and slope characteristics.



**Fig. 4.** Mountain Gum forest in Kanangra-Boyd National Park. Large shaggy trunks of *Eucalyptus dalrympleana* with smaller trees of *Eucalyptus pauciflora*, Snow Gum, in background.

### Slope

The steeper a slope, the more quickly water will run off, taking nutrients with it. The combination of slope and aspect has a profound effect on the eucalypt species present. South-facing slopes in the Blue Mountains are generally moister and steeper than north-facing (Holland et al 1992) and have different eucalypt species, particularly on the lower slopes where moisture can accumulate e.g. *Eucalyptus saligna*, *Eucalyptus cypellocarpa*. On the other hand, north-facing slopes more frequently support species tolerant of stronger sunlight and drier soils such as *Eucalyptus fibrosa* or *Eucalyptus crebra*.

### Fire, disturbances

Fire plays an important role in the growth and development of vegetation communities in Australia. After fire most eucalypt trees regenerate from dormant epicormic buds along the trunk or major branches. In some species particularly the mallees, the canopy and stems are killed and the plants resprout from underground lignotubers. Species which resprout may also shed seeds from capsules and recruit seedlings as well. A few species most notably *Eucalyptus oreades* are killed by fire and release their seeds into the ground that has been cleared by flame and made more fertile with ash. An interesting aspect of the reproductive strategy of *Eucalyptus oreades* is early seed production in trees with suppressed growth relative to dominant trees. This acts as a hedge against another fire in the period before the dominant trees reach maturity (Glasby et al, 1988).

Some species such as the *Angophora* species shed their seed annually with recruitment depending on rainfall conditions. Indeed rather than being particularly *fire-dependent* species as is sometimes claimed, many are dependent on disturbance conditions that provide suitable conditions for seedling recruitment e.g. the creation of bare areas following soil movement, flood alluvium, grazing, drought or sometimes fire. Saplings will often be seen on the edges of disturbed sites such as roadsides. *Eucalyptus oreades* will successfully establish along roadsides and in gardens in the absence of fire (DHB pers obs.).

### Biogeographic variation

The GBMWH extends from the Hunter Valley in the north to the Southern Highlands and is centred on the Central Coast and Central Tablelands botanical divisions of NSW, but includes parts of the Central Western Slopes and the North Coast divisions. The northern part of the region includes some eucalypts such as *Eucalyptus laevopinea* that are more widely distributed in northern NSW and Queensland. A disjunct population of *Eucalyptus nobilis*, a species more typical of the Northern Tablelands, has been discovered near Mount Coricudgy during a current survey of Wollemi NP (Stephen Bell pers. com.) will not be included in the list until the survey and identifications have been completed. In the

dry areas of northern Wollemi NP are eucalypts that occur primarily on the NSW western slopes such as *Corymbia trachyphloia* subsp. *amphistomatica*. The southern part of the GBMWH has several eucalypts that are widely distributed in southern NSW and Victoria, including *Eucalyptus smithii*, *Eucalyptus aggregata* and *Eucalyptus muelleriana*.

### Eucalypts and climate change

Changes in rainfall, evaporation, temperature and carbon dioxide levels associated with climate change are likely to alter the patterns of mortality, growth and phenology of individual eucalypts. It is likely that different species will respond differently to these changes, and that species will vary in their level of tolerance to these changes. Those species with a more plastic response may be advantaged over those with limited tolerance to change. As eucalypt seeds do not move very far in the landscape, large scale movement of individual eucalypt species in response to changing conditions is not likely, though there may be in-situ change (Dunlop & Brown 2008), where some species already present in the GBMWH will be favoured by climate change and may increase in abundance, while others may decline. The result of this process is likely to be shifts in the relative abundance of different eucalypt species.

In the Blue Mountains much of the wet sclerophyll forest occurs as relatively small patches within a matrix of drier forest. These patches are vulnerable to regular fire, especially where their topographic position does not offer protection from fire. The shale cap forests of the Blue Mountains are especially vulnerable because they occur on hill tops. The wet forests occurring as narrow bands along watercourses in the sandstone gorges are similarly vulnerable. The loss of limbs and foliage in dry periods may contribute to fire risk. Some canopy dominants typical of wet sclerophyll forest are weak resprouters (e.g. *Eucalyptus deanei*). Hence, they would be vulnerable to regular, intense fire. Regeneration of *Eucalyptus deanei* from seed may also be compromised by intense fire. It sheds its seed at maturity, with germination mainly occurring on bare ground that has been exposed following a low intensity fire or other periodic disturbance. Its capsules are not very woody and would be likely to burn in an intense crown fire. On the other hand it is possible that some capsules and seed may be blown long distances in the updraughts associated with such a fire, as are leaves and twigs.

### Conclusion

The 96 eucalypts (55 widespread, 41 restricted) known from the GBMWH occupy a very wide range of habitats being really only absent from rainforest and swamp sites. The majority of species have components of both stress-tolerator and competitor strategies and this has probably been a main contributor to their success. While we have been

able to make some generalisations about the habitat of many of the eucalypts, details of the ecology of most species are still poorly-known. How they will respond to the changed conditions as temperatures increase, available moisture changes and fire patterns change is impossible to predict with our current knowledge. To guide management in conserving all these species for future generations we definitely need more research on the ecology of these dominants of the Australian forests.

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**Fig. 5.** Unlike most eucalypt species, mature *Eucalyptus oreades* trees (Blue Mountains Ash) are killed by fire; vigorous post-fire seedling recruitment leading to groves of even-aged saplings as here in the misty forests of Blue Mountains National Park.

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