

# The distribution, abundance and habitat of *Eucalyptus dunnii* (Myrtaceae) (Dunn's White Gum) in New South Wales

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## Abstract

Benson, J.S.<sup>1</sup> and Hager, T.C.<sup>2</sup> (<sup>1</sup>National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, NSW, Australia 2000; <sup>2</sup>New South Wales National Parks and Wildlife Service, P.O. Box, 1967, Hurstville, NSW, Australia 2220) 1993. *The distribution and abundance of Eucalyptus dunnii* (Myrtaceae) Dunn's White Gum in New South Wales. *Cunninghamia* 3(1): 123–145. *Eucalyptus dunnii* is a tall, fast growing forest tree restricted to north-eastern NSW and south-eastern Queensland. It is phylogenetically close to *Eucalyptus angophoroides* which has its closest occurrences 700 km to the south. *E. dunnii* is a nationally listed rare species. In NSW it has a total population estimated to be 82,000 covering 800 hectares, scattered over 10 locations. The largest populations occur on the Koreelah and Tooloom Ranges near Urbenville, while substantial populations are present 140 km to the south on the ranges inland from Coffs Harbour (several small populations are also present in Queensland). Eighty-two per cent of the area containing *E. dunnii* in NSW is located in state forest and six per cent is protected in conservation reserves. *E. dunnii* is confined to rich basaltic or alluvial soils and mostly grows on the margins of rainforest. A consistent suite of associate plant species is present at most locations, varying due to fire frequency or logging history. It seeds in summer, which coincides with the bushfire season in the region. Extensive logging over the last few decades has led to the dominance (86%) of trees with dbh < 0.5 m. Relatively few large, old trees remain. Further conservation reserves are required to protect southern and western populations.

## Introduction

*Eucalyptus dunnii* Maiden (Myrtaceae) is a tall, smooth-barked tree with a recorded maximum height of 50 m (Yabbra State Forest) (Forestry Commission of New South Wales 1989a). It has a limited distribution in north-eastern New South Wales and just crosses the border into south-eastern Queensland (Figure 1). *E. dunnii* is currently regarded as a rare species on the national rare or threatened plant list with a conservation status of 3RCa (Briggs and Leigh 1988). This indicates it is distributed over a range exceeding 100 km, is rare but not in danger of extinction and has over 1000 individuals conserved in conservation reserves.

As *E. dunnii* often dominates the forest canopy it has been distinguished as Forest Type No. 51, Dunn's White Gum, on the forest-type maps produced by the Forestry Commission of New South Wales (1989b). Both Benson (1989) and Hager and Benson (1992) also recognise vegetation dominated by *E. dunnii* as a distinct plant community, one of a number of tall open-forest communities occurring on high nutrient soils in the 1100 to 1500 mm rainfall zone in the far north-eastern corner of NSW. Most of these forests have now been cleared for agriculture or logged and most of the remaining unlogged areas are proposed for logging over the next decade.

This paper presents data on the extent of *E. dunnii* on different land tenures; its abundance and size structure at sample sites; its estimated population in 10 geographically distinct locations; and reviews the conservation status of the species. An analysis of the similarities of site floristics is provided.

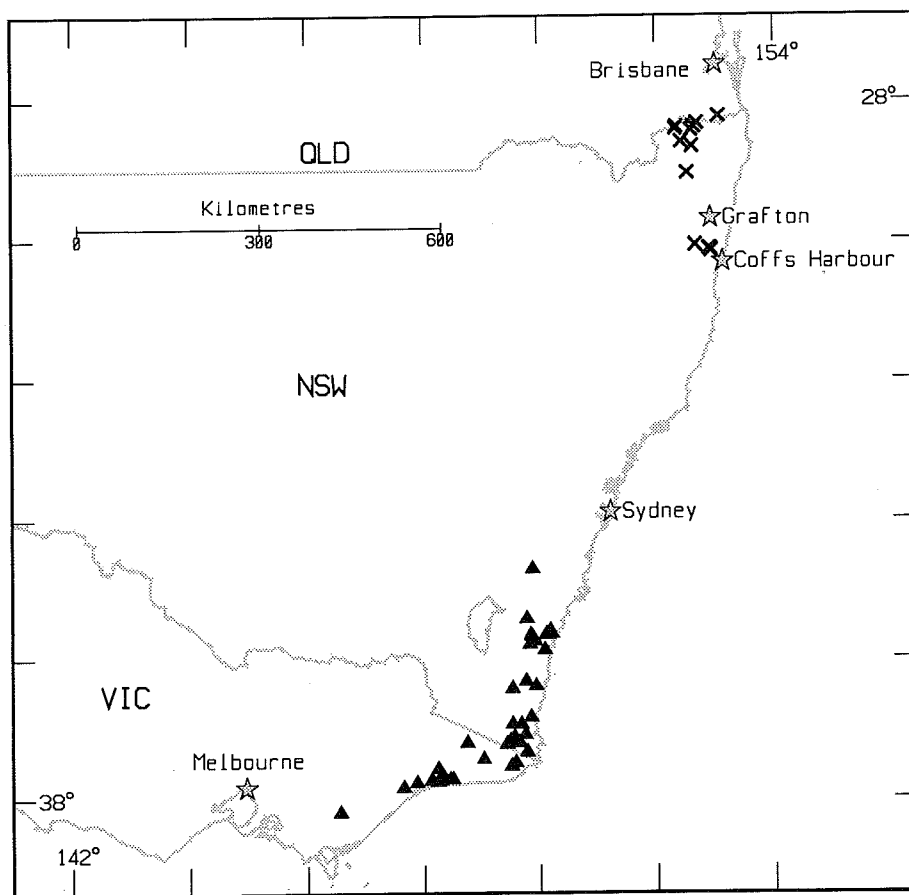


Figure 1. Collections of *Eucalyptus dunnii* (X) and its nearest related species *Eucalyptus angophoroides* (▲) showing their respective geographical ranges in south-eastern Australia. Data from NSW National Herbarium.

### Taxonomy

*Eucalyptus dunnii* has a fibrous, greyish bark on its lower trunk but the bark is smooth above, including the branchlets. Distinguishing morphological features include: juvenile leaves opposite, orbicular to ovate, cordate, dull grey-green (Figure 2); adult leaves narrow-lanceolate, dull green, concolorous; umbellasters 7-flowered; fruit hemispherical or conical or campanulate with exerted valves (Harden 1991).

The occurrence of *E. dunnii* in mixed stands with other smooth-barked eucalypts (gums), such as *E. saligna*, *E. tereticornis* or *E. grandis*, can make field identification of *E. dunnii* difficult. The juvenile leaves and fruit of *E. dunnii* are, however, very distinct from these other associated 'gum' species.

In their phylogenetic classification of *Eucalyptus*, Pryor and Johnson (1971) place *E. dunnii* in Section Maidenaria, Series Viminales and Subseries Bridgesianinae. They propose *E. angophoroides* (a species occurring 700 km to the south of the southern most occurrences of *E. dunnii*) in south-eastern NSW and north-eastern Victoria (Figure 1),



**Figure 2.** The distinctive orbicular, juvenile foliage of *Eucalyptus dunnii* is a major distinguishing feature of this species.

as being the closest related species. Both subspecies of *E. bridgesiana* (subsp. *bridgesiana* and subsp. *malacoxylon*), which occur on the tablelands west of the *E. dunnii* occurrences, are also suggested as close relatives to *E. dunnii*. This phylogeny is supported by both the weighted character and unweighted character cladistic analyses undertaken by Chappill (1988). These analyses group *E. dunnii* and 18 other taxa into a *E. globulus* clade within the 'Viminales' clade. The analyses suggest that the closest relative to *E. dunnii* is *E. angophoroides* with *E. bridgesiana* subsp. *bridgesiana* and the threatened Victorian species *E. crenulata* also exhibiting strong affinities. All of these last-mentioned species share the characteristic of crenulate juvenile leaves.

### Biology and use of timber

Most of the biological research on *E. dunnii* has been carried out on its growth rates in plantations in Brazil and South Africa, reflecting the importance of the species as a source of pulp for paper production in these countries.

*Eucalyptus dunnii* is one of the fastest growing eucalypts. Oliveira (1988) reports that it, along with *E. viminalis*, outgrew 31 other species of eucalypts during trials at Tres Barras, Santa Catarina in Brazil at an altitude of 775 m. Impressive growth rates have also been achieved in the Natal midlands, South Africa (Nixon and Hagedorn 1984).

On poorer soils in Brazil, however, *E. grandis* and *E. saligna* were found to be more efficient in using nutrients than *E. dunnii* (Silva H.D. *et al.*, 1983).

Limited studies of stand thinning and stand edges in Brazil (Graca 1987) show that flowering is more abundant with increased availability of light. In Australia, flowering occurs in March and capsules mature over winter. Observations from seed collectors suggest that there is a consistent shedding at the peduncle – pedicel joint, of the four outside capsules before they reach maturity thereby leaving three capsules in the umbellaster (C. Gardiner pers. comm.). Little is known about pollination in the species.

Oliveira (1988) notes that *Eucalyptus dunnii* produces a low quantity of seed in Brazilian plantations thus slowing down some planting programs. Similarly, it is generally a low and unreliable seeder in Australia (Oliveira 1988 and C. Gardiner pers. comm.). Because of its value in the development of overseas plantations, there has been a high demand for *E. dunnii* seed from Australia (valued at A\$1300 kg in 1991, C. Gardiner pers. comm.). The following observations on seed production have been made by C. Gardiner of the CSIRO Australian Seed Tree Centre:

\* A heavy crop of seed has been produced in only three of the last 25 years. Two of the three heavy seed crops were observed for the dry years of 1990 and 1991. Little seed was observed in 1992.

\* *Eucalyptus dunnii* seems not to be an opportunistic seeder as seed is consistently shed over the summer months before the next flowering begins.

\* Seed production is not uniform between populations. While one population may be bearing seed, another may not.

In Australia, the foliage of *E. dunnii* is prone to insect attack, particularly by members of the Psyllidae (lerps). Heavy infestations have been observed to cause death in trees (C. Gardiner pers. comm.) The relative attractiveness of *E. dunnii* to insect attack compared to *E. grandis* has led to it being planted as an insect lure on the edge of *E. grandis* plantations (A. Floyd pers. comm.).

Research on the resistance to termite (*Macrotermes natalensis*) attack (South African Institute for Commercial Forestry Research 1988) ranked *E. dunnii* as being more resistant than all other species of *Eucalyptus* tested. Little is known about its resistance to Australian termite species.

In contrast to its success in pulp production overseas (and use as veneer timber in Australia), Australian foresters and timber companies consider the saw-log timber derived from *E. dunnii* is low in quality, compared to species such as *E. saligna* (Sydney Blue Gum). It has a tendency to warp and shrink during the drying process (E. Chiswell pers. comm., M. Combe pers. comm.).

## Methods

Herbarium records from the National Herbarium of NSW, data from the NSW National Parks and Wildlife Service rare plant database and the Forestry Commission's forest type maps formed the basis for identifying the main locations of *E. dunnii*. The term location used in this paper refers to distinct geographic areas such as a mountain range or a creek catchment. Eight of the 10 locations were sampled by means of quadrat-based sites. A total of 30 sites covering the major habitat types and disturbance histories across the geographical distribution of the species were sampled in April 1991.

At each site two quadrats of different sizes were recorded. As far as possible, quadrats were positioned in the centre of stands of *E. dunnii*. The diameter of the tree trunk at breast height (dbh) of all specimens of *E. dunnii* was measured within a 50 X 50 m quadrat. The dbh measurements were assigned to one of three dbh classes (0–0.5 m, 0.51–1.25 m, >1.26 m).

A 20 X 20 m quadrat was placed within the 50 X 50 m quadrat and its floristic composition recorded. Each vascular plant species was assigned a percentage cover rating, using a modified Braun-Blanquet (1932) scale. A structural classification of the vegetation at each site was described using Walker and Hopkins (1990). This included the recognition of different strata in the vegetation and the dominant species therein. Estimates of the time since the last fire or logging were also recorded. Data on altitude, slope, aspect and substrate/soil were recorded.

Abundance data from the sample sites within each location were averaged and extrapolated to give estimates of present population for each of the eight sampled and two unsampled geographical locations. The dbh data are similarly grouped, but the proportion of trees in each size class are given for each site. Some smaller stands of *E. dunnii* on private land, including narrow bands of trees extending down creeks into drier, non-basalt country, were not sampled, although estimates of numbers at some sites are provided. The extent of *E. dunnii* communities on various tenures of land were estimated using a dot matrix overlay on Forestry Commission vegetation type maps and field checked with the assistance of aerial photographs. Geographic locations, such as the Tooloom Range (which extends for over 40 km north to south), contain several populations of *E. dunnii*.

Because some small, remote or inaccessible populations may have been overlooked during the survey, data on the total extent and total population should be considered to be an under-estimate.

To generate site and floristic classifications, the data were subjected to pattern analysis using the PATN package (Belbin 1989). The data matrix included 201 species. This excluded species that only occurred once in the survey and had a cover rating of 1, which add little to the analysis of patterns. The Bray-Curtis association measure (Bray and Curtis 1957) was used to compare the sites according to similarities in their species composition. This measure of association was used in a 'unweighted paired group arithmetic averaging' (UPGMA) (Sneath and Sokal 1973, Belbin 1989) hierarchical clustering strategy and a dendrogram was generated. The clustering parameter (Beta) was set at -0.1. A list was produced which records presence or absence of species from the major groupings defined in the UPGMA cluster analysis.

## Results

### Distribution and abundance

In NSW there are approximately 82,000 individuals of *E. dunnii* covering approximately 795 hectares distributed over 10 locations (Table 1) from just north of Moleton in the south (Lat. 30°08'S), to the Queensland–NSW border in the north (Lat. 28°18'S) (Figures 3 and 4).

The major populations of *E. dunnii* occur in the upper Clarence River catchment on the McPherson Range (which forms the border between NSW and Queensland) and the north-south orientated, basalt dominated ranges (Acacia Plateau, Koreelah Range, Tooloom Range and Richmond Range) that radiate from it (Tables 1 and 2, Figure 3). These ranges are eroded features of the Focal Peak Volcano which erupted in the

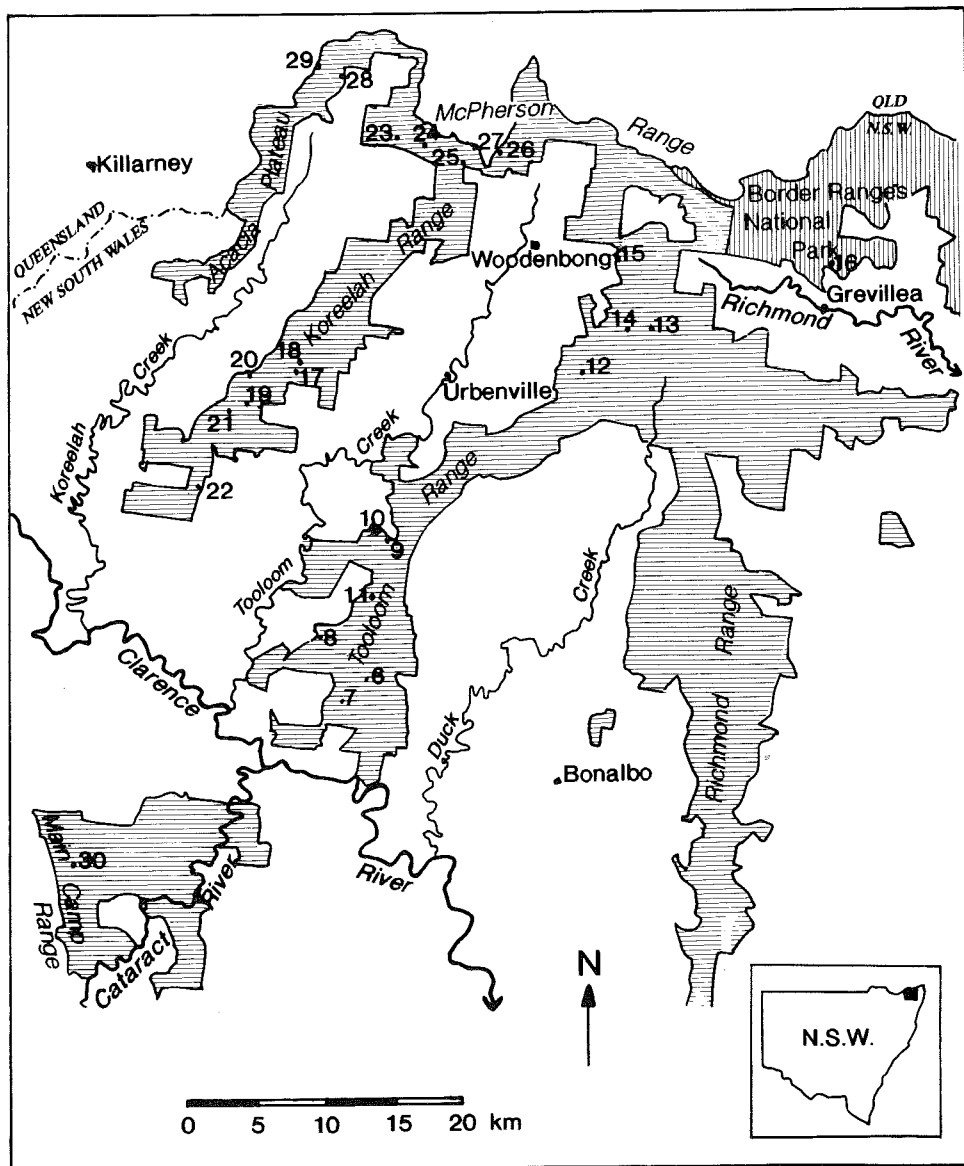


Figure 3. The major populations of *Eucalyptus dunnii* occur on the basalt capped ranges of far north-east NSW. The populations are restricted in size and extent and mainly occur in state forest which is hatched. Sample sites are numbered 6-30.

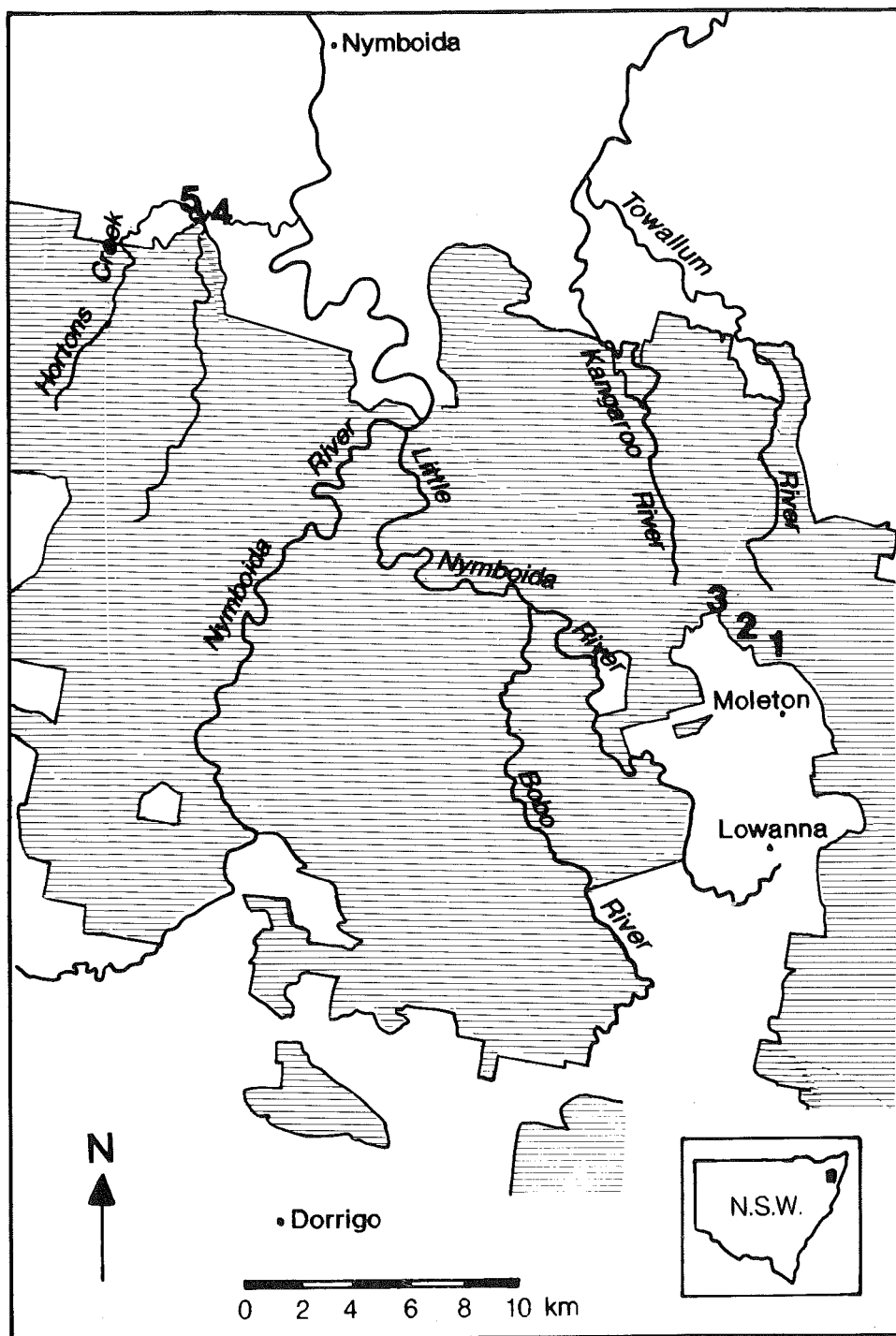


Figure 4. Occurrences of *Eucalyptus dunnii* in the Moleton-Hortons Creek areas inland from Coffs Harbour. Sites are numbered 1-5. Hatched area is state forest.

Tertiary period approximately 25 million years ago. This volcano produced numerous flows of basalt and rhyolite (Stevens 1977, Floyd 1979a, 1979b). Three small populations were recorded in the Richmond River catchment, the eastern-most of which was Terrace Creek, partly inside Border Ranges National Park.

Several populations occur 140 km south of the Focal Peak region (Figure 4). The southernmost locality for the species is at Mole Creek, 4 km north of Moleton which is situated on the coastal ranges 30 km north west of Coffs Harbour. Other populations occur in the adjoining state forests north of Mole Creek. An isolated population is present near the junction of Hortons and Clouds Creeks, 25 km north-west of Moleton and 10 km south of Nymboida. These southern stands of *E. dunnii* also grow on enriched loamy soils but these are derived from a different volcanic source than the rich soils in the Focal Peak region.

A small stand of *E. dunnii* in Gilgurry State Forest north east of Tenterfield represents a western outlier of the species. In common with southern occurrences it is growing on an enriched loamy red soil derived from a small area of residual basalt.

Areas of *E. dunnii* identified on Forestry Commission 1:25 000 scale forest type maps were generally confirmed by the survey. One notable exception is a 70 ha area below Acacia Plateau which was discovered to be *E. saligna*. This area is not accessible by road, which may have restricted ground truthing of the forest typing.

Several isolated populations of *E. dunnii* occur in Queensland near its border with NSW. One stand is on the north-western side of Lamington National Park at Duck Creek, mostly on the private land near O'Reilly's Guest House (W. McDonald pers. comm.). The species is also recorded from Main Range National Park (Briggs and Leigh 1988) in populations contiguous with or close to those of the MacPherson Range. A few hundred individual trees are known from Burnett Creek on the western side of Mount Barney. Clearing for pine plantation has limited the population of *E. dunnii* in Gamubal State Forest, north east of Killarny (P. Young pers. comm.). The most northern location of *E. dunnii*, and the largest stand in Queensland, is located at Spicers Gap on the Cunningham Gap Road approximately 25 km north of the NSW border. In total there would be approximately 300 ha of *E. dunnii* forest in Queensland (P. Young pers. comm.) but little data is available on population or size class structure.

### Habitat

Our survey confirmed that *E. dunnii* grows on high nutrient soils. All sample sites were located either on basalt, or on colluvium or alluvium influenced by the presence of basalt upslope or upstream. Surface soils have a neutral pH falling between 6.5 and 7 (C. Gardiner pers. comm.). At its southernmost locations near Moleton, *E. dunnii* grows on red-brown loams derived from residuals of the Towallum Basalt (Dorrigo-Coffs Harbour 1:250 000 geology map). Basalt is also present upslope from its occurrence at Hortons Creek (Floyd 1977). At its northern locations in NSW, *E. dunnii* most often grows on chocolate soils (black earths) derived from basalt (Beckman and Thompson 1977, Floyd 1979a, 1979b). One exception to this is the population in the Peacock Creek valley on the western side of the Richmond Range. This relatively dry site is underlain by sedimentary rocks but there is some basalt enriched alluvium on the creek flats which is where most of the *E. dunnii* grows. The Queensland populations of *E. dunnii* are also confined to basalt and enriched alluvium (P. Young pers. comm.).



**Table 1.** Occurrence of *Eucalyptus dunnii* communities on various tenures

<b>Location</b>	<b>Tenure</b>	<b>Area (ha)</b>	<b>Number of trees</b>
Kangaroo Creek SF, Moleton	State forest	60	4,900
Clouds/Hortons Creek	Private	23 <sup>#</sup>	3,600
	Crown land	9	2,600
Tooloom Range	State forest	90	9,500
	Private	5	530
Richmond Range	State forest	100	7,700
	Private	1	80
Koreelah Range	State forest	195	22,900
	Flora reserve	35	5,200
	Private	18	2,200
MacPherson Range	State forest	105	10,500
	Flora reserve	9	760
	National Park	5	260
	Private	5	490
Acacia Plateau	State forest	91	6,900
	Private	8	710
Gilgurry	State forest	8	690
Acacia Creek	Private	18	1,600*
Tooloom Creek	Private	5	710*
	Crown land	5	200*
<b>Total (ha)</b>	State forest*	649	63,100
	Reserves	49	6,200
	Crown land	14	2,800
	Private	83	9,900
	<b>Total</b>	<b>795</b>	<b>82,000</b>
<b>Total (%)</b>	State forest*	81.6	76.9
	Reserves	6.2	7.6
	Crown land	1.8	3.4
	Private	10.4	12.1

\* Excludes flora reserves \* Estimate

<sup>#</sup> Includes 10ha in the process of incorporation into a nature reserve

**Note:** Number of trees is extrapolated from quadrat data presented in Table 3. Locations recently disturbed by logging may have the greatest number of trees per ha due to regeneration, but these trees are generally smaller in size than those growing in less recently disturbed locations.

*Eucalyptus dunnii* grows on a range of aspects but rarely occurs on north-western facing slopes (Table 2). It mainly grows between the altitudes of 400 m and 650 m. The lowest recorded elevation is Terrace Creek in the Border Ranges National Park (210 m) and highest at Mount Clunie Flora Reserve on the McPherson Range (790 m) (Table 2).

**Table 2.** Site attributes for *Eucalyptus dunnii* occurrences

Location	Site	Easting	Northing	Elev. (m)	Slope (°)	Aspect (°)
Kangaroo Creek SF, Moleton	1	4905	66658	430	10	40
	2	4893	66662	460	2	0
	3	4884	66674	490	0	0
Clouds/Hortons Creek	4	4693	66811	220	2	110
	5	4692	66813	240	6	140
Tooloom Range	6	4495	68283	590	3	20
	7	4476	68267	320	2	10
	8	4462	68317	650	10	232
	9	4508	68383	660	10	170
	10	4500	68388	570	4	162
	11	4501	68342	560	2	274
Richmond Range	12	4651	68496	600	15	356
	13	4669	68528	440	5	270
	14	4682	68531	550	3	232
Koreelah Range	15	4683	68583	400	15	36
	17	4447	68501	420	1	80
	18	4452	68510	430	2	262
	19	4413	68482	630	8	240
	20	4415	68503	760	6	296
	21	4399	68399	610	5	115
MacPherson Range	22	4373	68412	540	8	110
	16	4826	68573	210	5	214
	23	4523	68666	790	20	162
	24	4544	68660	610	10	198
	25	4568	68651	600	12	130
	6	4592	68658	680	35	94
Acacia Plateau	27	4580	68663	630	4	310
	28	4487	6871400	595	0	0
Gilgurry	29	4466	6872300	770	20	96
	30	4281	6816300	670	10	45

**Note:** AMG eastings and northings include full digit code accurate to 100 m

**Table 3.** Number and proportion in size classes of *Eucalyptus dunnii* in sites and locations

Location	Site	No. of trees	$\bar{x}$	S.E.	Proportion of trees within DBH classes (metres)		
					0-.5	.51-1.25	1.26-2
Kangaroo Creek SF, Moleton	1	28	20.3	3.2	.68	.25	.07
	2	16			.94	.06	0
	3	17			.59	.29	.12
Clouds/Hortons Creek	4	73	NC	NC	.93	.05	.02
	5	11			.54	.36	.10
Tooloom Range	6	36	26.4	5.2	.97	.03	0
	7	18			.67	.22	.11
	8	36			.94	.06	0
	9	48			.94	.04	.02
	10	18			.67	.22	.11
	11	4			.75	.25	0
	12	25			.96	.04	0
Richmond Range	13	30	19	5.1	1	0	0
	14	18			.94	.06	0
	15	9			.89	.11	0
Koreelah Range	17	31	30.5	7.5	.97	.03	0
	18	12			.92	0	.08
	19	27			.96	.04	0
	20	68			.88	.11	.01
	21	31			.90	.10	0
	22	14			.93	.07	0
MacPherson Range	16	13	22.7	5.3	.77	.15	.08
	23	21			.1	0	0
	24	11			.1	0	0
	25	33			.88	.12	0
	26	12			.83	.17	0
	27	46			.98	0	.02
Acacia Plateau	28	21	NC	NC	.81	.10	.09
	29	17			.88	.06	.06
Gilgurry	30	30	NC	NC	.74	.22	.04
Acacia Creek	NR						
Tooloom Creek	NR						

NR: not recorded - Acacia Creek and Tooloom Creek locations were not sampled

NC: not calculated

Site: 50 X 50 m quadrat

 $\bar{x}$  (mean) and S.E. (standard error) are provided for locations where sites >2

### Population structure

The dbh data (Table 3) reveal that, as of 1991, an overwhelming proportion of the population was composed of small trees. Eighty-six per cent of individuals were in the 0-0.5 m size class compared to 11% in the 0.51-1.25 class and 3% in the >1.25 class. At undisturbed sites with moist understorey species the data suggests that 'old growth' stands may have a ratio of large/medium to small trees in the order of two to three. In contrast most of the current populations occur in recently disturbed sites and contain about nine small trees to each large or medium sized tree.

Very few stands of 'old growth' *E. dunnii* forest were located during the survey. Only five sites contained >30% of trees in the medium to large categories (>0.51 m dbh). These were site 1 near Averages Creek on the border of Kangaroo River State Forest and Bagawa State Forest; site 3 adjacent to Black Mountain Road in Kangaroo River State Forest; site 5 at Hortons Creek; and sites 7 and 10 in Yabbra State Forest on the Tooloom Range.

Regeneration of young trees was observed at all sites, but was most vigorous at sites where there had been recent disturbance (Figure 5), mainly due to logging or clearing over the last 40 years. Under natural conditions mass regeneration would probably



Figure 5. The quick-growing *Eucalyptus dunnii* regenerates well after disturbance although frequent fire may cause a long-term population decline.

occur after hot wildfires or cyclones have disturbed the forest. In this sense *E. dunnii* may behave in a similar fashion as other fire sensitive eucalypts, such as *E. regnans* which forms even aged stands after fire, regenerates on an ashbed and self-thins over time (Ashton 1976). At most locations the natural fire frequency would be expected to be low, since *E. dunnii* grows on moist sites dominated by largely non-flammable species. Large trees (Figure 6) would be common in areas that have not been severely burnt or affected by cyclones for over 150 years (authors' estimate).

### Associated plant species

Throughout its range *E. dunnii* occupies an ecotonal zone between drier eucalypt forest and rainforest. The understorey is usually dominated by colonising rainforest species, with the families Myrtaceae, Euphorbiaceae, Lauraceae and Meliaceae prominent.

*Eucalyptus saligna*, *E. grandis*, *E. microcorys* and *Lophostemon confertus* commonly co-dominate the forest canopy with *E. dunnii*. Several strata are generally present below the canopy of these tall eucalypts. Small to medium-sized trees up to 20 m high make up the next tallest stratum. This is mostly composed of regenerating



**Figure 6.** Due to logging over recent decades, few mature, large specimens of *Eucalyptus dunnii* remain. This large specimen was located adjacent to Wallaby Creek.

eucalypts but in the vicinity of mature rainforest *Araucaria cunninghamia*, *Diploglottis australis* and *Toona australis* are commonly present. The next layer is most often composed of rainforest trees, tall shrubs and vines including *Neolitsea australiensis*, *Neolitsea dealbata*, *Alectryon subcinereus*, *Cryptocarya rigida*, *Cryptocarya glaucescens*, *Diospyros australis*, *Polyscias elegans*, *Acacia maidenii*, *Rhodamnia rubescens*, *Acmena smithii*, *Croton verrauxii*, *Cordyline petiolaris*, *Cordyline stricta*, *Cissus hypoglauca* and *Cissus antarctica*. A frequently occurring and major weed species is *Lantana camara* which dominates the understorey at sites that have been substantially disturbed by logging, fire or clearing. *Senna floribunda* and *Ageratina adenophora* are other commonly recorded, introduced plants.

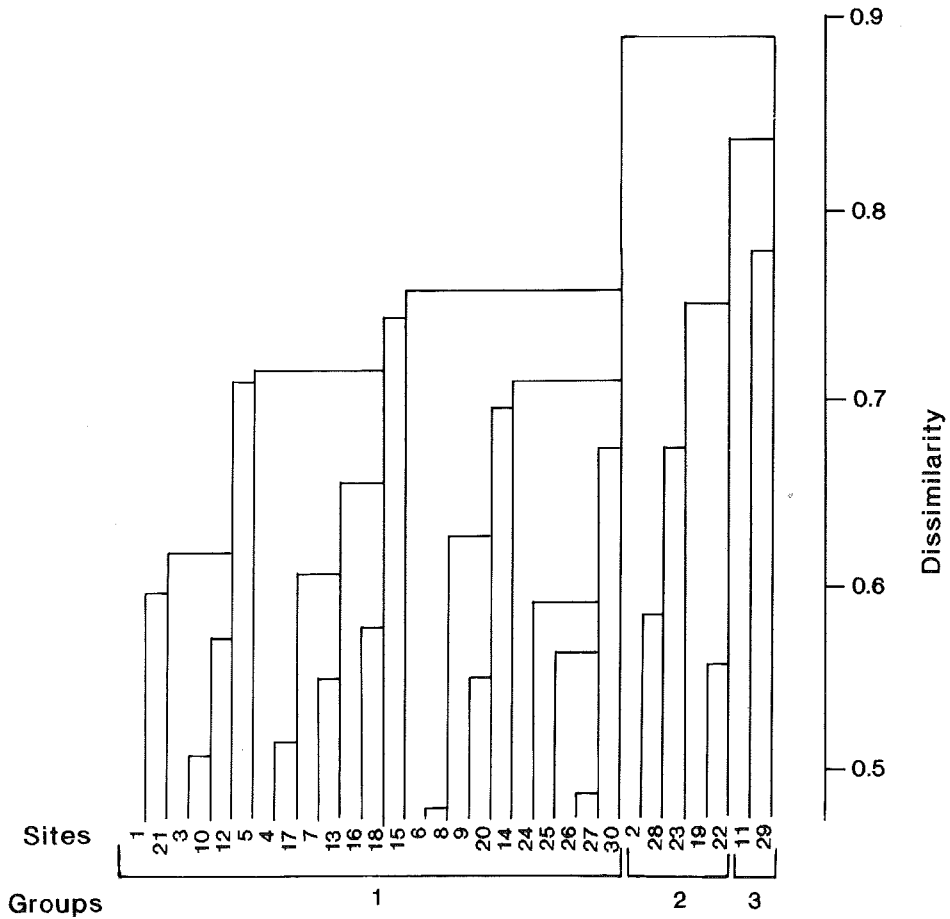
On moist sites, estimated by the authors not to have been burnt for more than 30 years, ferns, vines and herbs dominate the forest floor. Common species include the ferns *Adiantum formosum*, *Lastreopsis* spp., *Hypolepis glanduligera*, *Doodia aspera*, *Dennstaedtia davallioides*; vines such as *Derris involuta*, *Palmeria scandens* and *Rubus hillii* and forbs such as *Pollia cristata*, *Alpinia caerulea* and *Alocasia brisbanensis*.

A different array of ground species dominate at drier sites which have been regularly burnt (every 10 years or so) or which have been recently logged. These include *Pteridium esculentum*, *Imperata cylindrica* and *Poa labillardieri*. The herbaceous weed species, *Ageratina adenophora* (crofton weed), was present at heavily disturbed sites.

A total of 239 species of vascular plants were recorded as occurring with *E. dunnii* (Table 4) of which 12 species (5%) were introduced weeds.

### Plant community variation

There is a remarkable similarity of floristic composition throughout the range of *E. dunnii* forests in NSW. Observations suggest floristic differences can be explained by disturbance history, particularly recent fire or logging, rather than changes in physiography. This is supported by the UPGMA cluster analysis which grouped the sites into three main floristic groups (groups selected at the 0.8 level of dissimilarity, Figure 7). Group 1 contains sites rich in species, the great majority of which are either pioneer or latter stage rainforest plants. Group 2 contains a combination of rainforest pioneer species and dry sclerophyll species recovering after disturbance within the last two decades. Group 3 contains the two most heavily disturbed sites (11 and 29) both of which had been recently heavily logged and burnt and were species poor.



**Figure 7.** UPGMA generated dendrogram showing the floristic relationships between sites at which *Eucalyptus dunnii* occurs. Brackets show the floristic groupings at the 0.8 level of dissimilarity. This grouping appears to reflect disturbance history.

**Table 4.** Species occurring in *Eucalyptus dunnii* communities  
 (# after species denotes exotic)

UPGMA Group	1	2	3	UPGMA Group	1	2	3
PTERIDOPHYTES							
<b>Adiantaceae</b>				<b>Annonaceae</b>			
<i>Adiantum aethiopicum</i>	*	*		<i>Rauwenhoffia leichhardtii</i>	*		
<i>Adiantum formosum</i>	*	*		<b>Apiaceae</b>			
<i>Adiantum hispidulum</i>	*			<i>Hydrocotyle pedicellosa</i>	*		
<i>Pellaea falcata</i> var. <i>falcata</i>			*	<b>Apocynaceae</b>			
<i>Pellaea paradoxa</i>	*	*		<i>Alyxia ruscifolia</i>	*	*	
<b>Aspidiaceae</b>				<i>Melodinus australis</i>	*		
<i>Lastreopsis acuminata</i>	*			<i>Parsonsia fulva</i>		*	
<i>Lastreopsis decomposita</i>	*			<i>Parsonsia straminea</i>	*		
<i>Lastreopsis microsora</i>	*			<i>Parsonsia velutina</i>	*		
<i>Lastreopsis munita</i>	*			<b>Araceae</b>			
<i>Asplenium australasicum</i>	*	*		<i>Alocasia brisbanensis</i>	*		
<b>Blechnaceae</b>				<i>Gymnostachys anceps</i>	*	*	
<i>Blechnum cartilagineum</i>	*			<b>Araliaceae</b>			
<i>Doodia aspera</i>	*	*		<i>Cephalalaria cephalobotrys</i>	*		
<b>Cyatheaceae</b>				<i>Polyscias elegans</i>	*	*	*
<i>Calochlaena dubia</i>	*	*		<i>Polyscias murrayi</i>	*	*	
<i>Cyathea leichhardtiana</i>	*			<b>Arecaceae</b>			
<b>Davalliaceae</b>				<i>Archontophoenix</i>	*		
<i>Davallia pyxidata</i>				<i>cunninghamiana</i>			
<b>Dennstaedtiaceae</b>				<i>Linospadix monostachya</i>	*		
<i>Dennstaedtia davallioides</i>	*			<i>Livistona australis</i>	*		
<i>Hypolepis glandulifera</i>	*			<b>Asclepiadaceae</b>			
<i>Pteridium esculentum</i>	*	*		<i>Araujia hortorum</i> <sup>#</sup>			*
<b>Polypodiaceae</b>				<i>Gomphocarpus fruticosus</i> <sup>#</sup>		*	
<i>Platyterium bifurcatum</i>	*			<i>Marsdenia flavescens</i>	*		
<i>Platyterium superbum</i>	*	*		<i>Marsdenia suberosa</i>	*		
<b>Pteridaceae</b>				<i>Marsdenia velutina</i>	*	*	
<i>Pteris tremula</i>	*			<b>Asteraceae</b>			
<b>GYMNOSPERMS</b>				<i>Ageratina adenophora</i> <sup>#</sup>	*	*	
<b>Araucariaceae</b>				<i>Bidens pilosa</i> <sup>#</sup>	*	*	*
<i>Araucaria cunninghamii</i>	*			<i>Conyza albida</i> <sup>#</sup>			*
<b>ANGIOSPERMS</b>				<i>Ozothamnus rufescens</i>	*		
<b>Agavaceae</b>				<i>Helichrysum rutidolepis</i>		*	
<i>Cordyline petiolaris</i>	*	*		<i>Tagetes minuta</i> <sup>#</sup>	*		
<i>Cordyline stricta</i>	*			<b>Bignoniaceae</b>			
<b>Alangiaceae</b>				<i>Pandorea pandorana</i>	*	*	
<i>Alangium villosum</i>	*			<b>Boraginaceae</b>			
<b>Amaranthaceae</b>				<i>Austrocynoglossum latifolium</i>	*		
<i>Nyssanthes diffusa</i>	*	*		<i>Ehretia acuminata</i>	*	*	
<b>Anacardiaceae</b>				<b>Capparaceae</b>			
<i>Euroschinus falcata</i>	*			<i>Capparis sarmentosa</i>	*		



UPGMA Group	1	2	3	UPGMA Group	1	2	3
<b>Casuarinaceae</b>				<b>Eupomatiaceae</b>			
<i>Allocasuarina torulosa</i>		*		<i>Eupomatia laurina</i>	*	*	
<i>Casuarina cunninghamiana</i>	*			<b>Fabaceae</b>			
<b>Celastraceae</b>				Faboideae			
<i>Cassine australis</i>	*	*		<i>Austrostenisia glabristyla</i>	*		
<i>Celastrus subspicatus</i>	*	*		<i>Derris involuta</i>	*	*	
<i>Denhamia celastroides</i>	*			<i>Desmodium nemorosum</i>	*		
<i>Maytenus bilocularis</i>	*			<i>Glycine clandestina</i>		*	
<i>Maytenus silvestris</i>	*	*		<i>Goodia lotifolia</i>	*		
<b>Commelinaceae</b>				<i>Indigofera australis</i>		*	
<i>Aneilema acuminatum</i>	*			<i>Kennedia rubicunda</i>	*	*	
<i>Commelina cyanea</i>	*			<i>Swainsona galegifolia</i>	*		
<i>Pollia crispata</i>	*	*	*	<b>Caesalpinioideae</b>			
<b>Convolvulaceae</b>				<i>Senna floribunda*</i>	*	*	
<i>Dichondra repens</i>		*		<b>Mimosoideae</b>			
<b>Cucurbitaceae</b>				<i>Acacia filicifolia</i>	*	*	*
<i>Zehneria cunninghamii</i>	*			<i>Acacia irrorata ssp. irrorata</i>	*	*	
<b>Cunoniaceae</b>				<i>Acacia maidenii</i>	*	*	
<i>Aphanopetalum resinolum</i>	*			<i>Acacia melanoxylon</i>	*	*	*
<i>Caldcluvia paniculosa</i>	*			<b>Flacourtiaceae</b>			
<b>Cyperaceae</b>				<i>Scolopia braunii</i>	*		
<i>Carex appressa</i>	*	*		<b>Icacinaceae</b>			
<i>Gahnia melanocarpa</i>	*	*		<i>Pennantia cunninghamii</i>	*		
<i>Lepidosperma laterale</i>		*		<b>Lamiaceae</b>			
<b>Dilleniaceae</b>				<i>Plectranthus parviflorus</i>	*	*	
<i>Hibbertia scandens</i>	*	*		<b>Lauraceae</b>			
<b>Dioscoreaceae</b>				<i>Beilschmiedia obtusifolia</i>	*		
<i>Dioscorea transversa</i>	*			<i>Cinnamomum oliveri</i>	*		
<b>Ebenaceae</b>				<i>Cryptocarya erythroxylon</i>	*		
<i>Diospyros australis</i>	*	*		<i>Cryptocarya glaucescens</i>	*		*
<i>Diospyros pentamera</i>	*	*		<i>Cryptocarya microneura</i>	*	*	
<b>Elaeocarpaceae</b>				<i>Cryptocarya obovata</i>	*		
<i>Elaeocarpus obovatus</i>	*	*		<i>Cryptocarya rigida</i>	*	*	
<b>Epacridaceae</b>				<i>Cryptocarya triplinervis</i>			
<i>Acrotriche latifolia</i>	*			var. <i>pubens</i>	*		
<i>Trochocarpa laurina</i>	*			<i>Endiandra muelleri</i>	*		
<b>Euphorbiaceae</b>				<i>Endiandra sieberi</i>	*		
<i>Baloghia inophylla</i>	*			<i>Neolitsea australiensis</i>	*	*	
<i>Breynia oblongifolia</i>	*	*		<i>Neolitsea dealbata</i>	*		
<i>Bridelia exaltata</i>	*			<b>Liliaceae</b>			
<i>Claoxylon australe</i>	*	*		<i>Dianella caerulea</i>	*		
<i>Cleistanthus cunninghamii</i>	*			<b>Malvaceae</b>			
<i>Coelebogyne ilicifolia</i>	*			<i>Abutilon grandifolium</i>	*		
<i>Croton verreauxii</i>	*	*	*	<i>Hibiscus heterophyllum</i>	*	*	
<i>Drypetes australasica</i>	*			<b>Meliaceae</b>			
<i>Glochidion perakense</i>	*			<i>Anthocarpa nitudula</i>	*		
<i>Mallotus philippensis</i>	*	*		<i>Dysoxylum fraserianum</i>	*		*
<i>Omalanthus populifolius</i>	*			<i>Dysoxylum rufum</i>	*		
				<i>Melia azedarach</i>	*	*	
				<i>Synoum glandulosum</i>	*	*	
				<i>Toona australis</i>	*		

Table 4 (cont'd)

UPGMA Group	1	2	3	UPGMA Group	1	2	3
<b>Menispermaceae</b>				<b>Pittosporaceae</b>			
<i>Legnephora moorei</i>	*			<i>Billardiera scandens</i>		*	
<i>Sarcopetalum harveyanum</i>	*	*		<i>Citriobatus pauciflorus</i>	*	*	*
<i>Stephania japonica</i>	*	*	*	<i>Hymenosporum flavum</i>	*		
				<i>Pittosporum revolutum</i>	*	*	
				<i>Pittosporum rhombifolium</i>	*		
				<i>Pittosporum undulatum</i>	*	*	
<b>Monimiaceae</b>				<b>Poaceae</b>			
<i>Daphnandra micrantha</i>	*		*	<i>Imperata cylindrica</i>	*	*	*
<i>Doryphora sassafras</i>	*			<i>Oplismenus imbecillis</i>	*	*	
<i>Hedycarya angustifolia</i>	*	*		<i>Poa labillardieri</i>		*	
<i>Palmeria scandens</i>	*			<i>Themeda australis</i>		*	
<b>Moraceae</b>				<b>Proteaceae</b>			
<i>Ficus coronata</i>	*	*		<i>Grevillea robusta</i>	*		
<i>Ficus watkinsiana</i>	*			<i>Persoonia attenuata</i>		*	
<i>Maclura cochinchinensis</i>	*	*	*				
<i>Malaisia scandens</i>	*	*		<b>Ranunculaceae</b>			
<b>Myrsinaceae</b>				<i>Clematis aristata</i>	*		*
<i>Embelia australiana</i>	*			<i>Clematis glycinoides</i>	*		
<i>Rapanea howittiana</i>	*						
<i>Rapanea variabilis</i>	*	*		<b>Rhamnaceae</b>			
<b>Myrtaceae</b>				<i>Alphitonia excelsa</i>	*		
<i>Acmena smithii</i>	*		*				
<i>Angophora subvelutina</i>	*	*		<b>Rosaceae</b>			
<i>Austromyrtus bidwillii</i>	*			<i>Rubus hillii</i>	*	*	
<i>Callistemon salignus</i>	*	*		<i>Rubus rosifolius</i>	*	*	
<i>Eucalyptus acmenioides</i>	*						
<i>Eucalyptus dunnii</i>	*	*	*	<b>Rubiaceae</b>			
<i>Eucalyptus grandis</i>	*			<i>Canthium buxifolium</i>			*
<i>Eucalyptus maculata</i>	*			<i>Hodgkinsonia ovatiflora</i>	*		
<i>Eucalyptus microcorys</i>	*	*		<i>Morinda jasminoides</i>	*		
<i>Eucalyptus propinqua</i>	*	*		<i>Psychotria daphnoides</i>	*	*	
<i>Eucalyptus saligna</i>	*	*	*	<i>Psychotria loniceroides</i>	*	*	
<i>Eucalyptus siderophloia</i>	*						
<i>Eucalyptus tereticornis</i>	*	*	*	<b>Rutaceae</b>			
<i>Lophostemon confertus</i>	*	*	*	<i>Acronychia oblongifolia</i>	*	*	
<i>Melaleuca bracteata</i>	*			<i>Euodia micrococca</i>	*	*	
<i>Rhodamnia rubescens</i>	*	*		<i>Geijera salicifolia</i>	*	*	
<i>Rhodomlyrtus psidioides</i>	*			<i>Sarcomelicope simplicifolia</i>	*		
<i>Syncarpia glomulifera</i>	*	*		<i>Zanthoxylum brachyacanthum</i>	*		
<i>Syzygium australe</i>	*						
<i>Syzygium oleosum</i>	*			<b>Santalaceae</b>			
<i>Tristaniopsis laurina</i>	*			<i>Santalum obtusifolium</i>		*	
<b>Oleaceae</b>				<b>Sapindaceae</b>			
<i>Notelaea venosa</i>	*	*		<i>Alectryon subcinereus</i>	*	*	
<b>Orchidaceae</b>				<i>Arytera divaricata</i>	*		
<i>Calanthe triplicata</i>	*			<i>Cupaniopsis parvifolia</i>	*	*	
<b>Passifloraceae</b>				<i>Diploglottis australis</i>	*		
<i>Passiflora edulis*</i>	*	*		<i>Elattostachys nervosa</i>	*		
<i>Passiflora foetida*</i>	*			<i>Guioa semiglauc</i>	*	*	
<i>Passiflora subpeltata*</i>	*			<i>Sarcopteryx stipitata</i>	*		
<b>Philesiaceae</b>				<b>Sapotaceae</b>			
<i>Geitonoplesium cymosum</i>	*	*	*	<i>Planchonella australis</i>	*		

UPGMA Group	1	2	3	UPGMA Group	1	2	3
<b>Smilacaceae</b>				<b>Urticaceae</b>			
<i>Ripogonum album</i>	*			<i>Dendrocnide excelsa</i>	*	*	*
<i>Ripogonum discolor</i>	*			<i>Dendrocnide photinophylla</i>	*		
<i>Ripogonum elseyanum</i>	*			<i>Elatostema reticulatum</i>	*		
<i>Smilax australis</i>	*	*	*	<i>Urtica incisa</i>	*		
<b>Solanaceae</b>				<b>Verbenaceae</b>			
<i>Duboisia myoporoides</i>	*			<i>Clerodendrum tomentosum</i>	*	*	
<i>Solanum aviculare</i>	*			<i>Lantana camara*</i>	*		
<i>Solanum campanulatum</i>	*						
<i>Solanum cinereum</i>	*			<b>Vitaceae</b>			
<i>Solanum mauritianum*</i>	*		*	<i>Cayratia clematidea</i>	*		
<i>Solanum stelligerum</i>	*	*		<i>Cissus antarctica</i>	*	*	*
<b>Sterculiaceae</b>				<i>Cissus hypoglauca</i>	*	*	
<i>Heritiera antinophylla</i>	*			<i>Cissus sterculiifolia</i>	*		
<b>Symplocaceae</b>				<i>Tetrastigma nitens</i>	*	*	
<i>Symplocos thwaitesii</i>	*			<b>Winteraceae</b>			
<b>Thymelaeaceae</b>				<i>Tasmannia insipida</i>	*		
<i>Phaleria chermisideana</i>	*			<b>Xanthorrhoeaceae</b>			
<i>Pimelea ligustrina</i>			*	<i>Lomandra longifolia</i>	*	*	
<i>Pimelea pauciflora</i>		*		<b>Zingiberaceae</b>			
<i>Wikstroemia indica</i>	*	*		<i>Alpinia caerulea</i>	*		
<b>Ulmaceae</b>							
<i>Aphananthe philippinensis</i>	*						
<i>Trema aspera</i>	*	*					

## Conservation

Of the estimated 795 ha of *E. dunnii* forest community in NSW, 87% (693 ha) occurs in state forest. Of this 6% (44 ha) is protected in flora reserves managed by the Forestry Commission. The only sample represented in reserves managed by the NSW National Parks and Wildlife Service is 5 ha in Border Ranges National Park, the understorey of which is engulfed by *Lantana*. Therefore, just over 6% of the area of *E. dunnii* is located in conservation reserves. About 10% (83 ha) is estimated to remain on private land and a small area is located on Crown land (Table 1).

It is estimated that 6200 individuals of *E. dunnii* are conserved in reserves (Table 1). The largest protected population is in Tooloom Scrub Flora Reserve in Beaury State Forest near Urbenville. Another population is reserved in Mount Clunie Flora Reserve in Koreelah State Forest north of Urbenville. The two major reserved populations in flora reserves managed by the Forestry Commission have been partially logged in the past (Forestry Commission of NSW 1989b). They contain large numbers of post logging saplings.

The recently gazetted Hortons Creek Nature Reserve conserves 10 ha of *Eucalyptus dunnii* containing approximately 540 trees. Small stands are protected in two conservation reserves in Queensland (Main Range and Lamington National Parks).

## Discussion

The fact that *E. dunnii* survives in disjunct populations on high nutrient soil raises the question of its origin and history. Silva's (1983) findings that *E. grandis* and *E. saligna* grow better than *E. dunnii* on low fertility soils suggest that *E. dunnii* may be more dependent than these other eucalypts on the presence of rich soil such as that derived from basalt. Consequently, it may have been more common in the geological past but has been restricted by the erosion of much of the original Tertiary basalt, thus reducing the size of its potential habitat. Wallaby Knob near Wallaby Creek on the southern end of the Koreelah Range is one example of residual basalt in a valley now dominated by Jurassic sedimentary rocks (Floyd 1979c). Studies of genetic variation between isolated populations may yield information on the relative levels of differentiation and therefore estimates of the time since the population was more continuous. Alternatively, the disparate populations could have arisen through seed dispersal, although the mechanisms for this are not known.

The survival of *E. dunnii* seedlings in the presence of rainforest species indicates it has a capacity to grow rapidly after disturbance. Seedlings presumably need to gain height quickly to reach available light before they are smothered by broad-leaved rainforest vines and shrubs. It would seem that intermittent disturbance is important for the survival of stands of *E. dunnii*, otherwise it would eventually senesce and be replaced by rainforest, although we did observe seedlings germinating in localised openings (10 m diameter) of the rainforest canopy. There is little documentation on the frequency of disturbance (fire, cyclone) in pre-European times. In protected situations it may have been in the order of hundreds of years based on the size of several species of trees (*E. saligna*, *E. dunnii*, *E. grandis* and *Lophostemon confertus*) in undisturbed sites. While *E. dunnii* appears not to be opportunistic in timing its seed shedding, the fact that this happens during summer coincides with the wildfire and cyclone season. This may be an advantageous adaptation to ensure successful recruitment after disturbance.

## Threats

Since European settlement the main impacts on the population of *E. dunnii* have been due to clearing of river flats and foothills for grazing stock and logging of remaining forests. We do not have accurate figures on the species' original distribution but it would seem that a number of populations were cleared on alluvial flats at lower altitudes. This supposition is supported by the survival of old trees in the Urbenville Showground, along Tooloom Creek near Woodenbong and along Acacia Creek.

The size class data suggests that most of the populations of *E. dunnii* have been heavily logged over the last forty years. Few old growth stands remain and it appears that there has been a major shift towards smaller trees of younger age, but possibly a larger population.

Logging on a long rotation (say once in 150 years) is unlikely to threaten the species but increased fire frequency associated with post-logging management of the forest or repeated logging on short rotations may do so. If populations are burnt too often (at intervals less than 20 years) young trees, susceptible to even cool fires, may be killed before they reach seed-bearing age. This could lead to a fall in recruitment. Frequent fires also discriminate against fire sensitive rainforest understorey shrubs and trees.

Anecdotal evidence from seed collectors (C. Gardiner pers. comm.) suggests that

large, old trees yield more seed than young ones. This may be related, in part, to the fact that old, tall trees are exposed to maximum light and there is evidence that increased light leads to greater seed production (Graca 1987). Therefore, seed production (and regenerative capacity) could benefit from the protection of remaining old trees in each population. It could also benefit from more medium-sized trees being left to attain full maturity.

Other threats include seed collection, insect attack and weed infestation. Some old trees have been severely pruned by seed collectors. The long-term effects of this activity have not been researched. *Lantana camara* is a major weed in some locations and may inhibit seedling establishment. Its vigour tends to decrease with increased shade that results from regrowth of trees in the middle and upper strata of the vegetation.

### Adequacy of conservation

The present population statistics provide a somewhat inflated impression of the species abundance because of the degree of regeneration after recent logging of most stands. It is likely the population will decrease over time due to natural thinning in the stands.

It is estimated that between 5% and 10% of the 795 ha of *E. dunnii* forest remains unlogged, containing a relative high proportion of large, mature trees (derived from Tables 1 and 3). While the species is reasonably well conserved in the northern part of its range, there is very little overall representation of mature forest in these reserves. In the absence of repeated logging or burning this situation could improve over the next century.

*Eucalyptus dunnii* is not protected at its western-most occurrence in Gilgurry State Forest near Tenterfield. This small but geographically distinct population was heavily logged in 1990. Prior to logging, this stand was one of the last old growth *E. dunnii* forests remaining in NSW. Because *E. dunnii* is regenerating at the site, along with the presence of a good patch of sub-tropical rainforest, it is suggested that the Gilgurry site should be protected in a flora reserve.

The unlogged stand of *E. dunnii* at site 3 adjoining the Black Mountain Road at the southern end of its distribution warrants flora reserve status not only for *E. dunnii* but also for the unusual ridgetop presence of *Toona australis* (Red Cedar). To the east the existing Twelve Sixty Flora Reserve should be extended to protect the *E. dunnii* population near Averys Creek (site 1).

Only part of the *E. dunnii* stand at Hortons Creek is conserved in the Hortons Creek Nature Reserve. Most of the population is downslope and outside the reserve on land adjacent to Cloud's Creek. This area should be added to the nature reserve.

Additional areas of *E. dunnii* could also be protected in Yabbra State Forest which contains significant populations of the species. Also, further populations may be able to be conserved in Queensland where the species is apparently rarer than in NSW.

Based on its population and the likely impact of existing threats, *E. dunnii* is in no immediate danger of extinction. Due to its restricted distribution retention of the 3RCa status on the national rare or threatened list (Briggs and Leigh 1988) appears to be warranted.

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