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ASPECTS OF THE ECOLOGY OF A RARE TREE SPECIES, *EUCALYPTUS BENTHAMII,* AT BENTS BASIN, WALLACIA

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ABSTRACT

Benson, D.H. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, New South Wales, Australia 2000) 1985. Aspects of the ecology of a rare tree species, Eucalyptus benthamii, *at Bents Basin, Wallacia. Cunninghamia 1(3), 371–383.* Measurements of the population size and structure of the rare tree species, *Eucalyptus benthamii,* at Bents Basin, Wallacia, New South Wales, together with general observations made over a period of nearly 50 years, indicate that at this site the species is endangered by environmental changes associated with adjacent rural and urban development, particularly through increases in nutrients and exotic weeds and by frequent burning. Ways by which management may enable it to survive there are suggested.

INTRODUCTION

Eucalyptus benthamii Maiden & Cambage (Camden White Gum) is a tree of restricted distribution in coastal New South Wales, occurring naturally only in an area to the south-west of Sydney. Its survival in some localities is in doubt; it is included in the rare or threatened Australian plants list of Leigh, Briggs & Hartley (1981) and in Pryor's (1981) list of endangered eucalypts. The species is coded SPIKQ and placed in Series Viminales, Subseries Viminalinae, by Pryor & Johnson (1971). The most closely related species appear to be *Eucalyptus "dorrigoensis",* which has previously been regarded as a variety of *E. benthamii* but is now considered a separate taxon (L.A.S. Johnson, pers. comm.), and *E. kartzoffiana.* Both species have relatively restricted distributions; *E. "dorrigoensis"* is found near Dorrigo on the North Coast and *E. kartzoffiana* near Araluen on the South Coast of New South Wales.

The original habitat for *Eucalyptus benthamii* was to the south-west of Sydney, on the flats of the Nepean River and its tributaries, particularly Coxs River. Since the arrival of European man, most of this habitat has been cleared for agriculture or submerged beneath the waters of Warragamba Dam. Today, one small population and a number of scattered individuals occur along the Nepean River between Wallacia and Camden (Figure 1). Another larger population is on Kedumba Creek (33° 49′S, 150° 22′E) about 5 km upstream from the junction with the old Coxs River. The Coxs River is now flooded by Lake Burragorang.

The population on the Nepean River is at Bents Basin, 8 km south of Wallacia, and is partly included in the Bents Basin State Recreation Area. Following a major bushfire there in December 1979, a study was begun to provide management guidelines for its survival in this locality.

THE BENTS BASIN POPULATION

Site description

The main stand of *Eucalyptus benthamii* at Bents Basin is confined to parts of a sandy ridge between the Nepean River and a normally dry flood channel, and to the western riverbank (33° 05′S, 150° 38′E). The stand on the sandy ridge is dominated

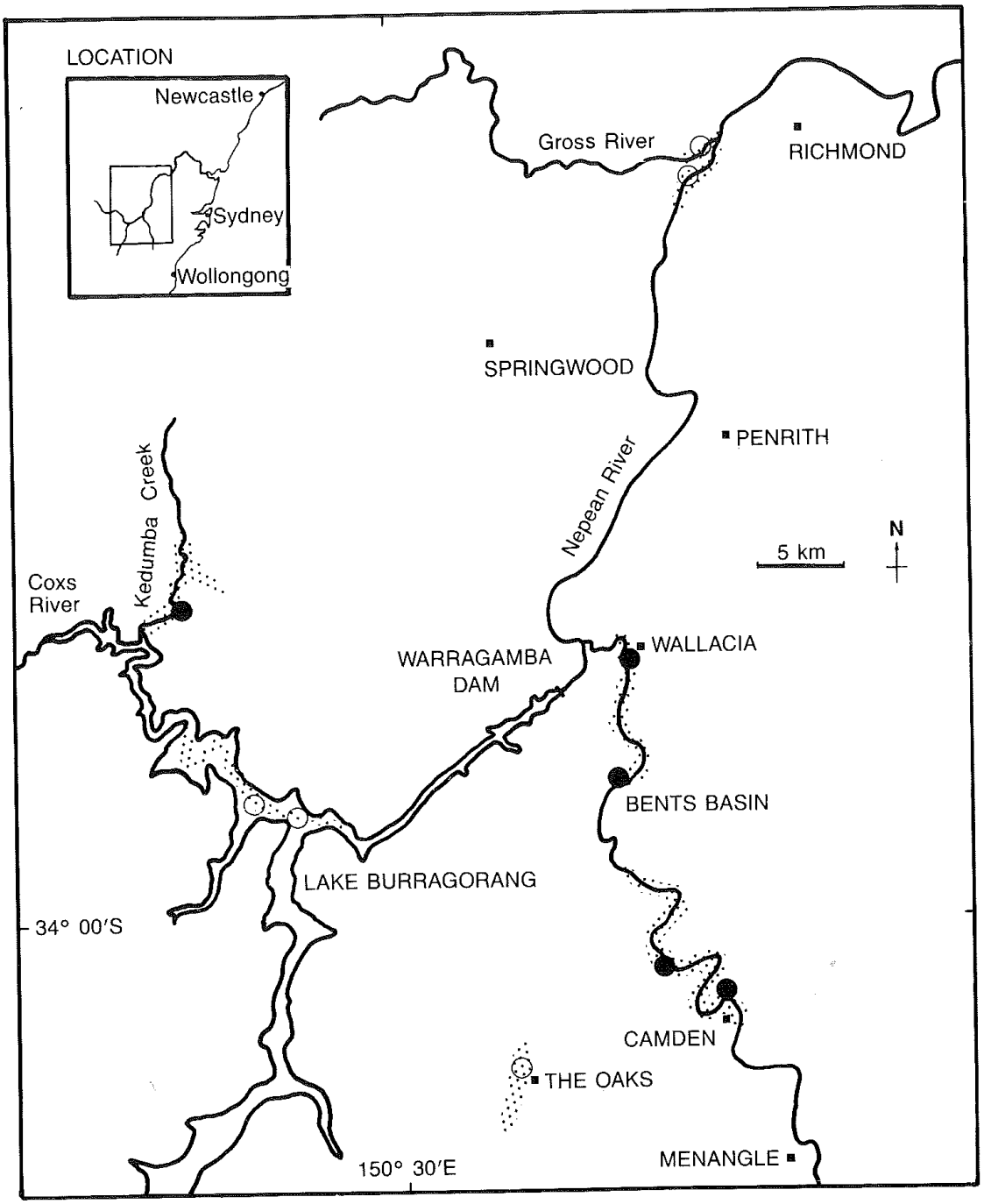


Figure 1. Presumed original distribution of *Eucalyptus benthamii* (dotted). Collection sites for herbarium specimens where the species still exists (●) or is now extinct (○) are shown.

by large, old trees up to 40 m high with stem diameters up to 1.5 m (Figure 2). After 1964 and prior to 1979, there was a tall shrub layer of *Acacia binervia* (formerly known as *A. glaucescens*) and a ground cover of smaller shrubs, many of which were exotic weed species. The *E. benthamii* trees on the riverbank are generally much smaller than those on the sandy ridge. A fire in 1979 severely affected the large trees on the sandy ridge, scorching the crowns of many and killing the *Acacia* shrub layer. The riverbank trees were not affected by that fire but were subsequently burnt by a hot ground fire in 1981.

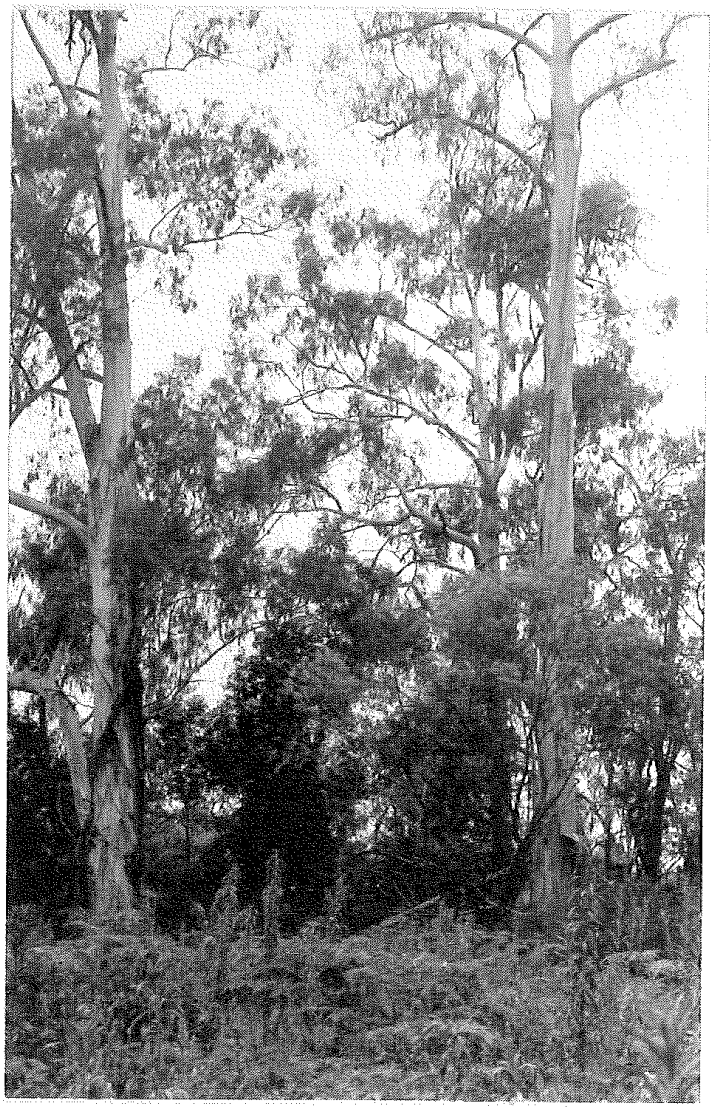


Figure 2. Large old trees of *Eucalyptus benthamii* prior to the 1979 fire.

Methods

Population number and size classes, phenology, and flood and fire patterns were examined. All individuals of *E. benthamii* were measured (diameter at breast height), including specimens of known age. Flowering and fruiting times (phenology) were recorded from specimens held at the National Herbarium of New South Wales and noted in the field. Shortly after the 1979 fire, a 200 × 10 m transect was run along the sandy ridge through the *E. benthamii* stand. Stems (>5 cm d.b.h.) of all species were measured. Soil was augered at 30 m intervals along the 200 m transect and depth, texture, colour and pH were recorded.

Data on past flood heights at Wallacia and Camden were obtained from the Metropolitan Water Sewerage and Drainage Board. Observations on flood and fire patterns since 1933 were given by a local resident, Mr R.S. Venables.

Population size and age

The present population at Bents Basin is of about 100 individuals, most of which are single-stemmed trees although some have two or three main stems. Stem diameter/frequency classes are shown in Figure 3a. Most of the dead stems resulted

from the 1979 fire and, as the measuring was done soon after the fire, these data may be included with the data from the living trees to give a picture of the stand structure prior to the fire. Two peaks are indicated in Figure 3a, a major peak for the 11–30 cm d.b.h. class and a peak for 80–110 cm d.b.h. The diameter size classes are also shown for two groups of trees from the riverbank, known to have grown following coppicing in 1945 (Figure 3b) and after flooding in 1964 (Figure 3c), respectively (R.S. Venables, pers. comm.). Comparison of these data suggests that the first peak in Figure 3a may be related to tree establishment after the 1964 flood.

Maiden & Cambage (1914) in their description of the species include references to trees up to 180 cm d.b.h., sizes commensurate with the largest trees present today. Herbarium notes for collections at the National Herbarium, other than those at Bents Basin, refer to smaller trees. A number of collections have no information. (There may be a bias towards collecting specimens from smaller trees because of easier accessibility.) The large trees at Bents Basin have remained largely unchanged since the 1880s (pers. comm. of old resident to R.S. Venables in 1930s), though the canopies of some are now deteriorating, hastened by the recent fire.

Phenology

Buds are found on some trees at any time of the year except February. Flowering takes place in April–May and mature fruit has been collected between April and June, and October and December. Flowering and fruiting abundance seems to vary considerably between individuals. Freshly collected seed has good viability. Under natural conditions, young trees 5 m high, and probably only 6 to 10 years old, may produce mature seed capsules.

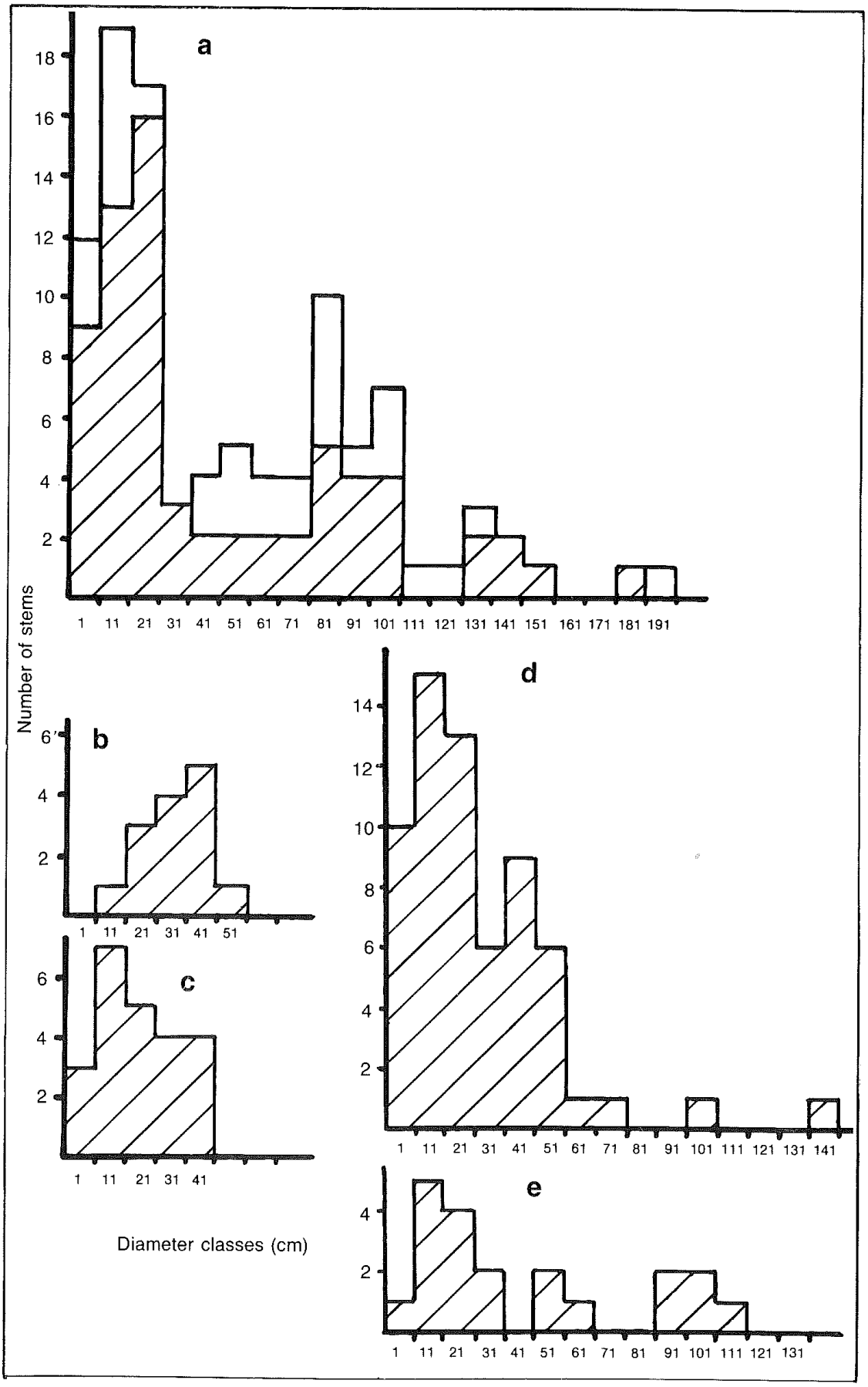
Associated species

Native. Table 1 lists species associated with *Eucalyptus benthamii.* The main tree species is the quick-growing riparian *E. elata* (River Peppermint), which grows to about half the size of *E. benthamii.* Tree species that occur sporadically are *Angophora subvelutina, Eucalyptus saligna, E. tereticornis* and *E. baueriana;* these tend to be more abundant on alluvium further from the river.

In 1977 the understorey associated with the *E. benthamii* on the sandy ridge included tall shrubs of *Acacia binervia* and *A. floribunda* (8 to 10 m high) and smaller shrubs such as *Breynia oblongifolia* and *Hymenanthera dentata* (Benson, 1977). Ground cover was discontinuous with patches of *Lomandra longifolia, Pteridium esculentum* and *Cynodon dactylon.* Weed species, including *Olea africana* and *Tradescantia albiflora* were frequent. On the western end of the sandy ridge was scrub of *Acacia binervia* and *A. floribunda.*

The 1979 fire destroyed most of the above ground vegetation, though by February 1980 regeneration by seedlings and resprouting from burnt plants was evident. Of the tall shrubs, only *Acacia binervia* was killed by fire. *Acacia floribunda, A. parramattensis, Hymenanthera dentata* and *Breynia oblongifolia* resprouted from the stem base or suckered from roots. Unfortunately, no quantitative data are available for pre-fire conditions, except the dead stem densities of *A. binervia* recorded after the fire. Stems of *A. binervia* within the *E. benthamii* stand are thicker than those restricted to the scrub ($p < .001$). The smaller stems established from seed

Figure 3. Stem diameter/frequency classes for *Eucalyptus benthamii* (living plants hatched, dead plants unhatched). Populations from a) Bents Basin sandy ridge, b) Bents Basin riverbank coppiced 1945, c) Bents Basin riverbank regeneration 1964, d) and e) Kedumba Creek (two stands). (Vertical axis is number of stems, horizontal axis is diameter class in cm.)


a
b
c
d
e
Number of stems
Diameter classes (cm)
1 11 21 31 41 51 61 71 81 91 101 111 121 131 141 151 161 171 181 191
1 11 21 31 41 51
1 11 21 31 41
1 11 21 31 41 51 61 71 81 91 101 111 121 131 141
1 11 21 31 41 51 61 71 81 91 101 111 121 131

after the 1964 flood. Establishment was also noted after the 1949 flood. (R.S. Venables, pers. comm.). *Acacia binervia* also establishes after fire, and prolific germination followed the 1979 fire. It is likely that the larger stems germinated after the 1957 fire.

Exotic. Exotic species are a major component of the understorey associated with *E. benthamii.* Of the 36 recorded (Table 1), about two-thirds are cosmopolitan weeds (predominantly annuals or short-lived perennials of agricultural situations, disturbed ground, roadsides, etc.) and a third are garden exotics (commonly perennials, often woody shrubs) with the ability to invade relatively undisturbed bushland. Both types respond vigorously to increases in available nutrients.

TABLE 1

Native and exotic species associated with *Eucalyptus benthamii* at Bents Basin, Wallacia. Exotic species of garden escape (G) or agricultural/cosmopolitan origin (A) are indicated.

PTERIDOPHYTES
ADIANTACEAE
Adiantum aethiopicum
DENNSTAEDTIACEAE
Pteridium esculentum

DICOTYLEDONS
ACERACEAE
**Acer negundo* G
ASCLEPIADACEAE
**Araujia hortorum* G
ASTERACEAE
**Bidens pilosa* A
**Bidens subalternata* A
Calotis dentex
**Chondrilla juncea* A
**Conyza albida* A
**Gnaphalium sphaericum* A
**Hypochaeris radicata* A
Senecio hispidulus
**Senecio mikanioides* A
**Tagetes minuta* A
**Xanthium chinense* A
APIACEAE
**Foeniculum vulgare* G
BORAGINACEAE
Cynoglossum australe
Ehretia acuminata
BRASSICACEAE
**Rapistrum rugosum* G
CACTACEAE
**Opuntia* sp. G
CAMPANULACEAE
Wahlenbergia gracilis
CARYOPHYLLACEAE
Polycarpum tetraphyllum
Stellaria flaccida
**Stellaria media* A
CHENOPODIACEAE
Chenopodium ambrosioides
**Chenopodium carinatum* A
Einadia hastata
CYPERACEAE
Gahnia sp.
EUPHORBIACEAE
Breynia oblongifolia
Phyllanthus gasstroemii
FABACEAE
Acacia binervia (Mimosoideae)
Acacia floribunda (Mimosoideae)
Acacia obtusifolia (Mimosoideae)
Acacia parramattensis (Mimosoideae)
**Gleditsia triacanthos* (Caesalpinioideae) G
Glycine sp. (Faboideae)
Kennedia rubicunda (Faboideae)
LOBELIACEAE
Pratia purpurescens
MALVACEAE
**Modiola caroliniana* A
Sida rhombifolia
MELIACEAE
Melia azedarach var. *australasica*
MENISPERMACEAE
Stephania japonica var. *discolor*
MYRTACEAE
Angophora subvelutina
Backhousia myrtifolia
Eucalyptus benthamii
Eucalyptus elata
OLEACEAE
**Ligustrum sinense* G
**Olea africana* G
PASSIFLORACEAE
Passiflora herbertiana
**Passiflora subpeltata* G
PITTOSPORACEAE
Bursaria spinosa
Hymenanthera dentata
Pittosporum revolutum
POLYGONACEAE
**Acetosa sagittata* A
**Acetosa vulgaris* A
Rumex brownii
**Rumex crispus* A
RANUNCULACEAE
Clematis aristata
RUTACEAE
Eriostemon myoporoides
SANTALACEAE
Santalum obtusifolium
SCROPHULARIACEAE
**Verbascum virgatum* A
Veronica plebeia

SOLANACEAE
**Datura stramonium* A
**Solanum gracilius* A
**Solanum nigrum* A
**Solanum prinophyllum* A
**Solanum pseudocapsicum* A
STERCULIACEAE
Brachychiton populneum
URTICACEAE
Urtica incisa
VERBENACEAE
Clerodendron tomentosum
VITACEAE
Cayratia clematidea

MONOCOTYLEDONS

ASPARAGACEAE
**Asparagus officinalis* G
**Myrsiphyllum asparagoides* G
COMMELINACEAE
Commelina cyanea
**Tradescantia albiflora* G
DIANELLACEAE
Dianella laevis
LOMANDRACEAE
Lomandra longifolia
PHILESIACEAE
Geitonoplesium cymosum
POACEAE
**Bromus unioloides* A
**Cynodon dactylon* A
Echinochloa sp.
Entolasia marginata
Microlaena stipoides
Oplismenus aemulus
Paspalidium sp.
**Setaria geniculata* var. *pauciseta* A

TABLE 2

Dates and heights of major floods on Nepean River at Menangle (1806–1900) and Wallacia since 1870

Date of flood		Height above standard datum (m)	
Year	Month	Menangle	Wallacia
1806	August	69.4	—
1864	June	75.9	—
1873	February	77.9	47.0
1891	June	72.9	—
1892	September	72.2	—
1893	January	71.4	—
1894	March	71.9	—
1895	February	74.5	—
1897	June	72.7	—
1898	February	77.0	—
1899	July	71.3	—
1900	July	75.1	42.4
1925	June	—	37.2
1949	June	—	38.4
1952	July	—	36.9
1956	February	—	38.1
1961	November	—	41.5
1964	June	—	44.2
1975	June	—	38.7
1978	March	—	42.4

Flood patterns, soil and effects on germination

Table 2 gives the height and date (year and month) of the highest recorded floods. Floods may occur at almost any season, though they are most frequent in June–July.

The sandy ridge is at least 2 m deep and underlain by red clay deposits that are exposed along the eastern bank of the river and at the south-eastern side of the sandy bank. Much of the sand is reported to have been deposited during a succession of floods in 1949 (R.S. Venables, pers. comm.). In general, a big flood fills the river with sand, and small floods scour it out. The frequency of small floods has decreased since 1933 when Nepean Dam was completed, resulting in a build-up of driftwood and sand (R.S. Venables, pers. comm.).

Seedlings of *E. benthamii* have been observed to germinate only once since 1933, in the silt deposited by the 1964 flood (R.S. Venables, pers. comm.). Whilst the

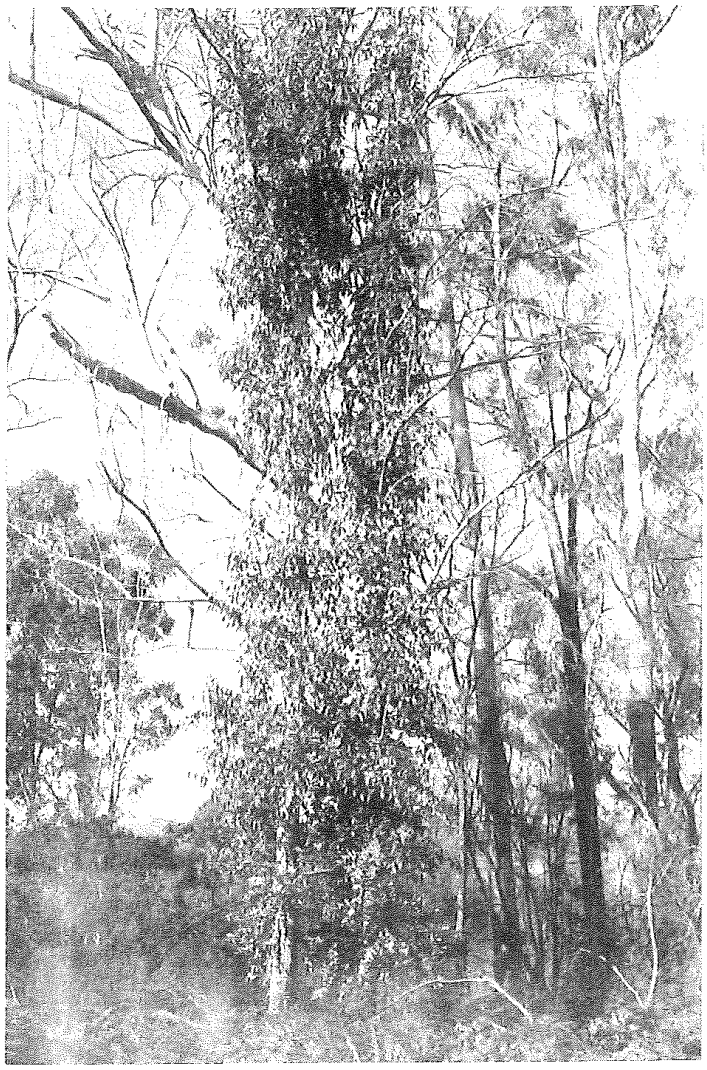


Figure 4. Burnt small tree of *E. benthamii* with regenerating epicormic foliage. Unburnt tree in background.

Figure 5. Large burnt stump of *E. benthamii* (centre) with resprouting shoots (right). Main trunk has collapsed (left) following the fire.

1964 flood was the second highest on record (the highest was in 1873), there have been a number of floods that would have flooded the bases of most of the present population of *E. benthamii,* and therefore at least have given possible conditions for germination.

Fire patterns and effect on *E. benthamii*

Since 1933, three fires have affected the *E. benthamii* population; a small creeping fire in December 1957, a major hot fire in December 1979 and a hot ground fire in October 1981, the last two burning different parts of the population (R.S. Venables, pers. comm.).

The intensity of the 1979 fire was high, causing crown scorching in some of the large 40-m-high trees. Mature *E. benthamii* reacts to fire by producing epicormic shoots along the trunk and major branches and/or resprouting from the base of the trunk (Figures 4, 5). Small stems less than 20 cm d.b.h. may be killed by fire, while stems larger than 10 to 20 cm d.b.h. may produce epicormic shoots that grow to re-form the canopy. In 1979, some trees of all sizes were killed outright and the ultimate recovery of some of the large old trees, although showing epicormics at first, is unlikely. Old stumps, however, may resprout. One had a ring of six sucker stems with diameters ranging from 9 to 23 cm, all but one of which were killed by the 1979 fire. Suckers from old stumps have the ability to reach tree size. One coppice or sucker stem that had grown from an old stump (150 cm diameter) was 32 m high with a 54 cm diameter. Fire had weakened it at its junction with the old stem and caused its collapse. The original main stem, also lying on the ground, had been 40 to 45 m high. A nearby stump had a sucker stem with a diameter of 145 cm and a height of 43 m. This stem was leaning and appeared susceptible to future fire damage at the base. It collapsed four years later, possibly during a storm. The theoretical immortality of a series of sucker stems from a damaged stump appears to be limited by the cumulative damage to the base caused by recurring fire (Figure 6).

Fire does not appear to stimulate seedling establishment as it does in *Acacia binervia.* Only one seedling of *E. benthamii* appeared to establish after the 1979 fire, but after reaching about 10 cm in height, it was lost within two years in a rapidly growing thicket of 2 m high *Acacia binervia.*

THE KEDUMBA POPULATION

The population of *E. benthamii* at Kedumba is several times larger than that at Bents Basin and consists of stands of trees up to 30 m high, almost all single-stemmed and generally looking younger than those at Bents Basin. There is the general impression of a number of groups of even-aged trees though this is not as marked as at Bents Basin (Figure 3d, e). The stands of *E. benthamii* are almost pure with only occasional trees of *E. deanei* (Deane's Gum). Ground cover is grassy and open with patches of *Imperata cylindrica* and occasional shrubs such as *Leptospermum flavescens.* With the exception of a few agricultural/cosmopolitan species there are virtually no exotic weeds. Stands occur above the top water-storage level in Lake Burragorang and appear to have been unaffected by the construction of Warragamba Dam. There are no indications of recent floods in Kedumba Creek nor any recent evidence of bushfire; the only burn marks noted suggested a light fire many years ago. The relative absence of fire may be related to the Water Board Catchment prohibitions on access. Adjacent land has been cleared and used for grazing and there is a vigorous stand of young saplings of *E. benthamii* on sandy loam exposed during recent clearing by bulldozer, amongst some of the large *E. benthamii* trees. As the best known stands here are on private property, protection of these from clearing should be a matter of major concern.

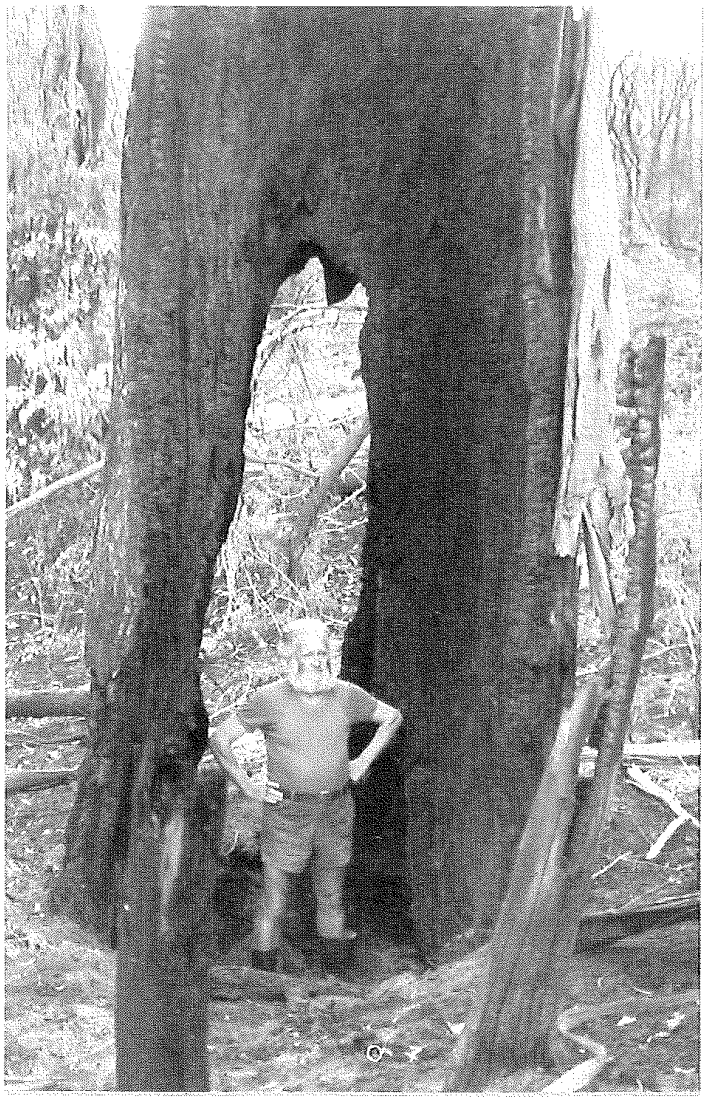


Figure 6. Hollow base of large tree showing cumulative fire damage. Such trees are susceptible to storm damage. Figure is R.S. Venables.

ECOLOGY AND MANAGEMENT OF *EUCALYPTUS BENTHAMII* AT BENTS BASIN

At Bents Basin the ecology of *E. benthamii* involves cycles of flood and fire. The species appears to have a life expectancy as a tall single-stemmed tree of possibly over 150 years, after which, weakened at the base by fire, it may collapse, to regrow a coppice stem that may survive for another 100 years or so (Figure 7). Growth of further stems may be possible, giving the individual plant a life of at least 250 years and possibly more. Other *Eucalyptus* species such as *Eucalyptus regnans* (Mountain Ash), a fire-sensitive tree species, may live for 300 to 400 years (Ashton, 1981).

The population at Bents Basin appears to consist of individuals from two or possibly three recruitment periods. The most recent followed a flood in 1964, and it is likely that the other periods were associated with major floods early last century. For management purposes, the evidence suggests that the need for establishment of more trees might not be expected until after the year 2050, and that current management should aim to protect the young 1964 trees, which should survive until then. In contrast, individuals of the associated but shorter lived *Eucalyptus elata,* which came up as seedlings in 1940, are now dying.

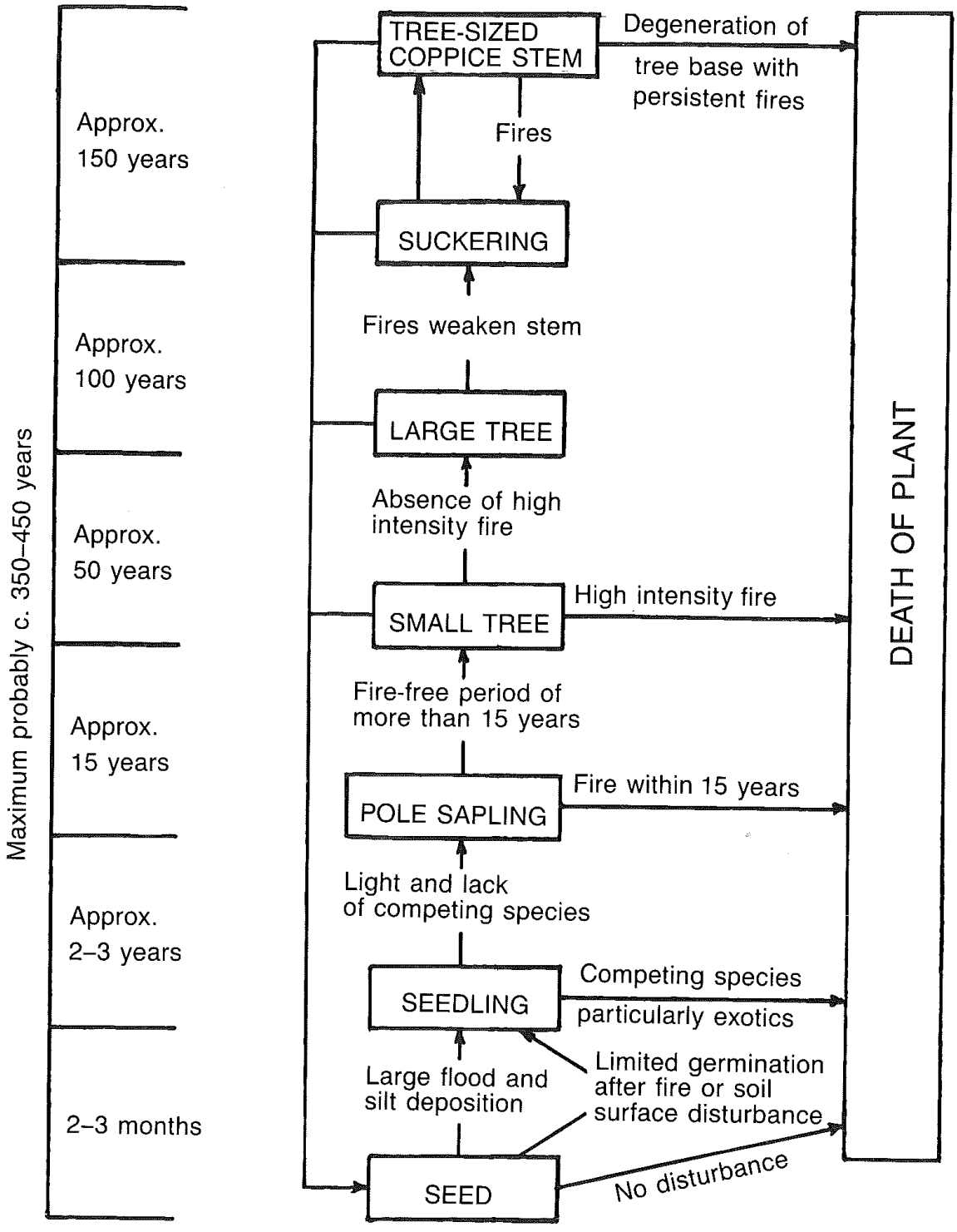


Figure 7. Postulated life expectancy of *Eucalyptus benthamii* individual.

However, conditions have changed since 1900. The upper Nepean water storage dams, Cataract (completed 1907), Cordeaux (1926), Avon (1927) and Nepean (1935), have altered flood patterns and the amount of driftwood and debris piled up against the trunks of large trees has increased. This renders the trees more susceptible to bushfire damage as it increases the localized fire intensity at their bases; this in turn makes them more liable to subsequent collapse during storms.

The nutrient levels in sediment deposited by floods also appear to have changed. More fertilizer has been used for agriculture, and urban development, particularly near Camden, has expanded. The higher nutrient levels at Bents Basin are indicated by the abundance of exotic weeds (40 per cent of total species recorded). Agricultural weeds have probably been present for at least a century but there are also a number of exotics that would have originally been introduced to the Camden area as garden plants. Extensive gardens were developed around Camden last century (e.g. that of Sir William Macarthur at "Camden Park" and Sir William Macleay's "Brownlow Hill") and a great variety of exotic species were grown. The presence of exotic weed species such as *Ligustrum sinense* and *Araujia hortorum* poses a long-term threat as they tend to form a denser cover than the native species and prevent the establishment of the light-sensitive eucalypt seedlings.

The data from Kedumba indicate that regeneration of *E. benthamii* may occur following surface soil disturbance and be very successful where competition from other species is limited. Such regeneration has not been noted at Bents Basin.

The future for *E. benthamii* at Bents Basin appears to depend on the young trees that regenerated after the 1964 flood and that, provided they remain healthy, appear to have the potential to live for up to 200 years (Figure 8). At some time during that period it is likely that flood conditions will be suitable for the recruitment of another group of seedlings though these may have to be protected from competition by exotic species. The immediate threats to the young (1964) trees are land clearance (as some are in private ownership) and fire. The first may be best overcome by addition to the

Figure 8. Stand of young trees of *E. benthamii* that germinated after the 1964 flood.

Bents Basin State Recreation Area, although the survival of the present population so far has been due to the special protection given to them by the landowner. It would be best to protect the stand from fire for at least 40 years and to remove flood debris from around the bases of individual trees to decrease potential damage from an unplanned fire.

ACKNOWLEDGMENTS

I wish to thank Mr R.S. Venables whose astute observations on the changing nature of the bushland at Bents Basin inspired this paper and without whose foresight and determination many of the trees would not have survived, Helen Bryant for her cheerful help in collecting the data, David Keith for preparation of the diagrams, and the Metropolitan Water Sewerage and Drainage Board for flood height data and access to catchment areas.

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