THE ECOLOGICAL BIOGEOGRAPHY

OF *CALLITRIS* VENT.

IN TASMANIA

by

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Submitted in fulfilment of the
requirements

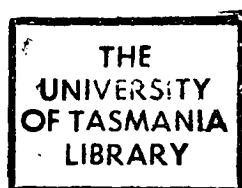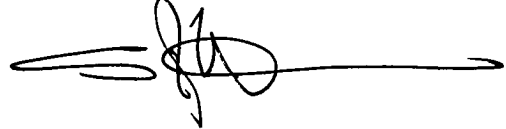for the degree of

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ABSTRACT

Callitris rhomboidea and *Callitris oblonga* have a parapatric distribution in Eastern Tasmania. *C.rhomboidea* occurs on the East Coast and *C.oblonga* is mainly confined to a few coastal and inland river valleys between Launceston and the East Coast.

C.rhomboidea is capable of continuous gap-phase regeneration. Natural stands are often multi-aged but even-aged cohorts often reflect burning. *C.oblonga* regenerates after fire or after mechanical damage to cone bearing branches (usually during floods). It is therefore an episodic regenerator which does not appear to regenerate continuously in the absence of exogenous disturbance.

The two species are ecologically differentiated by frost tolerance, waterlogging and shade tolerance. *C.oblonga* is more tolerant of frost and waterlogging but *C.rhomboidea* still occupies a very wide ecological amplitude, although it possibly has a competitive advantage on the driest sites. *C.oblonga* is well adapted to a riparian and floodplain niche, a distribution which is reinforced by the higher fire frequency in non riparian habitats. Hybrids between the two taxa are rare because timing of their peak pollen release is asynchronous.

Climatically suitable areas apparently occur for both species beyond their present range but a temperature reduction during the Last Glacial may have limited *C.rhomboidea* to the east of the Eastern Tiers and *C.oblonga* to a small glacial refuge within the northern part of the Eastern Tiers. Expansion beyond these palaeogeographically determined limits has been retarded by the slow overland migration rates of both species, and by the onset of anthropogenic burning. Limited post-

glacial dispersal of *C.oblonga* has been aided by downstream spread of propagules.

An increase in fire frequency with the arrival of Aboriginal man about 30,000 years ago may have not only constrained the expansion of *Callitris* but also caused the extinction of *C.rhomboidea* in the far north east of Tasmania. A further increase in burning from the early nineteenth century, has caused a decline in the extent of *Callitris*. Frequent burning has forced *C.rhomboidea* into fire protected habitats such as cliffs, deep gullies and rocky knolls, and *C.oblonga* into areas protected by anastomosing channels, cut off meander loops or rocky benches and cliffs.

Prior to human colonisation of the "Tasmanian peninsula", *C.rhomboidea* was probably found on more xeric sites in juxtaposition with rainforest and wet sclerophyll forest on other sites. Frequent burning is hypothesised to have caused a shift in forest patterns.

C.oblonga is inadequately reserved. Management of the species should aim to protect the most upstream stands, which provide sources of propagules for downstream habitats. *C.oblonga* conservation would be helped by fire prevention, enrichment planting and weed control. *C.rhomboidea* is adequately reserved but fire frequency should be reduced throughout its range, and outlying stands, especially on islands, should be reserved and protected.

ACKNOWLEDGEMENTS

CHAPTER 1

INTRODUCTION

There have been many studies carried out on western Tasmanian conifers in recent years (for example Davies 1983, Ogden 1978, Pedley, Brown and Jarman 1980, Gibson 1986, Cullen 1987, Cullen and Kirkpatrick 1988 a,b, Brown 1989). These resulted from land use pressures on vegetation in western Tasmania, interest in vegetation dynamics in the humid and perhumid zones stimulated by Jackson's (1968) theory of ecological drift, and also the perception that Tasmania was a stronghold of Gondwanan floral elements (Barlow, 1981) symbolised by the gymnosperms (Hitchcock 1988) and enhanced by their rainforest context (Macphail 1980). The two native conifers (*Callitris rhomboidea* R.Br. ex L.C.Rich and *Callitris oblonga* L.C. Rich) peculiar to eastern Tasmania have attracted minimal attention despite equivalent claims to Gondwanan ancestry (Page and Clifford 1981). They have also suffered reductions in their ranges as a result of land uses which conflict with forest conservation.

The number of genera and species of conifers is relatively low in comparison to the angiosperms but they form the largest numbers of individuals in many regions, particularly in the northern hemisphere where they are the dominant forest trees over large areas. There is evidence that they were even more widespread (Florin 1963, Dallimore and Jackson, 1974) but have suffered from competition with angiosperms (Bond, 1989). It has been suggested that genetic senescence has prevented speciation in diverse ecological niches (Scagel et al 1968).

Callitris belongs to the Cupressaceae, the largest of 7 extant families in the Order Coniferales of the Gymnospermae. The Cupressaceae is the most bihemispherical family of any of the conifers and taxads (Florin, 1963).
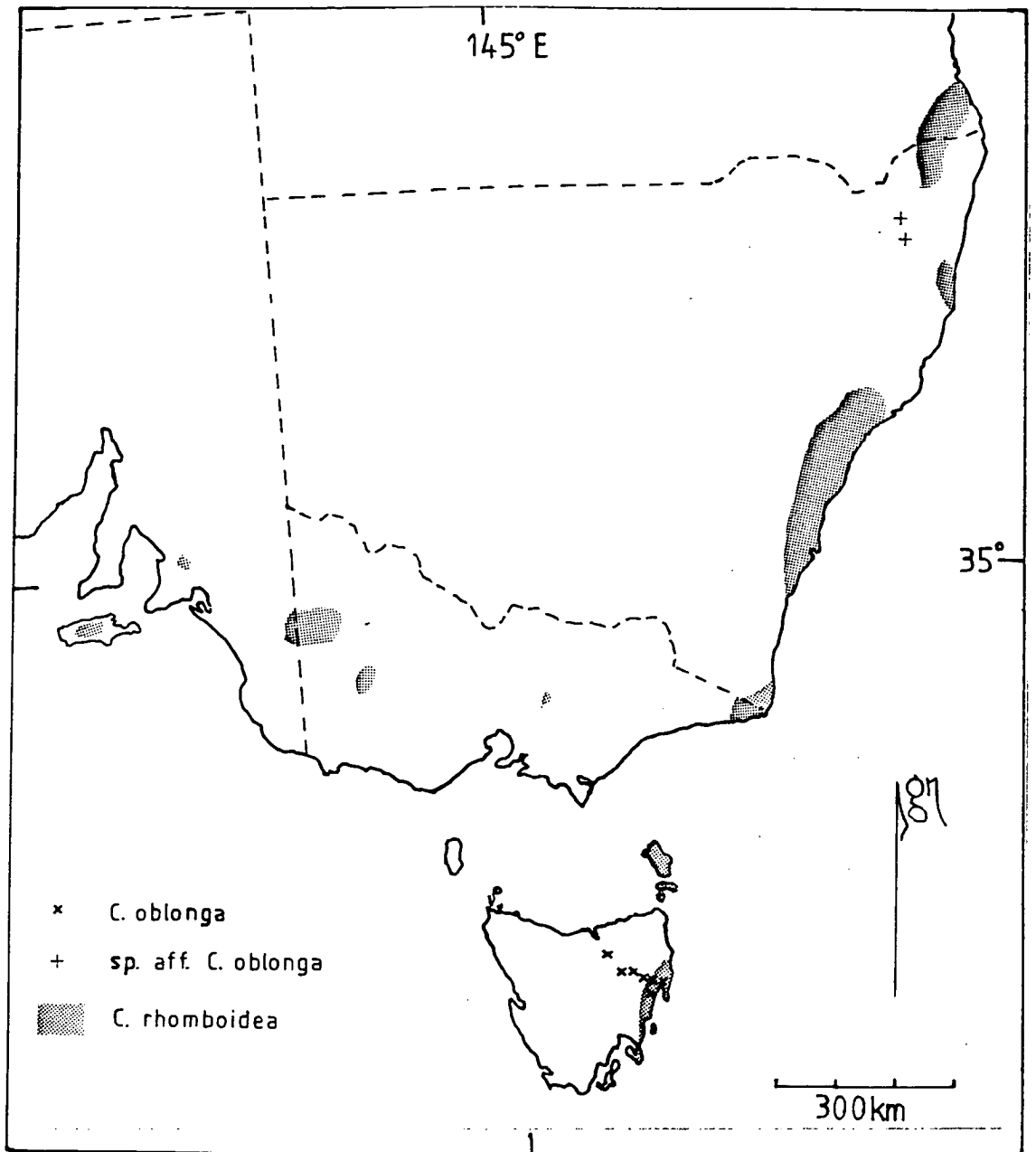
FIGURE 1.1

Generalised distributions of *C.oblonga* and *C.rhomboidea*. South Australian, NSW and Queensland distribution of *C.rhomboidea* is after Garden (1956), Victorian distribution after Adams (1985).

Callitris is confined to Australia (including Tasmania) and New Caledonia. Scagel et al. (1968) list 16 genera in the family, seven of which are monospecific. *Juniperinus* is the largest genus with 70 species, followed by *Cupressus* with about 20 species and *Callitris* with about 15 species.

The Cupressaceae have been divided into 2 sub-families (Li, 1953) comprising the northern hemisphere Cupressoideae and the southern hemisphere Callitroideae (Florin, 1963). The Callitroideae genera are: *Actinostrobus, Callitris, Diselma, Fitzroya, Neocallitropsis, Pilgerodendron* and *Widdringtonia*.

Callitris was formerly considered to have closest affinity to *Widdringtonia* (Baker and Smith, 1910), a South African genus and also a close affinity with *Neocallitropsis*. Gadek and Quinn (1985) reported the results of a chemotaxonomic survey of all genera of the sub-family Callitroideae and suggest that the closest affinity of *Callitris* is with the S.W. Western Australian genus *Actinostrobus* and the Chilean genus *Fitzroya*.

The depauperate fossil record for *Callitris* consists of material no older than Tertiary age and all fossils are found within the present range of the genus. The Cupressaceae in general have a prominent fossil record from the early Mesozoic but according to Scagel et al (1968) most genera did not become distinct until the later Cretaceous and Tertiary. Although other gymnosperms may be common in reconstructed palaeofloras (e.g. Hill and Macphail 1983), few *Callitris* fossils have been detected. This probably indicates a narrow range in the past.

Many other Australian gymnosperms such as those in the genera *Araucaria, Athrotaxis,* and *Lagarostrobos* were apparently more widespread across the Australian continent in early Tertiary times (Page and Clifford, 1981) but have since become much more restricted possibly due to changing climates. Page and Clifford suggest that with the onset of drier and cooler conditions in the Pliocene, a geographic extension and

speciation of *Callitris* occurred, which, along with many newly evolved taxa, were adapted to more xeric conditions. *Callitris* now extends across the continent and the blurred morphological distinctions at some species boundaries suggest that the genus is still speciating.

Most of the extant *Callitris* species are in southern and eastern Australia with *C. glaucophylla* (Thompson and Johnson, 1986) widespread across the continent. *Callitris oblonga* is one of the more restricted species. Fluctuating taxonomic definition makes it difficult to map distributions. The two species represented in Tasmania are confined to south eastern Australia and occur as shown in Figure 1.1.

There are some interesting disjunctions in the distribution of *Callitris rhomboidea*. Adams (1985) discusses the present distribution of the species in Victoria and speculates on the possibility of discontinuities in its range as resulting from major climatic or other change and also the intervention of Europeans. A major disjunction in the Tasmanian distribution also deserves examination.

A recent focus of attention has been the regeneration strategies of high latitude gymnosperms.

The traditional view of succession (Clements 1916) saw vegetation proceeding through a series of communities until a stable situation was reached. This stable climax vegetation was presumed to be in equilibrium with the climate. Natural catastrophes such as landslides were seen as mere perturbations interrupting an orderly progression to the climax vegetation.

It was assumed that stands of shade intolerant gymnosperms would eventually die, after which succession would proceed through a series of stages until the climax was again reached. This autogenic cycle was used to explain regeneration of shade intolerant gymnosperms. Difficulties were experienced in

interpreting mosaics in southern hemisphere rainforests containing long lived gymnosperms. Some old stands of gymnosperms had no younger cohorts while elsewhere the same species may have had thriving young regeneration (for example, Wardle 1963, 1978).

In the extensive northern hemisphere boreal forests regeneration occurs in even age stands after fire, and gap regeneration is insignificant (Lorimer, 1989). It has become evident that southern rainforest dynamics cannot be interpreted in terms of this simple succession. Workers examining regeneration strategies of rainforest trees in South America (Veblen and Ashton 1982, Veblen 1982) and New Zealand (Ogden 1985, Ogden et.al. 1987) concluded that gap phase regeneration or a mosaic regeneration or kinetic model fitted the high latitude southern gymnosperms, which occur within a mosaic pattern in the rainforest context. Gap phase regeneration relies on stochastic disturbances in the forest, which create gaps and provide opportunities for regeneration of light requiring plants. Such disturbance may include landslides, snow avalanches, volcanic activity, earthquakes or windthrow, all or some of which are common in the high latitude, high altitude environments of the many southern cool temperate rainforest gymnosperms. The model also applies to other rainforest trees such as Nothofagus (Veblen 1979). Evidence has been accumulating (Veblen 1982, Veblen and Stewart 1982, Norton 1983) to refute the suggestions of earlier workers that the gymnosperms were relicts and were declining because they were out of equilibrium with their climate (Holloway, 1954).

Cullen (1987) also set out to test this hypothesis for Athrotaxis selaginoides in Tasmanian rainforests and concluded that the species was a successful gap phase regenerator in evergreen rainforests, but nevertheless was suffering a great reduction in range due to fire. The only other ecological regeneration studies on Tasmanian gymnosperms have been for Athrotaxis cupressoides (Cullen and Kirkpatrick,

1988) *Lagarostrobos franklinii* (Pedley, Brown and Jarman, 1980, Gibson 1986) and *Phyllocladus aspleniifolius* (Read and Hill, 1988). The question of whether the gap phase or kinetic model can be extended to xeric conifers in relatively stable environments is not clear. The genus *Callitris* is atypical in habitat and distribution in comparison to the conifers of the western Tasmanian rainforest because it is widespread in xeric environments and even extends into arid conditions in inland Australia. It does occur with tropical rainforest species on ridges in the Northern Territory (Dr D Bowman, pers.comm.) and is even contiguous with cool temperate rainforest in eastern Tasmania. On the one hand, fires appear to be inimical to *Callitris* yet, on the other hand, species exist within dry sclerophyll forests where the fire frequency is high. What is the regeneration strategy of *Callitris* species under these conditions? Perhaps they are relicts which are heading for extinction.

The steep west to east precipitation gradient (long term annual average at Queenstown 2521 mm and at Swansea 614 mm) is reflected in a substantial change in Tasmania's vegetation (Kirkpatrick and Dickinson 1984). Similar steep precipitation gradients occur in the south island of New Zealand and in Patagonia. The environmental parallels are strong (Kiernan 1978). All three areas have rainforested western regions while their eastern regions have been the focus of more intense human activity. These xeric rainshadow areas have suffered higher fire frequencies (for example, Jackson 1968, Taylor 1958) and support dry sclerophyll plant communities in eastern Tasmania and predominantly grasslands and open woodlands with only remnant forest patches in south island New Zealand and Patagonia. Thomasson (1959) claims that fires and grazing may be preventing forest regeneration in the steppe country east of the Andes. Burrows and Greenland (1979) describe the pre-European destruction of *Podocarpus hallii* forests in New Zealand, and Wells (1972), working in the dry Central Otago area, found that fire rather than climate was the factor preventing regeneration of *P.hallii*. The demise of

the close *Callitris* relative in Patagonia, *Fitzroya cupressoides,* has been attributed to a high fire frequency and destruction of suitable seedling substrate (Veblen and Ashton, 1982).

A comparison of southern hemisphere xeric conifers is instructive. For example, Veblen and Lorenz (1987) examined post-fire stand development of the xeric tree *Austrocedrus chilensis* and concluded that it establishes abundantly after stand destroying fires, yet is capable also of some gap regeneration. These authors do not discuss the longer term trends which result from different fire frequencies or whether the species is expanding or contracting throughout its whole range.

Despite the much earlier separation from Gondwanaland, African conifers also provide some interesting parallels. South African workers have indicated high fire frequencies as a cause of decline in conifers of the Cupressaceae. Chapman (1961) describes the restriction of *Widdringtonia nodiflora* in Malawi to rocky situations because of high fire frequency, and Kerfoot (1964) describes the same situation for *Juniperus procera* in Zaire and Malawi. Manders (1987) describes the destruction of the range of *Widdringtonia cedarbergensis* in the rainshadow area (annual rainfall 939mm) of the Cedarberg Mountains in the southwestern Cape Province and claims that although there is strong post fire regeneration, a high anthropogenic fire frequency has caused a shift to younger age classes which have smaller seed banks and decreased recruitment to older age classes. Manders (1987) noted the high flammability of the surrounding sclerophyllous vegetation characterised by Proteaceae, Ericaceae and Restionaceae shrubs. Manders (op.cit.) also notes that: "Mature cedars suppress the surrounding vegetation and closed stands have little or no vegetation beneath them. Thus to some extent closed stands may be self protecting from fire." This leads directly to question what role fire plays in the delimitation of *Callitris* distribution in Tasmania.

The above studies suggest that an increased knowledge of the survival and regeneration mechanisms of the two Tasmanian *Callitris* species could help us to understand palaeogeographic environments and to predict future trends so that, if necessary, species conservation measures can be taken.

The Tasmanian *Callitris* species have parapatric distributions at the State level, and hybrids are extremely rare, while the western Tasmanian *Athrotaxis* species have parapatric distributions at the local level where a hybrid taxon is common (Clifford and Constantine, 1980). The scant references to Tasmanian *Callitris* in the literature (for example Harris and Kirkpatrick 1982, Kirkpatrick, Brown and Moscal, 1980, Kirkpatrick 1981, Duncan and Duncan 1984) suggest a riparian niche for *C.oblonga* and a more widespread eastern coastal distribution for *C.rhomboidea*. This suggests that climatic influences may be determining range differentiation of the two species. If they occupy different environments then their regeneration niches may differ from each other. Cullen and Kirkpatrick (1988) found *Athrotaxis selaginoides* to be more widespread in rainforests in the mountains of western Tasmania but *Athrotaxis cupressoides* to be restricted to the highest altitude areas and inter-montane valleys. This differentiation was consonant with the greater frost resistance and less shade tolerance of *Athrotaxis cupressioides*. This indicated the potential of a strong analogy between *Athrotaxis* in western Tasmania and *Callitris* in eastern Tasmania.

This study is an exploratory examination of the ecology and biogeography of *Callitris rhomboidea* and *C.oblonga* in Tasmania and attempts to:

(i)   determine the environmental correlates of species distribution and, particularly, assess the impact on possible distribution of palaeoenvironmental conditions;

(ii)   explain the extent to which fire has constrained the distribution of the two species; and

(iii) examine whether the two species distributions are differentiated according to climatic factors, regeneration niches, or by environmental factors such as soils, aspect, geology and topography.

This study commences in Chapter 2 with an examination of some phenological and morphological characteristics of *C.rhomboidea* and *C.oblonga* which may have relevance to the aims of the study. This is followed by a discussion of the present and past distribution of both species in Tasmania (Chapter 3). Stand structures and regeneration strategies are examined in Chapter 4. In Chapter 5 the *Callitris* plant communities and their habitats are discussed, as is the role of environmental factors in limiting distributions, or differentiating between the habitats of the two species. The focus in Chapter 6 is then placed on two important variables — climate and fire. Chapter 7 integrates all facets of the study in the context of the above aims.

CHAPTER 2

CHARACTERISTICS AND PHENOLOGY OF
CALLITRIS RHOMBOIDEA AND *CALLITRIS OBLONGA*

2.1 COMPARATIVE PHENOLOGY AND MORPHOLOGY OF
C. RHOMBOIDEA AND *C. OBLONGA*

2.1.1 Introduction

Life history information is required to enable some understanding of the physiological strategies developed by the tree species and to help understand physical ability to compete in different niches. The relative advantages of r and K strategies has been discussed by Harper (1977) who points out that most trees tend towards K selection because a trunk is the ultimate manifestation of such. Phenological information about a tree should be examined before deciding how close the species should be placed towards the K end of the spectrum.

There has been limited attention paid to the life histories of *Callitris* spp. since the early work of Saxton (1910, 1913) and Doyle (1940). The most definitive work was that of Baird (1953) who included *C. rhomboidea* in a general examination of *Callitris* life history and observed that "the genus has been well covered and it is unlikely that species not investigated would show any significant differences" (p. 259).

No life history data whatsoever has been published for *C. oblonga*. It was considered important to document the broad phenological characteristics of the two Tasmanian species which could at least corroborate Baird's view and hopefully add some further knowledge relevant to the major research questions posed in chapter one.

2.1.2 Methods
Phenology
1. Phenological observations were carried out during floristic and environmental sampling within 100m2 quadrats throughout the range of *C.oblonga* and *C.rhomboidea*.

Sampling was arranged so that if possible, at least one quadrat fell within each 10 km2 cell across the range of the taxa, however not all 10 km2 cells could be sampled. Field work for quadrat sampling variously took place between October and March in the summers of 1986/87, 1987/88 and 1988/89. A more detailed description of the quadrat sampling methods is found in Chapter 5.

Phenological observations were also made throughout all seasons on trees of both species in the field.

2. Cone bearing trees were examined to visually assess approximate proportions of opened/unopened cones on a tree.

3. The number of cones on a *C.rhomboidea* of 16.6 m height with a diameter at breast height of 50 cm was estimated on a fallen individual at Lisdillon in the following manner. Eight smaller order branches were selected as a representative sample from the 121 similar order branches on the tree and the cones counted. The total number on the tree was then estimated by extrapolation. This figure was then used to estimate the potential yield of seed if a fire killed a hypothetical stand of 16 trees of such size.

Foliage, cone and amenta characteristics

1. A binocular dissecting microscope was used to investigate the nature of the male amenta and pollen sacs.

2. From all quadrats, at least 20 specimens each of foliage, female cones and male amenta were collected from at least 5 different trees and immediately placed in plastic bags. On return from the field, measurements on an indicative sample (usually at least 20) were made of the length of leaf, the length of male amenta, whether male amenta were borne singly, or the number in clusters and whether male amenta were terminal or axillary. These were among

characters suggested by Venning (1978) as being useful characters in discriminating between species.

The leaf measurements were made by measuring the visible length of decurrent leaves near the ends of branchlets but back from the growing tips. Measurements were made to the nearest 0.5mm using a ruler graduated in mm. Female cones were placed in numbered paper envelopes and stored to await opening. Once opened, a selection of 18 cones of each species was chosen randomly from different quadrats and the seeds were counted on a tray. The cones and seed were stored for further analysis.

Germination

1. To test viability and germination rate, cones were collected from Honeymoon Bay, Freycinet Peninsula (*C.rhomboidea*) and the Lower Apsley River *(C.oblonga)* on 11 December 1982. Cones were placed in numbered paper bags and dry stored during which time seed was released. After 135 weeks, sixty seeds of each species were placed on filter paper moistened with distilled water in 8 petri dishes, with 15 seeds per dish. The dishes were kept at room temperature (estimated as diurnally fluctuating between ±12°C and ±23°C but averaging ±18°C) and emergence of radicles scored daily.

2. For *C.oblonga*. The germination rate of *C.oblonga* was tested again on seed collected from the Grange Road population. The cones were collected on 21 November 1983 and kept stored dry in paper bags for 61 weeks. Two hundred and five seeds were then roughly divided into 8 lots and placed in petri dishes on moist filter paper at room temperature. A cumulative score of emerging radicles was kept daily.

3. A third germination trial was held with *C.oblonga* and *C.rhomboidea* seed collected in January 1985 from Benham on the St. Pauls River *(C.oblonga)* and from Apslawn

(*C.rhomboidea*). The cones had been stored in dry conditions in numbered paper bags for 82 weeks after collection. Subsequently 4 lots of 50 seeds for each species were placed on moist filter paper in petri dishes. The dishes were immediately placed in a Sanyo controlled temperature cabinet at 10°. After 43 days the petri dishes were removed to the same room temperature regime as described above. For the duration of the experiment, the daily total of emergent radicles was recorded.

The results of the three germination trials were plotted as cumulative frequency graphs.

2.1.3 Results and Discussion
2.1.3.1 Male Cones

On *C.rhomboidea* male cones appear annually about April/May as tiny green 'buds' terminating the growing tips of some branchlets. The ends of some branchlets have dense clusters of cones while other branchlets have only sparse cones or none at all. Cones are nearly always borne singly on the tips of branchlets. Very occasionally, in the Tasmanian population, and more commonly in the Furneaux Islands population, the male cones may be axillary near the growing tips. In the latter population multiple coning occurs on the same branchlet, a feature which is rarer in the Tasmanian population. Mean length of cones is 2.09mm (s = 0.82, n = 110, min. 1mm., max 4.5mm).

On *C.oblonga*, male cones become apparent as clusters of tiny green 'buds' from about March onward. The cones occur as clusters of up to 9 but more commonly in groups of 3 to 5. The cones almost always terminate branchlets but on a small number of specimens, single cones occurred within leaf axils. The mean length of cones is 1.4mm (s=0.53, n=110, min. 0.5mm, max. 3mm) and are variously globular or oval in shape.

The development of cones is similar for both species. For example, in *C.rhomboidea* the small juvenile cones elongate and the scales grow lighter around the edges before the whole scale turns light brown. The green colour completely recedes as the brown darkens. In mid July the scales are completely brown and begin to lift. The sporangia, until this time being somewhat sticky spheres, protrude beyond the scales, dry out and open. About 35-40 sporangia occur in each cone. At this stage the pollen is readily dispersed in a slight breeze. In late July-early August the largest pulse of pollen release occurs and by early September, massive quantities of detached male cones can be found under trees. However, rapidly decreasing amounts of pollen are released until early the following year (see Figure 2.1).

By March, nearly 12 months after their appearance, the last of the male cones are detaching. Very rarely, a few spent cones persist on trees after this time.

The major difference with *C.oblonga* is that the peak of ripening is reached at the end of February when the cone scales are brown and commence opening up. Pollen release follows. There is therefore, asynchrony in pollen release between the two species. Both species though, have male cones in any stage of development at all times of the year but the asynchronous pulse of pollen release would minimise the potential for hybrids. Only one putative hybrid tree was observed, this being on the Cygnet River. This contrasts with *Athrotaxis* where reproductive phenology is synchronous and hybrids are common where the two species occur together (Cullen, 1987).

2.1.3.2 Female Cones

Female cones of *C.rhomboidea* are produced annually in clusters on the growing tips of some branches. The clusters are composed of apparent racemes of about 4 amenta on each branch. The female amentum appears about July/August and is ready for pollen reception by late August.

The young female amentum is a flower-like structure about 2 mm in diameter comprising 6 spirally arranged sporophylls ('petals') and about 21 ovules packed around the primordial columella. The sporophylls gradually thicken and close over the ovules. Flower-like amenta tend sometimes to grow from existing clusters of mature fruit and as successive pollination of these occur, the original cluster becomes larger and larger.

The female cone matures and enlarges over about 3 seasons before becoming the woody cone of mature fruit. The colour of the female cone is a rough indicator of maturity. Immature growing cones are reddish brown while mature cones are more grey brown. There is little appreciable increase in size of female cones beyond about 3 years.

Observation of embryonic development was beyond the scope of the present study but Baird (1953) reported that for *Callitris robusta* (syn. *C.verrucosa*, see Willis, 1970) the minute cones remain unchanged for a year or more before growth is resumed. Growth is then rapid to almost full size within a couple of months, fertilisation occurs and then embryos develop over about 4 months. Baird states that:

"Thus the interval between pollination and fertilisation is typically nineteen months, of which the first twelve were spent in a dormant condition and almost all the enlargement of the cone took place in the last seven months. Cones have almost, if not quite, reached their full size at fertilisation but become more woody as the seeds mature."

The amenta of *C.oblonga* are more difficult to observe on the tree than those on *C. rhomboidea* because the former tend to cluster near the growing apex of the tree.

By January the branchlets of amenta become prominent and are ready for pollen reception. The cones are small and green at first but change to light brown and then grey after at least one year. The cones form dense clusters mainly on the main vertical trunks and only occasionally on secondary branches. The fruit enlarges on the tree to a maximum length of approximately 30mm.

Female cones persist on the tree unopened until the tree or the particular stem on which they are borne, dies. The cones on *C.oblonga* form very tight clusters and often are attached to the major stems with no supporting branches evident. This arrangement of cones fits the species well for its habitat where floods carry debris which can tear pieces from the tree. The resilience of cones to mechanical damage can frequently be seen where unopened cones adhere to the upstream sides of flood worn and bruised stems.

sporophyll receptive

maturity ♂ cones — peak pollen release

J F M A M J J A S O N D

(a) C. rhomboidea

sporophyll receptive

peak pollen release

J F M A M J J A S O N D
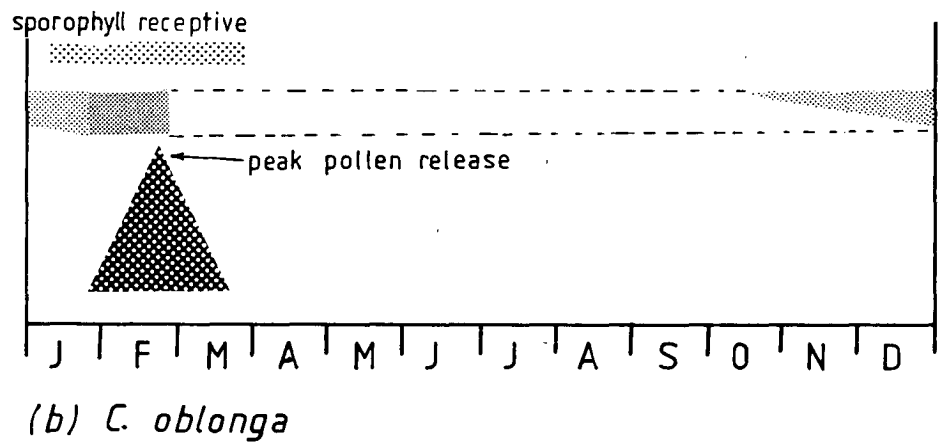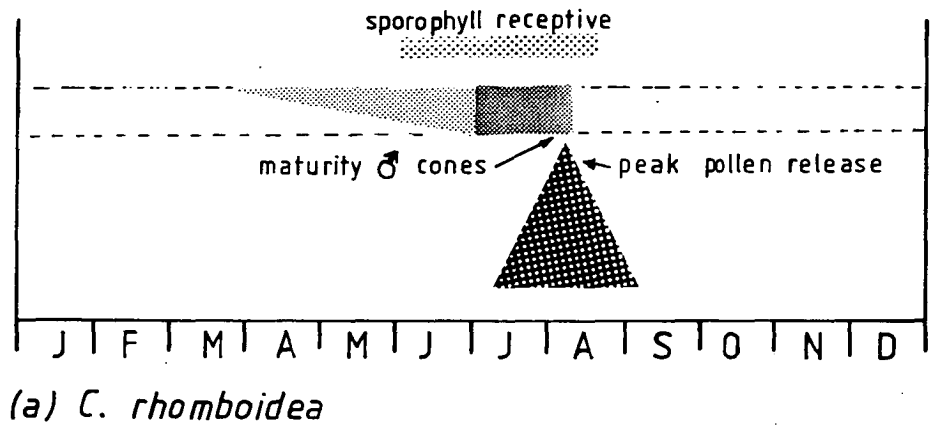
(b) C. oblonga

Figure 2·1 Schematic diagram showing timing of sporophyll receptivity, cone maturity and peak pollen release in C. oblonga and C. rhomboidea

2.1.3.3 Seed and Cone Numbers

The mean number of seeds/cone for *C.rhomboidea* is 41 (X=41.5, n=18, s=4.8). A fallen *C.rhomboidea* near Lisdillon was found to be 50cm in diameter and therefore judged to be equivalent to an age of at least 160 years (see regression of age on dbh for specimens at Cape Tourville, Figure 4.6 in Chapter 4). It had 39,000 cones. A hypothetical stand of 16 such trees if killed by fire would yield + 25.5 million seeds.

Seed release appears to be a continuous process because numerous seedlings of various ages can be observed in many undisturbed, mature stands. However, *C.rhomboidea* seeds are released en masse from female cones after a tree has been killed by fire. These seed release mechanisms account for the presence of both even and uneven-aged stands of the species (see Chapter 4). Uneven-aged stands are common.

It is uncertain what the exact triggering mechanisms are for seed release in the absence of fire. In the occasionally observed instances where large trees had been windthrown into other trees and continued living, numerous opened cones were observed. This was probably a response to physiological stress. Numerous seedlings were usually observed under such trees. On trees which have suffered no stress or injury, open cones are present but scarce and would comprise <1% of all cones. Commonly, opened cones occurred on lower branches where heat from ground fires may have been the trigger. Occasionally individual small branches on a tree may have died from various reasons including in some cases, mechanical damage caused by falling limbs from overtopping eucalypts. Where branches had died, cones had opened.

As with *C.rhomboidea*, all *C.oblonga* seed is released after a tree has been killed by fire. In the burnt portion of a stand of *C. oblonga* at Milford Hole on the St Pauls River, all dead trees had open cones but cones remained intact on live trees. In *C.oblonga* flood debris can cause mechanical damage to limbs

bearing seed cones and occasionally a dead limb on a live tree bore the tree's share of open cones. Obviously only extreme stress or death will cause seed cone opening. Seed will not fall if there has been no disturbance, lethal damage or extreme stress to any part of the tree. On trees where there had been no stress or injury, there were no open cones visible.

The mean number of seeds in each mature cone is 59 (X=58.8, n=18, s=12.1) with an average number of 'good form' seeds of 33 (a preliminary germination trial not described in this study, showed that 'poor form' seeds had a remarkably lower rate of germination compared with 'good form' seeds). A 'good form' seed is symmetrical in shape with an inflated embryo, and winged. 'Poor form' seeds are contorted in shape, relatively flat and often not winged.

2.1.3.4   Foliage

The juvenile leaves of *C.rhomboidea* are produced in whorls of 4. Leaves are linear, 8 - 12 mm long, acute and almost pungent. These give way to leaves which are almost wholly appressed to the stem for their length but sometimes having a free portion at their tip. The appressed adult leaves are 3 ranked and elongate on the stem or branch with age. Thus, depending on where on the tree the leaf length is measured, leaves may measure from 2-3 mm on the growing tips of branchlets, to >30mm in length. On foliage just back from the growing tips, i.e. on foliage at least one year old, numerous measurements from trees across their range showed that the visible portion has a mean length of 2.69 mm (n=110, s=0.88). The most distinctive aspect of the foliage of *C.oblonga* is its greyish blue-green colour.

Plate 2.1 In open forest situations, *C.rhomboidea* is a tall
symmetrical tree like the specimen in the centre of this
photograph. The shapes of trees vary widely according to
conditions of growth.

Plate 2.2 *C.oblonga* has a distinctive crown of dense bluish
grey foliage. Lateral branching is weakly developed.

Plate 2.3   These seedlings are the same age and are over 12 months old.   They show the foliage dimorphism.   *C.rhomboidea* in this photograph bears only juvenile foliage and *C.oblonga* shows juvenile and adult foliage.   Note the stronger root development in *C.oblonga*.

C. rhomboidea
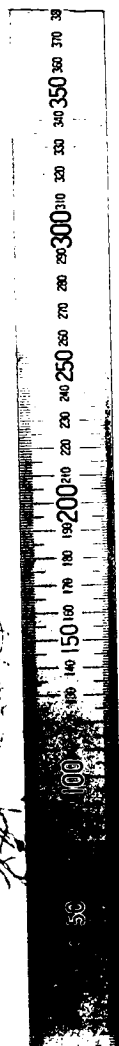
C. oblonga
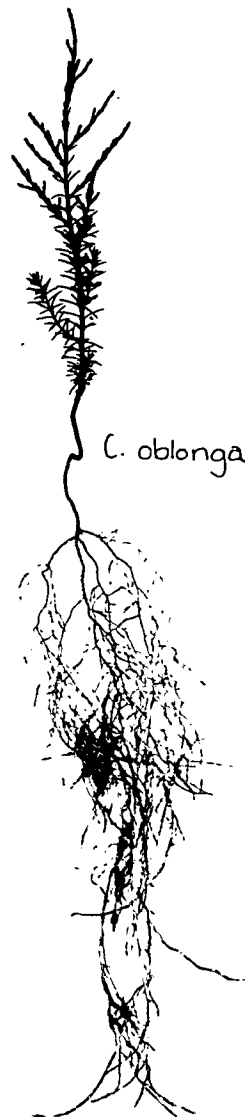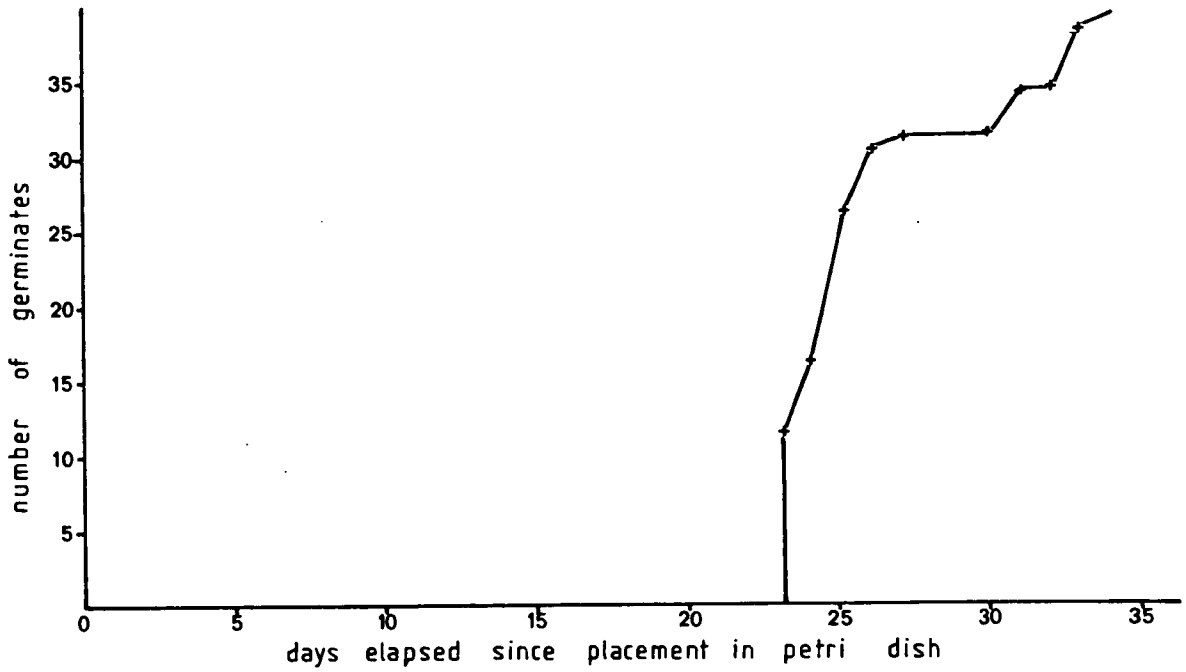
Figure 2·2   Initial   germination   rate   for   *C. oblonga*

+ *C oblonga*   ● *C rhomboidea*
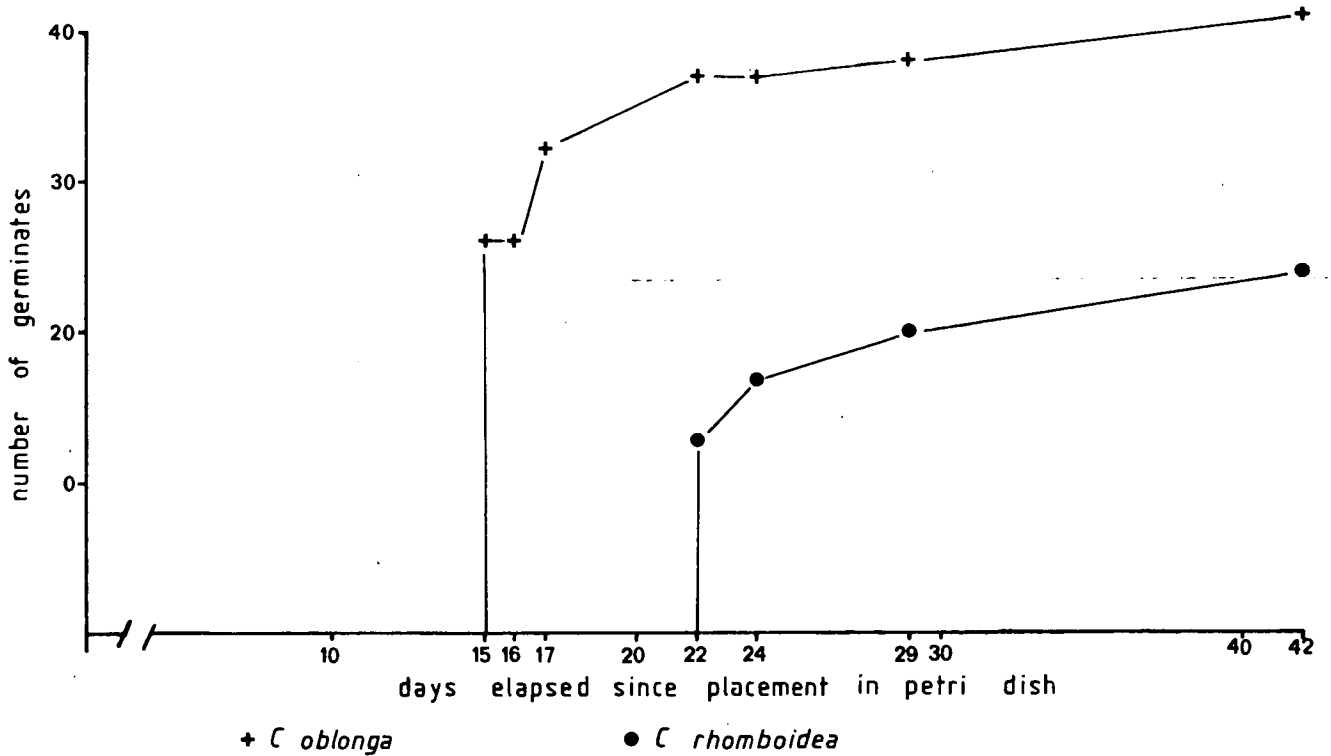
Figure 2·3   Relative   initial   germination   rates   for   *Callitris*   seed
after   storage   for   135   weeks.
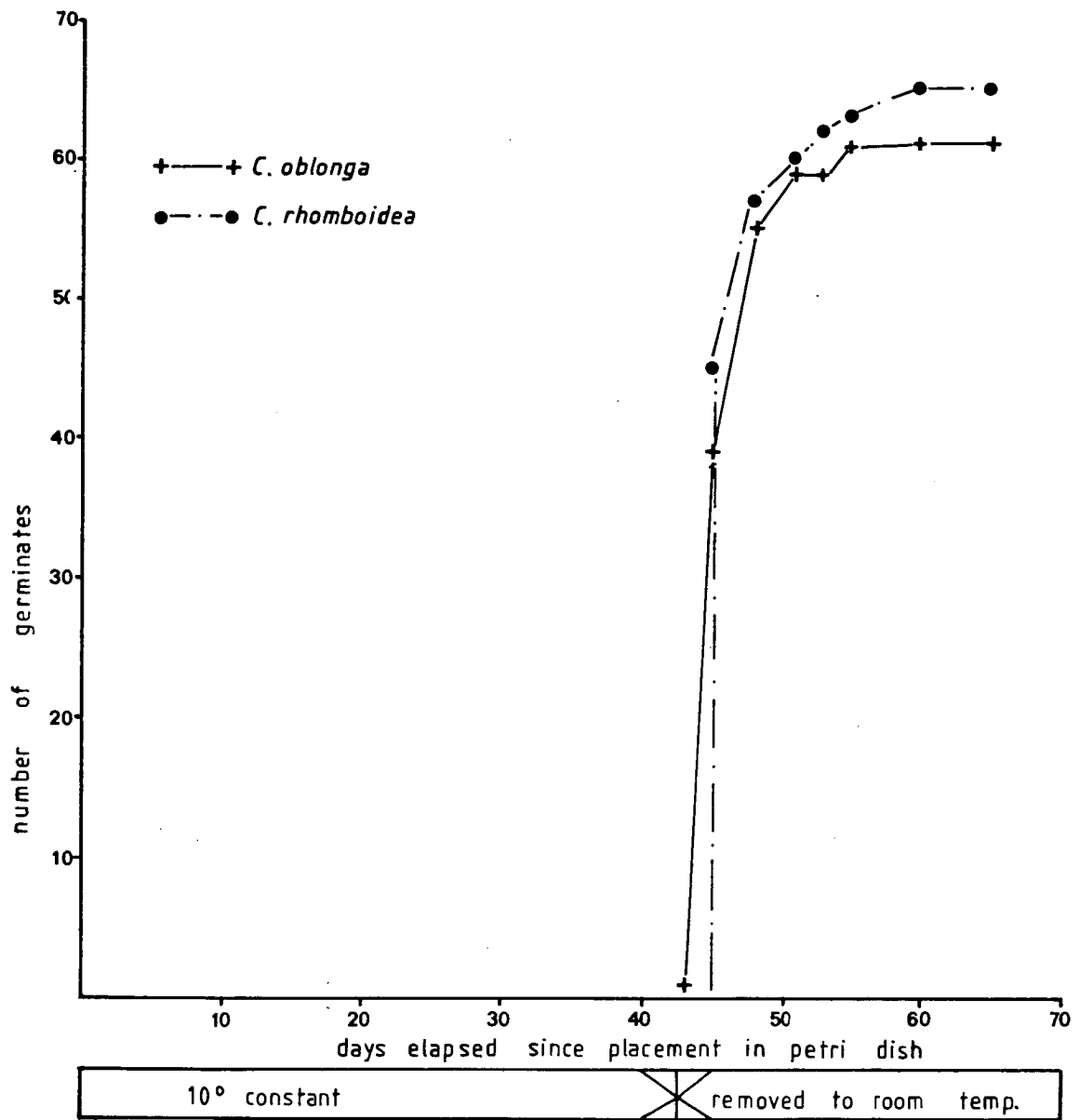
Figure 2·4 Cumulative frequency of *Callitris* germinates in relation to a changed temperature regime.

As with *C.rhomboidea, C.oblonga* has horizontally spreading acutely pointed leaves. This habit persists up to a height of around 300mm, the plant at this stage being vaguely 'prickly' when grasped by the hand. This may be an adaptation to deter grazing. Beyond the juvenile stage the leaves elongate on the stem and persist on older stems for a considerable period. The leaves are completely appressed and have a sharp point. Where leaves are measured on branchlets just back from the growing tips, their mean length is 4.66 mm (n=110, s=1.51) therefore making the leaves generally 42% longer than those of *C.rhomboidea*.

2.1.3.5 Germination and Seedings

Callitris rhomboidea seed collected at Honeymoon Bay and germinated after being stored for 135 weeks showed a viability of 41.7%.

Once the seed is moistened, germination may take place after 22 days (see figure 2.3). From the time the radicle emerges it is around 9 days before the testa is shed and the paired cotyledonary leaves become evident. The seedling then produces juvenile foliage until it attains a height of around 10 to 20 cms.

The viability of *C.oblonga* seed collected from the Lower Apsley River and germinated following storage for 135 weeks was 68%. Seed 50 weeks old germinated 23 days after wetting (see Figure 2.2), seed 78 weeks old germinated 43 days after wetting and after changing the temperature regime (see Figure 2.4), and seed 135 weeks old germinated only 15 days after wetting (see Figure 2.3).

Observations on cotyledon development showed in one (presumed typical) case, a black tipped radicle emerging and lengthening to 32 mm after 14 days, with chlorophyll pigmentation along a third of its length. The testa is shed at this point and the pair of primary cotyledonary leaves become evident. When

planted in soil the cotyledon grows to about 20 mm height by which time there is a whorl of 4 primary leaves. These brown off as rapid growth off a leafy stem occurs above, and the leafless stem below becomes brown and woody. Both species display juvenile foliage comprising leaves perpendicular to the stem. This foliage may be produced until the seedling is between 10 and 20 mm in height.

2.1.3.6 A comparitive summary of some characteristics of *C.rhomboidea* and *C.oblonga*

The most striking phenological aspect of the two Tasmanian species is the total asynchrony in timing of pollen release. The approximate 6 month separation could have helped to perpetuate the two distinct species. Interspecific fertilisation between some mainland species has been documented (Garden 1956) although Venning (1979) plays down this aspect suggesting that only a few kilometres can effectively isolate them. Interestingly a hybrid *C. rhomboidea* X *C. oblonga* was found on the banks of the Cygnet River (about 200m upstream of ford on 'Gala' property) which had the overall habit, form and glaucousness of *C.oblonga* but with female cones of *C. rhomboidea*.

Other comparisons between the two species are:

(i)   both species have distinctive juvenile foliage which may act as discouragement to browsing animals. The production of terpenes and phenolics by *Callitris* species (Baker and Smith, 1910) generally means that less resources would be available for allocation to vegetative vigour (Harper 1977) therefore the 'spinous' leaves of seedlings may be a low energy way of discouraging some predators without jeopardising early growth development. This speculation is not always supported by the field evidence of many young chewed seedlings. The foliage dimorphism might alternatively be explained as an example of ontogenetic

recapitulation (De Beer, 1938) where an embryonic or juvenile descendant resembles an adult ancestor.

(ii)   *C. rhomboidea* can exceed 30 m in height and ± 150 years in age (see Chapter 7) while *C. oblonga* has not been observed exceeding 10 m in height or ± 70 years in age;

(iii) male cones on *C. rhomboidea* mostly occur singly (except in Furneaux Group population) and terminate branchlets while a few are axillary. The male cones of *C.oblonga* occur in clusters of up to 9 branches;

(iv)   both species release seed upon death of tree of cone bearing branches;

(v)   the amount of seed in cones of the same species is similar : ± 45 (n=7) for *C.rhomboidea* and ± 52 (n=10) for *C.oblonga*;

(vi)   seeds can remain dormant in dry storage conditions for at least several years, but in the wild, the role of predators in destroying the seed is not known. Seed can be germinated after storage for 135 weeks but *C. rhomboidea* then has a lower viability (41.7%) than *C. oblonga* (68%), and initial germination was slower for *C.oblonga*.

(vii) An intriguing aspect of all the germination graphs is the step in the cumulative frequency graphs for *C. oblonga*. Each shows an initial spurt of germination followed by a short period of from 1 to 4 days with no additional germinates, followed by a second spurt of germination until a plateau is reached. By contrast, the germination graphs for *C.rhomboidea* show smooth curves. The 2 pulses of *C.oblonga* germination might represent a predator satiation mechanism. If a single crop of seedlings were produced after a fire, heavy browsing may ensue where if the predator was an insect with a short synchronous life cycle, it may not be present when the second wave of germinates were produced. In this case it may be a good strategy to produce a second wave of germinates.

(viii) The trees themselves are distinctly different. *C.oblonga* has not been observed to be taller than about 10m with a maximum observed bole diamater of 25cm. The foliage occurs in a dense narrow crown. *C.rhomboidea* varies in form much more widely according to habitat. In some forest situations in gullies, the tree is very tall, slenderly pencil like and can grow to more than 30m in height. In open situations the species develops an umbrageous appearance and old specimens were observed with a bole diameter of up to 90cm. The species can occur as a component in wind pruned low closed-heath on the coast.

CHAPTER 3

DISTRIBUTION OF *CALLITRIS RHOMBOIDEA* AND *CALLITRIS OBLONGA* AT PRESENT AND IN THE RECENT PAST

3.1 Introduction

To understand what effect natural factors such as soils and climate have on the present distributions of the two *Callitris* species, the historical effects of anthropogenic burning and clearing need to be described. Historical vegetation reconstruction can be approached in various ways using both data on present floristics and using historical records and maps (Fensham, 1989). Some elements of these approaches have been used in Chapter 6 in discussing the change away from the dominance of *Callitris* in the vegetation of the Furneaux Islands. For mainland Tasmania there may well be scope for detailed work using historical papers and maps. The purpose here however, is not a detailed historical study, but to assess evidence of the historical demise of *Callitris*.

The likely natural determinants of the broad distribution patterns are discussed in Chapter 6. The decline in the extent of *Callitris* communities through human factors is discussed in general terms in this section. The anthropogenic fire theme will be discussed again Chapter 6 (section 6.2.2.)

3.2. Methods

Present distribution

1. The range of both species was mapped during fieldwork for various botanical surveys in eastern Tasmania and the Bass Strait Islands between 1982 and 1989. Motor vehicle access was possible throughout much of the East Coast and on Flinders Island. The patches of *Callitris rhomboidea* in the Outer Furneaux Islands were mapped during a general biological survey in December 1986 in which 95 islands were landed on from a boat. Two aerial spotting flights were carried out over the mainland Tasmanian range in 1988 and 1989. Due to the scattered, fragmentary nature of

C.oblonga distribution, no attempt was made to assess its extent from the air.

Past distribution

A detailed report on the range, economic value and conservation of *C.rhomboidea* prepared in 1910 (Legge, 1911) for presentation to the Tasmanian Government was selected as a reliable and major statement on the range of the species at that time. This provides a valuable benchmark against which to assess changes in the extent of the conifer over a period of at least 80 years. Other published historical sources were examined for reference to locations of either species.

Specimens of *C.rhomboidea* and *C.oblonga* were examined at the Tasmanian Herbarium (HO) for locational information.

3.3 Results and Discussion

The present distribution in Tasmania of *Callitris* spp. is indicated in Figures 3.1 and 3.2. *Callitris rhomboidea* occurs on mainland Australia (see Figure 1.1) as well as on some other islands in Eastern Bass Strait north of the Furneaux Group, including Deal Island. The remarkable feature about the Tasmanian distribution of *C.rhomboidea* is the large disjunction in north eastern Tasmania between Clarke Island and the Douglas River.

C.oblonga is much more restricted in distribution and in habitats. Its occurrence is concentrated along a few rivers which rise within a relatively small area in the highest parts of the Eastern Tiers between Mt St John (779m) and Snow Hill (971 m). The easterly flowing rivers which bear stands of the conifer are: Apsley River, Swan River, Brushy River, Cygnet River and Wye River. *C.oblonga* occurs on the St.Pauls River which flows west into the South Esk River and along the South Esk River below the confluence of the St.Pauls River. One small population occurs above the confluence, at the mouth of
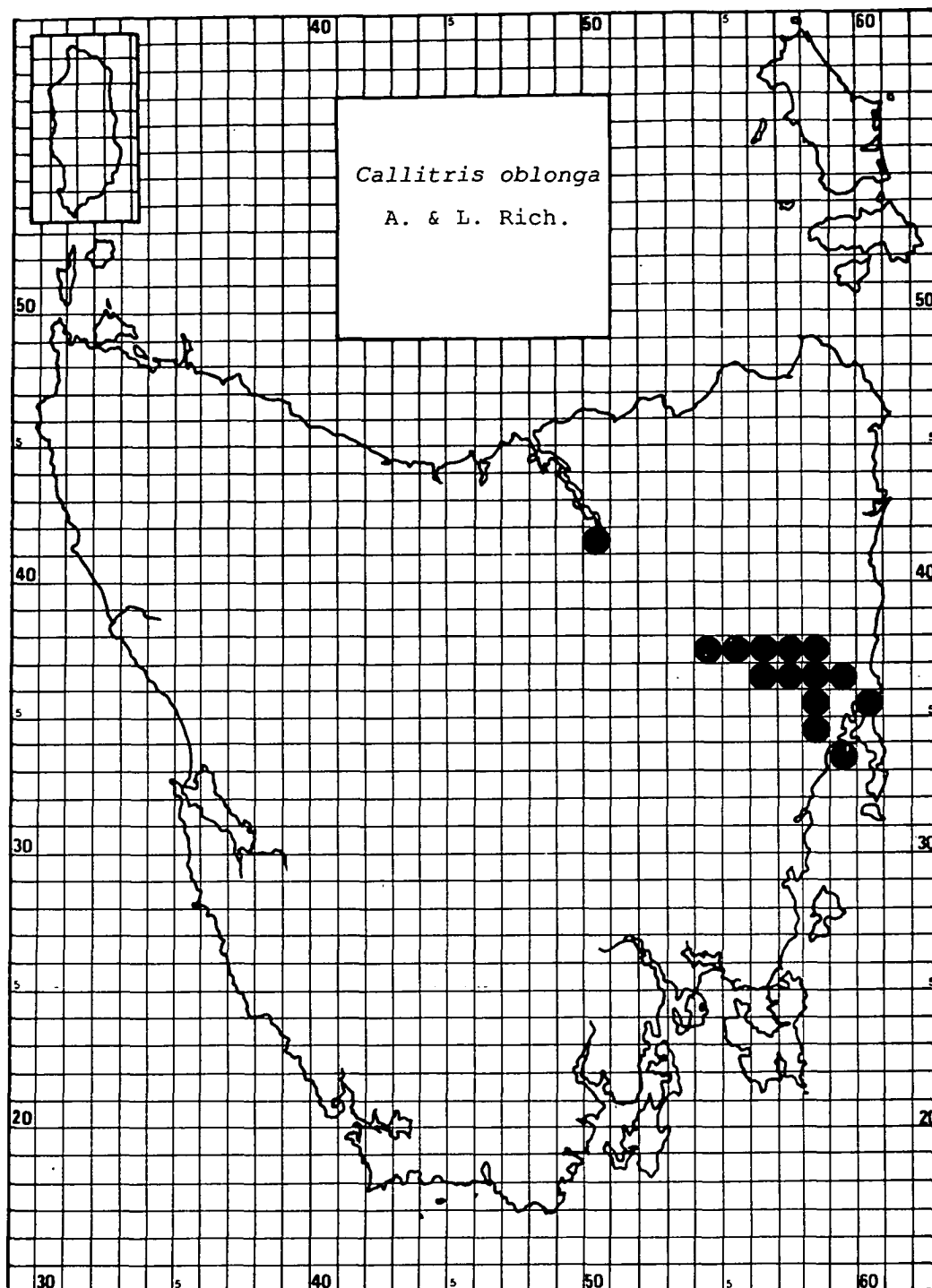
Figure 3.1 Distribution of *Callitris oblonga* on a 10 km grid
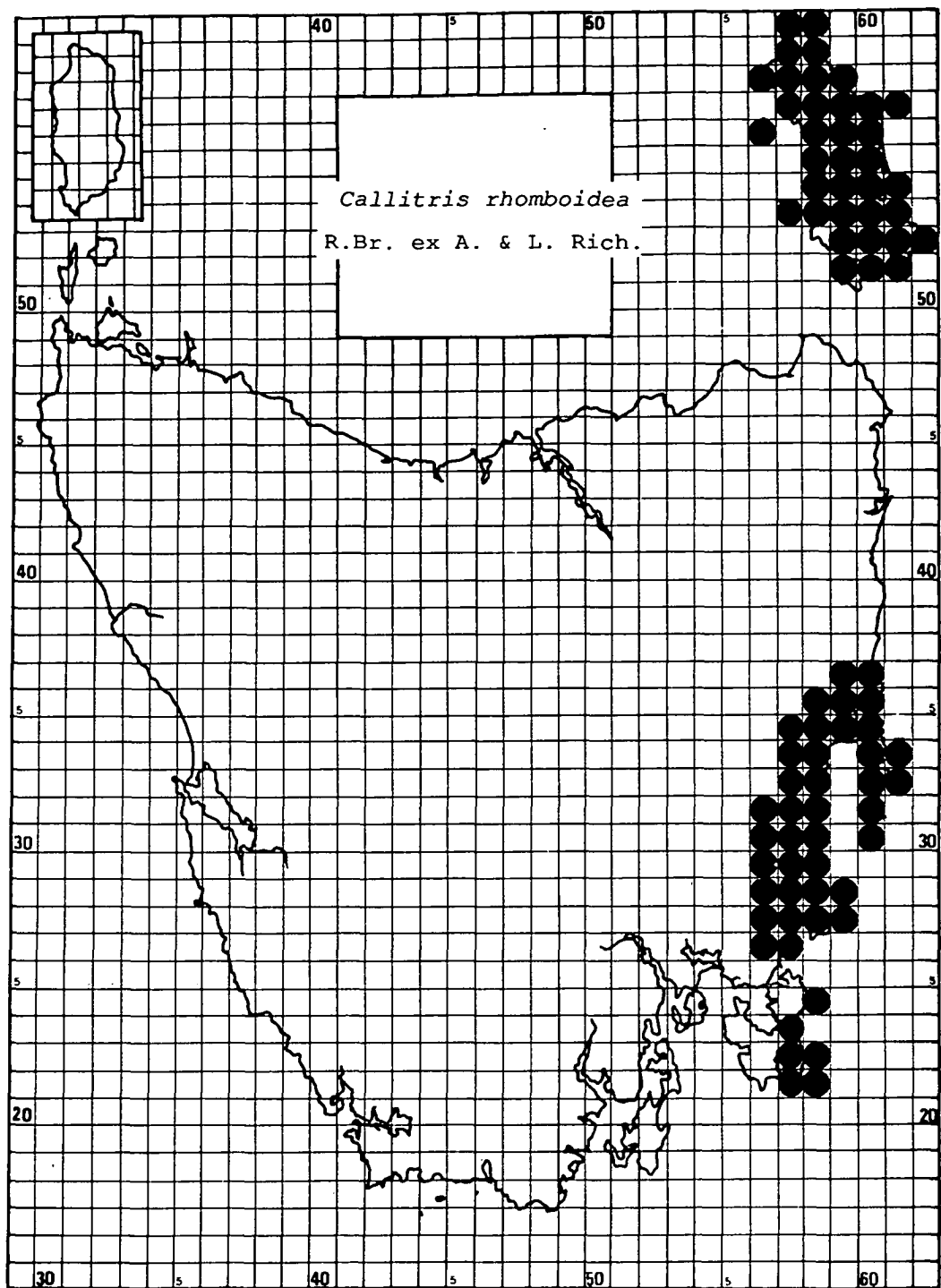
Figure 3.2 Distribution of *Callitris rhomboidea* on a 10 km grid

Rosiers Creek. *C.oblonga* has also been noted as an isolated individual on old sand dunes under *E.viminalis* and *Acacia dealbata* at Dolphin Sands (Kirkpatrick pers.comm.). Locations of *C.oblonga* are given in Kirkpatrick, Brown and Moscal (1980).

The earliest apparent reference to both *C.rhomboidea* and *C.oblonga* in the field is in Milligan (n.d. c1855) who describes the distribution of *C.rhomboidea* as:

> ".... the Eastern Coast of Tasmania along a belt of country a few miles in width only, extending from Spring Bay northwards, nearly to Falmouth"......"reappears upon the granite soils of Flinders and Cape Barren Islands, Bass's Strait, and is found with other species on the Australian continent."

The same author describes the distribution of *"Callitris Gunnii"* (syn. *C.oblonga)* as:

> "grows in picturesque groves along the banks of the St Pauls River, upon a portion of the 'South Esk', and on the Meredith River at Swanport."

Milligan had therefore noted the major disjunction in the extent of *C.rhomboidea* on the East Coast. His description for *C.oblonga* omits a number of East Coast rivers where the conifer is known today but mentions the Meredith River where it has not been found in recent times.

The most thorough report on either of the Tasmanian *Callitris* species was that of Legge (1911) who explored the East Coast on horseback to delineate the extent of *C.rhomboidea*. Legge described the mainland Tasmanian range:

> "The distribution of this pine in Tasmania is confined to a comparatively narrow belt of the East Coast. Although extending up the rivers named below, it is mainly a coastal tree, like several of its congeners in Australia, just alluded to. The furthest inland limit occurs on the

Little Swanport River, where it is plentiful on the Little Pine Creek, near Swanston. This tributary of the Little Swanport River is about 15 miles in a direct line from the coast. On the Swan River and its western branch, it occurs almost equally far from the sea. The littoral belt inhabited by it extends from a little south of the Douglas River to Bream Creek..."

Legge quantitatively described many observed and reported stands of pine in some detail and for his purposes describes the pine according to districts which are :

(1) Bicheno District, (2) Delta of the Apsley and Valley of the Swan, (3) Swansea, (4) Little Swanport, and (5) Triabunna district. The distribution described accords with the present main extent of its range. The Tasman Peninsula stands were not mentioned, understandably, because the species there is confined to the rugged eastern coast, especially on talus slopes and cliff edges. The northern mainland Tasmanian limit was specifically noted with Legge adding later:

"... it is difficult to understand why the Oyster Bay pine should be wanting throughout all the stretch of coastal country from the Douglas River to Cape Portland, and then reappear in Flinders Island."

While the broad distribution pattern of *C.rhomboidea* has probably changed little since first European settlement, the detailed distribution pattern has been greatly altered because of the effects of agricultural clearing and fires. Legge (op.cit) repeatedly describes the demise of this conifer through the settled districts of the east coast, for example:

"Up the coast towards Mt Murray it must have been plentiful, as in 1855 I found, when visiting the neighbourhood, that numbers of fine trees had been killed by ringbarking. It was a case, too often seen, where every vestige of tree growth has been swept away by axe and fire....";

and again:

"The peninsula between the township and Prosser's Bay formerly contained pine in small quantity, but it has been cut out and destroyed by bush fires."

Legge makes a number of references to 'fine stands' of *C.rhomboidea* in localities where it does not exist at all today. For example, a huge stand of pine is described near the 'Apslawn' property (Break O'Day 1:100,000 map - general area around 970 530), where none occurs now. The reason for its demise is foreshadowed in Legge's report:

"The Apsley estate and the adjoining block of Government land known as "Pine Hill" constitute one of the nuclei of pine timber on the coast. On the estate itself, which was much covered with this conifer in older times, there is but little left at the present time. Over the boundary, however, one of finest woods of pine that now exists clothes the hill in question, which overlooks the remarkable marshes in which the river loses itself. The extent is about 300 acres, and the ground is broken by shallow gullies and low spurs, all of which are covered by a continuous forest of pines in all stages of growth, among which are numbers of trees with good timber boles ....."Unfortunately the pine forest is in danger of being much spoilt by the lessee's annual burning off, numbers of beautiful trees having been destroyed in a recent fire, for which there was no justification, as all timber in the block is green."

Current 1:100,000 maps covering the range of *C.rhomboidea* show a number of features named for the conifer: Pine Creek, Pine Tier, Callitris Creek, and Pine Gully for example. The Pine Divide near Mt Walter, west of Cape Bernier indicates an early appreciation of the local inland extent of *C.rhomboidea* in that locality. These names more or less reflect part of the known distribution of *C.rhomboidea* but a further indirect means of assessing the relative extent and density of this conifer is by the frequency of its use as a timber in buildings and structures. Again, use of the timber reflects

the distribution of the species. The southernmost use is in buildings on Dunbabin's property at Bream Creek and the northernmost is in framing in a barn at "The Douglas" property on the lower Douglas River. *C.rhomboidea* was widely used throughout the Furneaux Group for framing timber and fence posts. Extensive and conspicuous use of the timber however has been made from Orford to Cranbrook. I have documented numerous examples of its use including framing spars and a staircase at the original Orford Post Office; flooring in the Piermont homestead; verandah posts at Swansea and Cranbrook; a log cabin; a log barn; tank stands; fencing and stockyards, scattered elsewhere on the coast.

Legge (op.cit) gives no more than a passing mention in a footnote to *C.oblonga*, 'St Pauls Pine' and any historical accounts of its distribution are rare. Baker and Smith (1910) however, state that:

> "This species is quite endemic to Tasmania, where it was collected by Robert Brown at Port Dalrymple, and on the gravelly banks of the South Esk River, near Launceston."

and also:

> "it is fairly common on the extreme edge of river flats on the South Esk River, also at St Annes (now St Pauls) River near Avoca, Tasmania."

The species is fire sensitive and has consequently thinned out considerably since earliest settlement. The only stand known on the Lower South Esk River is in the rugged, fire protected Cataract Gorge near Launceston, where a small population of less than 200 plants exist.

R.C. Gunn forwarded specimens of *Callitris oblonga* to Sir William Hooker in 1836 but Burns and Skemp (1961) incorrectly interpret a remark in Gunn's accompanying letter (after referring to *C.oblonga*: "... as also a new species from near Campbell Town") to mean that Gunn collected *C.tasmanica* (syn. *rhomboidea*) near that place. This is an incorrect assumption on the part of Burns and Skemp (op.cit) as *C.rhomboidea* would

not have occurred anywhere near Campbell Town. It is doubtful that Gunn ever collected *C.rhomboidea* as there are no duplicates in the Tasmanian Herbarium (HO) and it is unlikely that Gunn ever collected within the range of the species (Buchanan 1988, and pers.comm.)

It appears that the general distribution pattern of *C.rhomboidea* has remained unchanged at least during the last 90 years. *C.oblonga* has probably been as scarce as it is now for at least a century as it rates hardly a mention in historical literature. It is clear though, that the detailed pattern of distribution of the two species has changed in the last 90 years through fire and clearing. These same factors would have affected the distribution of *Callitris* during the nineteenth century as well. The disjunction in northeastern Tasmania in the *C.rhomboidea* distribution almost certainly existed at the time of first European settlement, but the gap south of Bream Creek has most likely occurred since European settlement.

CHAPTER 4

STAND DEMOGRAPHY OF *C.RHOMBOIDEA* AND *C.OBLONGA*

4.1   Introduction

Studying stand demography of a long lived conifer such as *Callitris* provides the most expedient means of deducing aspects of the species' life histories including growth rate, patterns of reproduction, competition and rates of stand expansion.   The demography of a number of Tasmanian conifers has been studied (e.g. Cullen 1987, Cullen and Kirkpatrick 1988, Gibson 1986 and Read and Hill 1988) and these studies were able to throw light on regeneration strategies.

Stand demographic study requires:

- a knowledge of the diameter/age relationship for the species;

- frequency of stems in different age/classes for one or preferably more stands;

- observations on prevalence of seedlings under different stand conditions;

- assessment of the proportion of vegetative to seedling reproduction in the stand; and

- other factors such as seed dispersal, fecundity, whether the species seeds annually or during most years, and what response the species has to catastrophic disturbances. This last requirement may itself be answered as a result of the other lines of enquiry.

A significant positive relationship between tree diameter and age must be demonstrated if diameter or circumference size classes are used as surrogates for tree age in assessing regeneration states.   This can be done by increment coring or sectioning stems (given the cautionary qualifier described in the Methods section below).   By examining the frequency of stems in different size classes for a stand, it is possible to assess whether regeneration is continuous or discontinuous.

The closer the age/class data for a particular stand fits a reverse J-shaped curve, the closer it is to being a

continuously regenerating population (Harper 1977). If the model does not fit the reverse J-shaped curve then it is more likely that some catastrophic or periodic events (such as fire, windthrow, flood) induce death and/or regeneration. Reverse J curves are also known as type III survivorship curves (Deevey 1947, cited in Hutchings 1986).

A power function equation proposed by Hett and Loucks (1976) has been found to consistently describe self thinning patterns in type III survivorship curves. The model is known as the self thinning law or the -3/2 power law. This is given as:
$$Y_t = Y_o x^{-b''}$$
where Y_t is the number of survivors at time t

Y_o is the initial population size

x is the age of the population, and

b'' represents a mortality rate which falls with age.

The -3/2 power law of self thinning is universally applicable across the plant kingdom (Weller 1987) but is empirically based with some speculation as to the explanation of the law in terms of spatial geometry of the plants.

The power function model is not statistically tested here, heeding Osawa and Sugita (1989) who advise caution in applying the self thinning rule without numerous data points for populations that share the self thinning line as a boundary. Otherwise, claim Osawa and Sugita (op cit) : "one cannot tell whether the slope of the fitted line is different from -1/2 [i.e. different from the slope of the straight line along which self thinning proceeds when plant yield is plotted against plant density on logarithmic scales] because the rule is innaccurate or because the choice of stands for analysis is inappropriate."

While it may be trite to statistically test a particular set of age/class data which obviously displays type III survivorship, against the -3/2 power rule it is valid and profitable to discuss stand data in terms of the model and its

possible ecological implications. The dynamics of *C. rhomboidea* and *C. oblonga* stands are poorly understood yet in terms of aiming at longer term conservation of these species in Tasmania it is important to know their regeneration strategies in the face of environmental vicissitudes such as fire, floods, grazing and mechanical damage. It is known that *C. rhomboidea* has declined in extent since European settlement (Legge 1911, see also Chapter 3) and *C. oblonga* has certainly declined as well (see Chapter 3).

4.2   Methods

A number of diverse sites were chosen to enable comparisons of regeneration patterns and stand structure in *C. rhomboidea*. At several sites attention focussed on *C. rhomboidea* and its local associated tree species. At a site at Paradise Gorge, (also interchangeably referred to as Prosser River in the following pages), contrasting community types across a valley, all containing *C. rhomboidea,* were examined to understand some of the factors which may influence stand demography. Similarly, analysis of stand structure, age classes of the species and relationship with co-occurring species were examined in different types of *C. rhomboidea* stands at Cape Tourville, Piermont and Rosedale Road. A synthesis of the results will allow some conclusions to be made about the regeneration strategies of this conifer. Seed distribution was examined by looking at the frequency and distance of seedlings from putative parents. Notwithstanding the problems of increment coring such as tree-ring eccentricity, merging and missing rings, and potential opening of the tree to insect attack, a number of *C. rhomboidea* trees was sampled at Cape Tourville. Ability to regenerate vegetatively was tested with *C. oblonga* and *C. rhomboidea.*

An opportunity to obtain accurate diameter/age data for *C. oblonga* was provided near Milford Hole on the St Pauls River where a stand had been fire killed. Basal sections were cut from these trees. Much of the information supplementing the

Milford Hole data comprised observations gained during extensive sampling across the range of the species.

4.2.1 *C.rhomboidea*

(i)   Field Techniques

A number of transects were positioned in various stands of *Callitris rhomboidea*. Transects were located at Paradise Gorge (6 transects), Rosedale Road, Piermont and Cape Tourville. These locations are shown in Figure 4.1.

The Paradise Gorge site comprised 2 transects in each of the following situations:
1.   a steep fire protected south facing slope,
2.   a shrubby riverine flat, and
3.   a dry moderate slope with a northerly aspect.

At Rosedale Road the transect was placed in a *Eucalyptus globulus-E.viminalis-E.amygdalina (C.rhomboidea)* low woodland occupying a very rocky site. The Piermont transect was placed in a *C.rhomboidea-E.viminalis* forest on flat near coastal land where grazing is a major activity. The Cape Tourville site was an *E.tenuiramis-E.amygdalina (C.rhomboidea)* woodland situated on gently sloping ground with granite soils.

Paradise Gorge →

Figure 4

Eastern Tasmania showing the location of some study sites

Milford Hole

Rosedale Rd

Piermont

see Fig. 6.2

Wingaroo

Camerons Inlet
(transect)

S T R A I T

F U R N E A U X

West Sister I

North Pt

Bligh Pt

Woxitipu Rk

Palana

Mt Killiecrankie
KILLIECRANKIE 319
BAY

Sentinel I

Mt Bayes

Mt Tanner

C Frankland

Leeka

Tanners Bay
29

Roydon I

Marriott Reef

North Pasco I

FLINDERS

Middle Pasco I

MARSHALL

South Pasco I

BAY

Lughrata

Babel I 200

Cat I

Storehouse I

Port Davies

Emita

The Patriarchs 192

Settlement Pt

Memana

Burnett Lagoon

Wybalena

Lillies Bay

Brougham St 454

Prime Seal I

ARTHUR

Blue Rocks

Watkers 10 413

Pillingers Pk

Mt Leventhorpe 501

Lackrana

Cameron Inlet

G R O U P

BAY

177

Safe Passage

Chalky I

Blue Rocks Pt

Mile I

ISLAND

The Dutchman 202

Low Islets

Reef I

Isabella I

Whitemark

Lit Chalky I

PARRYS BAY

Ranga

2A

Logan Lagoon

East Kangaroo I

314 Barclays St

Samphire R

Big Green

STRZELECKI PKS 758

Lady Barron

Vinegar Hill 107

Fotheringate Bay

Loccota

Trousers Pt

Razorback Mtn

ADELAIDE BAY

Lit Green I

Ann It

Lit Dog I

Great Dog I

Briggs It

Vansittart I

Mt Chappell I 202

FRANKLIN

Pigs Head Pt

CHAPPELL IS

Lit Badger I

Lit Anderson I

Tin Kettle I

SOUND

Puncheon Pt

Lit Goose I

Goose I

9

Badger I

Anderson I

ANDERSON IS

Apple Orchard Pt

Dover

Unicorn Pt

Beagle I

Dough Bay

Ned Pt

Munro Bay

15

Long I

Boxen I

Cape Barren Island

Mt Munro 686

Double Peak

CAPE   BARREN   ISLAND

Harley Pt

C Sir John

Key I

Thunder & Lightning Bay

Mt Kerford 503

C Barren Gu

30

KENT BAY

Wombat Pt

Sloping Pt

Seal Pt 12

28 Cone Pt

Preservation I

Night I

Rum I

ARMSTRONG CHANNEL

Kangaroo Bay

Forsyth I

Passage I 45

CLARKE ISLAND

Black Pt 18

Lookout Heads 87

Low Its

Moriarty Bay

29 Moriarty Pt

B A N K S

S T R A I T

Foster Is

Cygnet I

Lit Swan I

19

C Portland

52

Swan I

Waterhouse I

72

Lit Waterhouse I

Waterhouse Pt

GREAT MUSSELROE BAY

23 C Naturaliste

Croppies Pt

RINGAROOMA BAY

Boobyalla

Stumpys Bay

South Croppies Pt

Hardwickes Hill 117

Tomahawk I

Tomahawk Pt

Bowlers Lagoon

Boulder I

Big Waterhouse

Blackman Lagoon

Waterhouse

Mt William 216

Cod Bay

George Rks

East Double Sandy Pt

ANDERSON BAY

Gladstone

551

Mt Cameron

234

Purdon Bay

Eddystone Pt

C

At Paradise Gorge, Rosedale Road, Piermont and Cape Tourville, the point centred quarter method of sampling (Mueller-Dombois and Ellenberg 1974) was used. At Paradise Gorge sampling points were arranged in parallel lines across each of the three sites. The sampling transects were at approximately 30m spacing so as to avoid double counting of individual trees.

The information obtained was : distance from quadrat centre to the nearest tree in each quarter, record of the nearest tree species and a measure of its near basal circumference, and record of the species of sapling and shrub closest to the centre point in each quarter. Approximately 30 quadrats were sampled at each site.

At Rosedale Road and Piermont the single transects, each of 20m long, were placed in homogeneous vegetation. The information collected was as for Paradise Gorge but excluded shrubs and saplings. In these cases near basal diameter was measured with a diameter tape. Only stems measuring more than 1 cm basal diameter were recorded.

At Cape Tourville a grid of 25 10x10 m quadrats was used as a basis for point-centred quarter sampling. A nested transect was laid out within this area and the absolute frequency of all species was recorded in each of 16 5x5 m quadrats. Circumferences of *C. rhomboidea* and other trees occurring within the 10x10m quadrats were recorded, including circumferences of dead trees and heights of tree seedlings.

At all sites either circumference or diameter classes were used as a surrogate for age classes. According to Ogden (1985), if reproductive behaviour in perennial plants seems more specific to size than age, then predictions about the dynamics of a population are best based on size rather than age. Harper (1977) asserted that: "It is unrealistic ... to assume any relationship between the size of trees and their age, other than the vague principle that the largest trees in a canopy are likely to be old." To define the relationship

between diameter and age, fifty three *C.rhomboidea* trees were sampled with an increment corer at breast height. The cores were stored in paper straws and subsequently removed, glued into rebated boards and sanded smooth.

To gauge seed dispersal and survival of seedlings around a number of putative parent trees near Hazards Beach in Freycinet National Park, seedling distance and number were measured. The stand had been relatively undisturbed although traversed by a walking track. Four parent trees of heights 5m, 6.5m, 15m and 30m were chosen. Distance to seedlings and their number was scored along 2 transects placed at right angles and intersecting through the putative parent.

To test the ability to regenerate vegetatively, three cuttings were taken from each of four trees for both *C.oblonga* (collected: Grange Road) and *C.rhomboidea* (collected: beside McKays Road near the Tasman Highway). The cuttings were planted in pots with a standard commercial potting mixture, kept outdoors and hand watered.

(ii) Data Analysis

Calculations using the data from the Piermont and Rosedale transects were made to give mean distance or spacing between trees at each site. This was then used to calculate the absolute density of the total tree species. The density of each species was determined and expressed as a relative density such that :

number of individuals of species per 100m2   X 100
number of all species' individuals per 100m2

This is a useful means of comparing the importance of a species within different stands.

Histograms were constructed of numbers of *C.rhomboidea* stems in various basal diameter classes of 3cm increments. The circumference data from the Paradise Gorge transects were converted to basal areas and subsequently expressed as a relative basal area for each species at each of the 3 sites. The relative basal area of each tree species allowed the tabulation of a dominance ranking within the site and the species accounting for greater than 1% of the total basal area of the stand were plotted as histograms below a topographic profile of the study area. Histograms of frequency of stems for all species and for the dominant species within basal area size classes at each site were constructed.

The shrub and sapling data from Paradise Gorge were tabulated in 3 groups according to the absolute frequency of species. The near basal circumference data for trees in the Cape Tourville quadrats was treated in the usual manner for point-centred quarter sampled data. In addition the absolute frequency of each of all vascular plant species recorded within each of 16 contiguous quadrats was graphed. The near basal circumference data were grouped in circumference classes and plotted as histograms.

The 53 Cape Tourville increment cores, after sanding, were subjected to a ring count. Where small sections of core were missing because of breakage or missing the centre, extrapolation was necessary and was based on the average increment width in the existing core. A good deal of caution is required doing this because often the earlier increments may be much narrower due to early suppression. The results were graphed as number of growth rings against diameter at breast height.

The circumferences recorded for the tree data were grouped into size classes and used to construct histograms. From the seedling distance/frequency data, seedling frequencies and distances from the putative parent were graphed.

4.2.2 *C.oblonga*

(i) Field Techniques

Conclusions on regeneration strategy are based both on general observations across the range and some detailed stand measurements made in a partly burned stand at Milford Hole. The stand was burned (possibly by local farm hands or hunters) in September/October 1986 and all the *C.oblonga* trees were still intact although flattened by flood water (see Plate 4.1). A selection of stems across all size classes were cut at the base and a section taken for age (tree ring) basal diameter data. For the same trees, tree height was measured and the number of seed bearing cones counted. Age class data were recorded along a transect on the Lower Apsley River. This transect crossed a probable old fire boundary.

(ii) Data Analysis

The Milford Hole data were tabulated and graphs drawn of height of trees against diameter, height of trees against number of growth rings, and diameter against number of growth rings. The frequency of stems in different age classes was portrayed in a frequency histogram. The number of female cones on each tree was regressed against basal diameter.
The age class data from the Lower Apsley River was transformed into an age/class frequency histogram.

4.3   Results

(i)   *C.rhomboidea*

The transects at Piermont and Rosedale reveal different basal diameter class patterns when *C.rhomboidea* stem numbers are graphed (Figures 4.2 and 4.3). At Piermont there is a lack of small trees in the <4cm diameter class and a large number of individuals in all classes between 4 and 29 cm diameter. At Rosedale the situation is closer to a reverse J curve with large numbers of *C.rhomboidea* stems in the <7 cm diameter classes but a sudden decrease in stem frequency in subsequent classes.

The absolute density of the forest at Piermont is much greater than that at Rosedale Road (Table 4.1) and in both forests *C.rhomboidea* contributes more stems per unit area than any other trees. The dominance rank of *Eucalyptus amygdalina* and *E.globulus* exceeds *C.rhomboidea* at Rosedale Road because of the large diameters of few individuals, (Tables 4.2 and 4.3).

At Paradise Gorge, relative basal area of tree species (> 5m ht) by site showed *C.rhomboidea* clearly dominant (Table 4.6) at site 3 which is the steep rocky fire protected site. Eucalypts were more important in terms of basal area at the riverine site (site 2) and the dry northerly aspect site (site 1). When absolute density and mean spacing of trees is calculated (Tables 4.4 and 4.5) it is clear that distance decreases and density increases from site 1 to site 3. In site 3 the number of trees/100m^2 is 18.9 compared with only 1.1 trees/100m^2 at site 1. The high stem density at site 3 is contributed by *C.rhomboidea* but the species contributes little to the relative density at site 1 on the drier site with the northerly aspect. *Eucalyptus pulchella* contributes the greatest percentage relative basal area (see Table 4.6 and figure 4.4) at site 1 while at site 2 basal area percentage is spread over more species but with *E.globulus* providing the greatest percentage. A greater shrub and sapling density

occurs at site 2 but this is not adequately reflected in the tables. The diversity of shrubs and saplings is clearly shown in Table 4.6 which also indicate no young regeneration of eucalypts at the fire protected site 3 but numerous (50) young trees of *C.rhomboidea*.
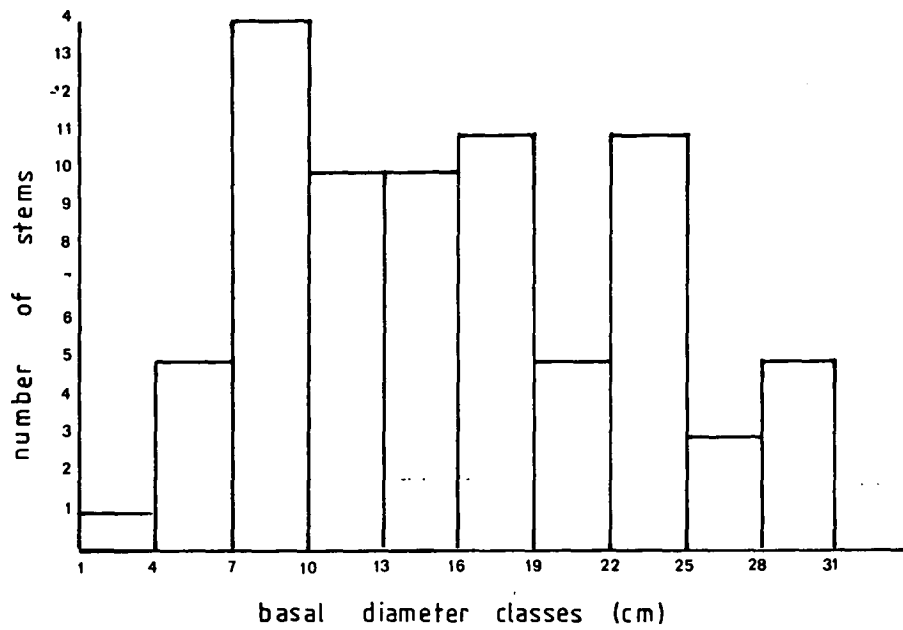
Figure 4·2 Numbers of *C. rhomboidea* stems in various basal diameter classes along a transect at Piermont.
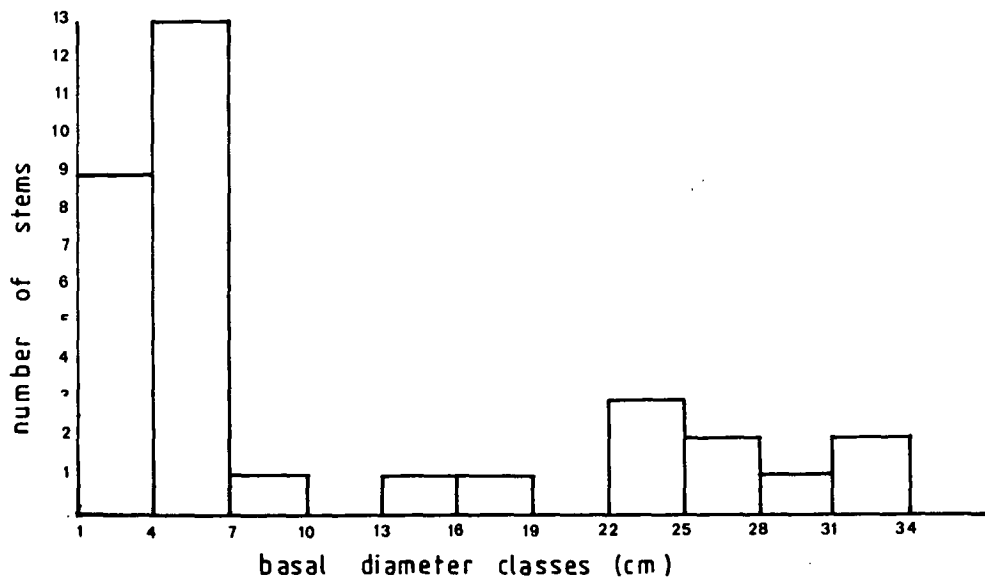
Figure 4·3 Numbers of *C. rhomboidea* stems in various basal diameter classes along a transect at Rosedale Rd.

Plate 4.1 A stand of *C.oblonga* on the St Pauls River, destroyed by fire about October 1986 and flattened by floodwater.

Plate 4.2 A stand of heavily browsed *C.oblonga* occupying an atypical site at least 10m above flood level, near the St Pauls River. Note coppiced stems.

Table 4.1

Absolute Number of Tree Species at Piermont and Rosedale Road

	Piermont	Rosedale Road
Absolute density (trees/100m^2)	15.5	8.8

Table 4.2

Dominance ranking and number of stems per 100m^2, of tree species in a transect at Piermont

Species	Dominance Rank	No. of trees/100m2
Callitris rhomboidea	1	14.18
Eucalyptus amygdalina	2	0.58
E. viminalis	3	0.39
Acacia mearnsii	4	0.39

Table 4.3 Dominance ranking and number of stems per 100m^2, of tree species in a transect at Rosedale Road

Species	Dominance Rank	No. of trees/100m^2
Eucalyptus amygdalina	1	1.1
E. globulus	2	0.53
Callitris rhomboidea	3	3.96
Allocasuarina verticillata	4	2.53
E. viminalis	5	0.11
Allocasuarina littoralis	6	0.33
Leptospermum grandiflorum	7	0.11
Bursaria spinosa	8	0.11

Table 4.4

Absolute Density of Tree Species by Stand at Paradise Gorge

	1	2	3
Absolute density (trees/100m^2)	1.1	2.3	18.9

Table 4.5

Relative Density of the Tree Species by Stand at Paradise Gorge

Species Name	Relative density (percentage)		
	Site 1	Site 2	Site 3
Callitris rhomboidea	5.5	14.8	82.0
Eucalyptus pulchella	61.8	8.3	5.8
Eucalyptus globulus	–	26.1	–
Acacia mucronata	–	24.3	4.8
Eucalyptus viminalis	13.6	–	–
Pomaderris apetala	–	10.4	–
Eucalyptus amygdalina	9.1	4.8	–
Allocasuarina verticillata	4.5	0.9	–
Acacia mearnsii	2.7	3.9	–
Cyathodes divaricata	–	–	3.2
Banksia marginata	–	–	2.1
Allocasuarina littoralis	–	1.7	1.1
Asterotrichion discolor	–	1.7	–
Bedfordia salicina	–	–	1.1
Bursaria spinosa	0.9	0.9	–
Eucalyptus obliqua	–	0.9	–
Leptospermum lanigerum	–	0.9	–
Acacia dealbata	0.9	–	–
Exocarpus cupressiformis	0.9	–	–

Table 4.6

Absolute Number of Shrub and Sapling Species at Each Site, Paradise Gorge

Species Present at 3 Sites	1	2	3
Acacia mucronata	7	32	4
Callitris rhomboidea	4	5	50
Exocarpus cupressiformis	4	3	1
Bursaria spinosa	2	10	8
Beyeria viscosa	18	27	1

Species Present at 2 Sites	1	2	3
Eucalyptus pulchella	23	2	-
Eucalyptus amygdalina	3	1	-
Acacia mearnsii	2	2	-
Astroloma humifusum	10	4	-
Hibbertia riparia	2	6	-
Cyathodes divaricata	22	-	53
Lomatia tinctoria	2	-	5
Callistemon paludosus	-	4	1
Pomaderris apetala	-	25	2
Micrantheum hexandreum	-	25	4
Coprosma quadrifida	-	2	3
Notelaea ligustrina	-	3	24
Parahebe formosa	-	4	6

Species Present at 1 Site	1	2	3
Eucalyptus viminalis	17	-	-
Acacia dealbata	9	-	-
Allocasuarina verticillata	6	-	-
Leptospermum scoparium	2	-	-
Helichrysum lycopodioides	72	-	-
Dodonaea viscosa	3	-	-
Eucalyptus globulus	-	1	-
Allocasuarina littoralis	-	3	-
Asterotrichion discolor	-	2	-
Leptospermum lanigerum	-	11	-
Hakea microcarpa	-	1	-
Pultenaea juniperina	-	1	-
Epacris tasmanica	-	2	-
Spyridium obovatum	-	1	-
- var.*velutinum*			
Banksia marginata	-	-	2
Bedfordia salicina	-	-	5
Epacris exserta	-	-	5
Pimelea nivea	-	-	1
Correa reflexa	-	-	3
Zieria arborescens	-	-	1
Goodenia ovata	-	-	2

Table 4.7

Relative Basal Area of Tree Species by Site at Paradise Gorge (tree species >5m)

Species Name	Relative Basal Area (percentage)		
	Site 1	Site 2	Site 3
Eucalyptus pulchella	84	18	29
Eucalyptus viminalis	8	–	–
Eucalyptus amygdalina	5	9	–
Eucalyptus globulus	–	44	–
Eucalyptus obliqua	–	6	–
Acacia mearnsii	0.4	1	–
Acacia dealbata	0.1	–	–
Acacia mucronata	–	14	2
Allocasuarina verticillata	0.9	0.1	–
Allocasuarina littoralis	–	0.4	0.2
Callitris rhomboidea	1	6	67
Exocarpus cupressiformis	0.2	–	–
Bursaria spinosa	0.1	0.1	–
Pomaderris apetala	–	2	–
Asterotrichion discolor	–	0.1	–
Leptospermum lanigerum	–	0.1	–
Cyathodes divaricata	–	–	1
Banksia marginata	–	–	0.8
Bedfordia salicina	–	–	0.1

Figure 4.4 shows size class distribution for trees at the different sites. At site 3 the dominant species, *C.rhomboidea* shows a classic reverse J curve distribution across size classes indicating continuous regeneration in contrast to the 'pulse' regeneration of the dominant eucalypts at sites 1 and 2 (Figure 4.5).

The Cape Tourville data represents a pulse regeneration of *Callitris* following a past fire event. This pulse is represented by the strong cohort in the 10-40cm classes. A fire pulse origin is supported by the frequency histogram of *Banksia marginata* which shows three possible cohorts representing different fire ages. *B.marginata* cohorts are an excellent indicator of fire events because they almost always germinate only as a result of fire and can be easily aged (Podger and Brown, cited in Bell 1983). The 10-30 cm *Banksia* cohort probably corresponds with the same fire event which instigated the *C.rhomboidea* cohort. If there are no further

fires for a long time the three classes with the highest frequency will move to the right of the graph. Although suffering mortality with increasing size (age) the cohort will remain as a peak in the graph. There is a drop in the number of *C. rhomboidea* stems in the less than 10 cm class which could indicate a low intensity fire eliminating many young seedlings. Such a fire emphasises the major cohort and masks the fact that *C. rhomboidea* is continuously producing seedlings at this site. The *Callitris* stand at site 3 at Paradise Gorge however has remained unburned long enough to show continuous regeneration.

The younger age classes have fewer representatives, as most of the sampled individuals fall between 40 and 68 years old with the oldest tree being recorded as 81 years old (Figure 4.6). There is a rough constant positive relationship (Figure 4.6) between growth ring numbers and dbh but there is fairly wide scatter such that for example, trees with diameters of 7.5 cm and 20.5 cm are shown to be the same age (59 years). Associated tree species in the stand show a similar size class structure (Figures 4.76, and 4.9 a and b) with a marked relative paucity of seedlings in the youngest size class for each species except the eucalypts.

In examining seed dispersal, it was found that the heights of putative parents had only a poorly defined relationship with distance to peaks of seedlings. There was a remarkable concordance between the distances of seedling 'peaks' regardless of parent tree heights. Combining all transects from all parents, seedling numbers were greatest within 9m of the parent (Figure.4.7) whereafter the number declines rapidly until seedling numbers beyond 17m are negligible. 44.5% of seedlings occur within 4m of the parent, 29.6% of seedlings occur between 4 and 8m from the parent, while the remaining 25.9% occur between 8 and 17m from the parent. The pattern of seed dispersal is more or less similar in both upslope and downslope directions from the parent, with slightly more seedlings on the downslope side (Figure.4.11).

Many more seedlings were recorded (306) on the transect for the 30m parent but seedling numbers on the transects of the other parents bore no direct relationship to the height of trees.

Seedling frequency on transects generally shows a multi modal pattern and when frequencies on all transects are combined the principal modes occur in decreasing amplitude at 3, 7 and 12.5 metres from the "combined parent".

It might have been expected that seedling frequency would be almost non-existent beneath the parent canopy due to possible allelopathic litter and shading effects.

Table   4.8

The 'relationship' between tree height and canopy radius and distance to most seedlings

Tree Height(M)	Canopy Radius(M)	Nearest Modal Frequency(M)
30	3	3
15	2	5
6.5	1	1
5	1.3	2

The above table demonstrates that the nearest modal frequency of seedlings to the parent does not occur within the canopy radius. However, many other sites have been observed where seedlings occur right up to the bole of the supposed parent.

No assessment of the role of prevailing wind direction in seed dispersal was made. The distinctively winged structure of many of the seeds suggests some aerodynamic performance.
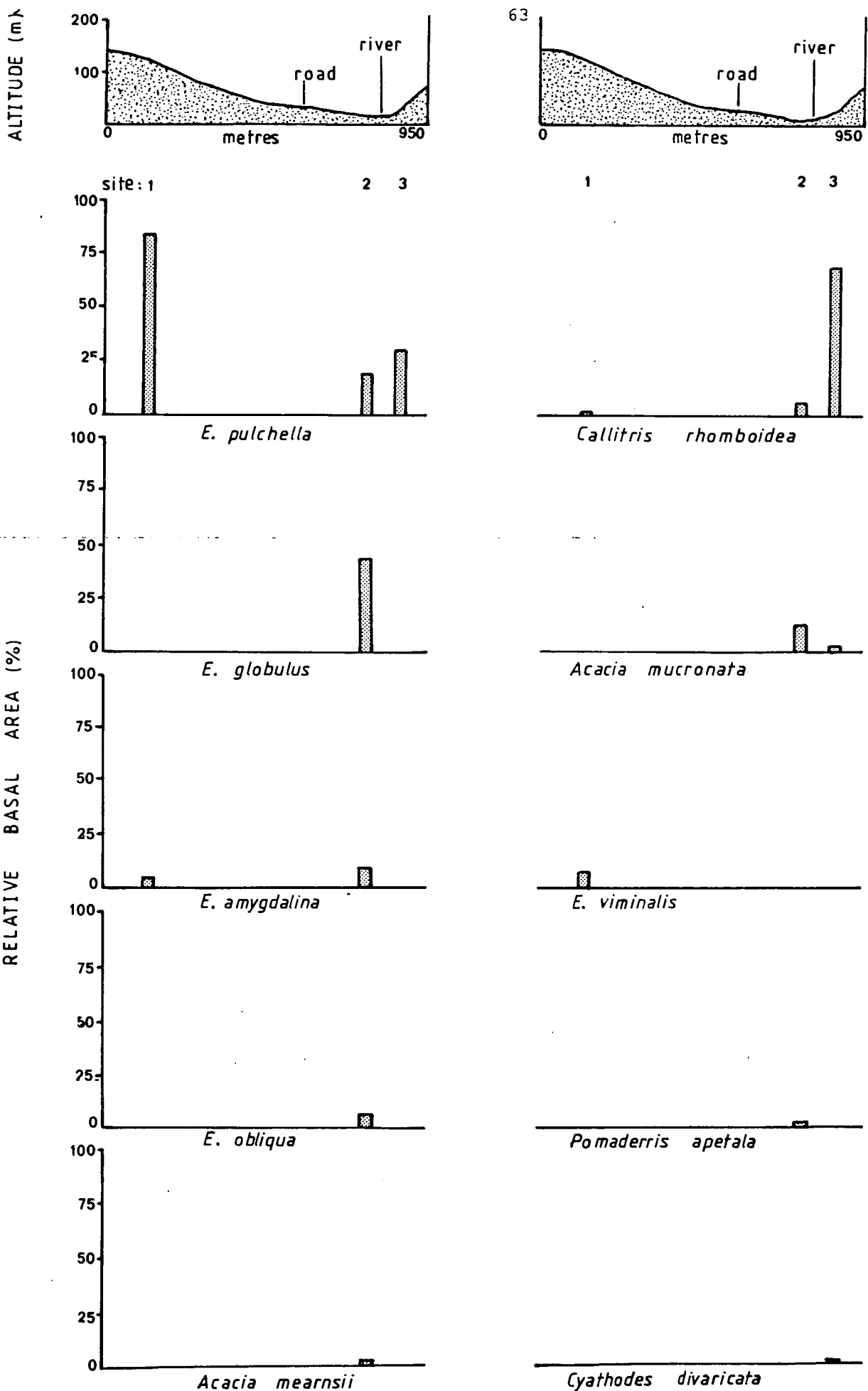
Figure 4·4 Topographic cross section at the Prosser River showing variation in the relative basal area of the major tree species (basal area >1%) at three sites.
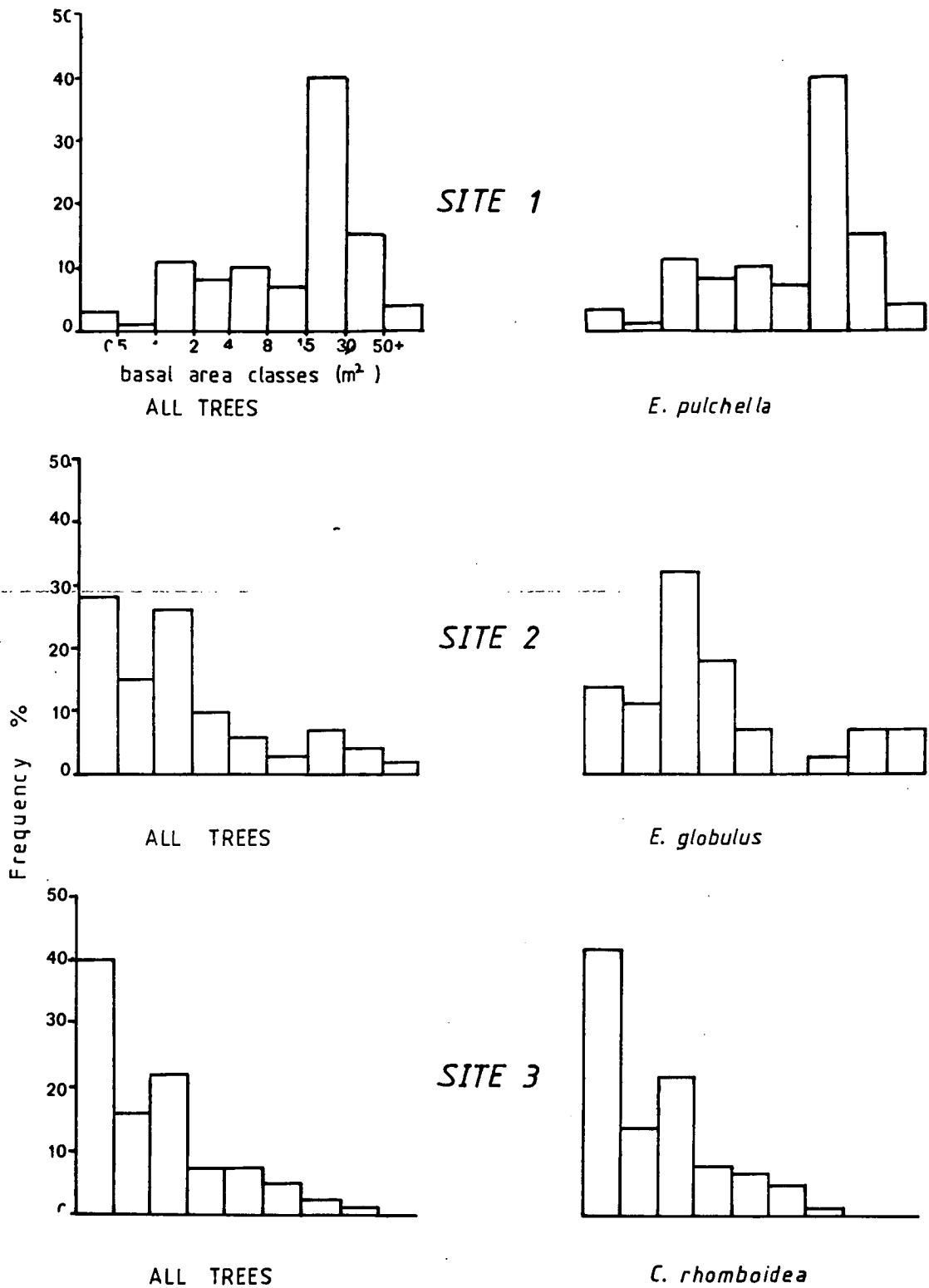
Figure 4·5 Size class distribution of the basal area (m²) by stand, for the dominant species and for the total tree species, at three sites at the Prosser River.
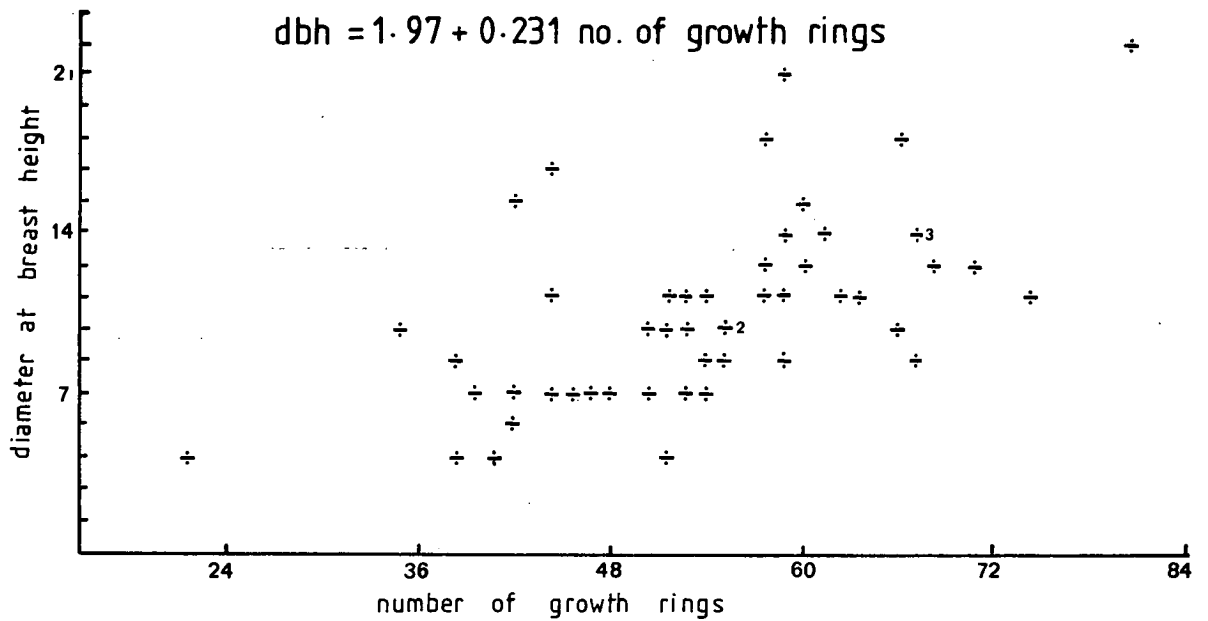
Figure 4·6 Regression of diameter (dbh) on number of growth rings (correlation = 0.614, p < .0001) for data from Cape Tourville.
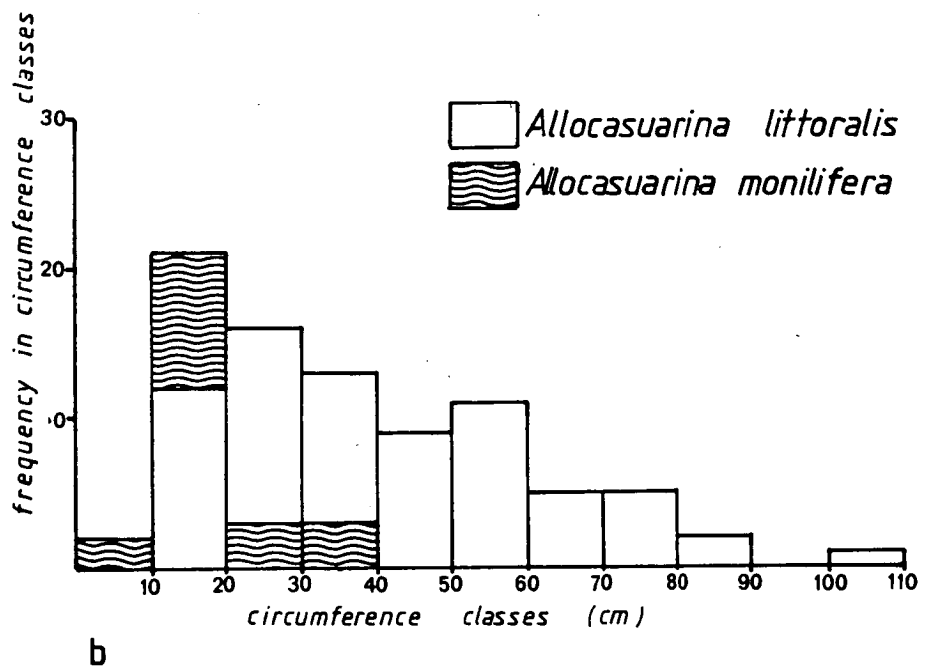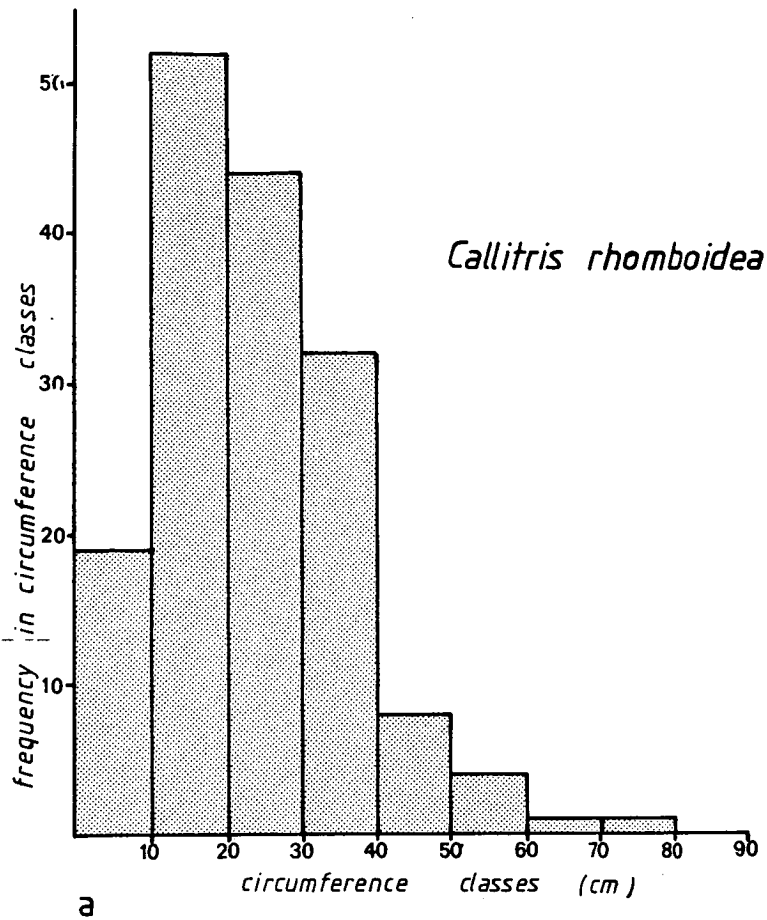
Figure 4·7 a & b Frequency in circumference classes, in a forest at Cape Tourville of - a: *Callitris rhomboidea* , b: *Allocasuarina littoralis*, *Allocasuarina monilifera*
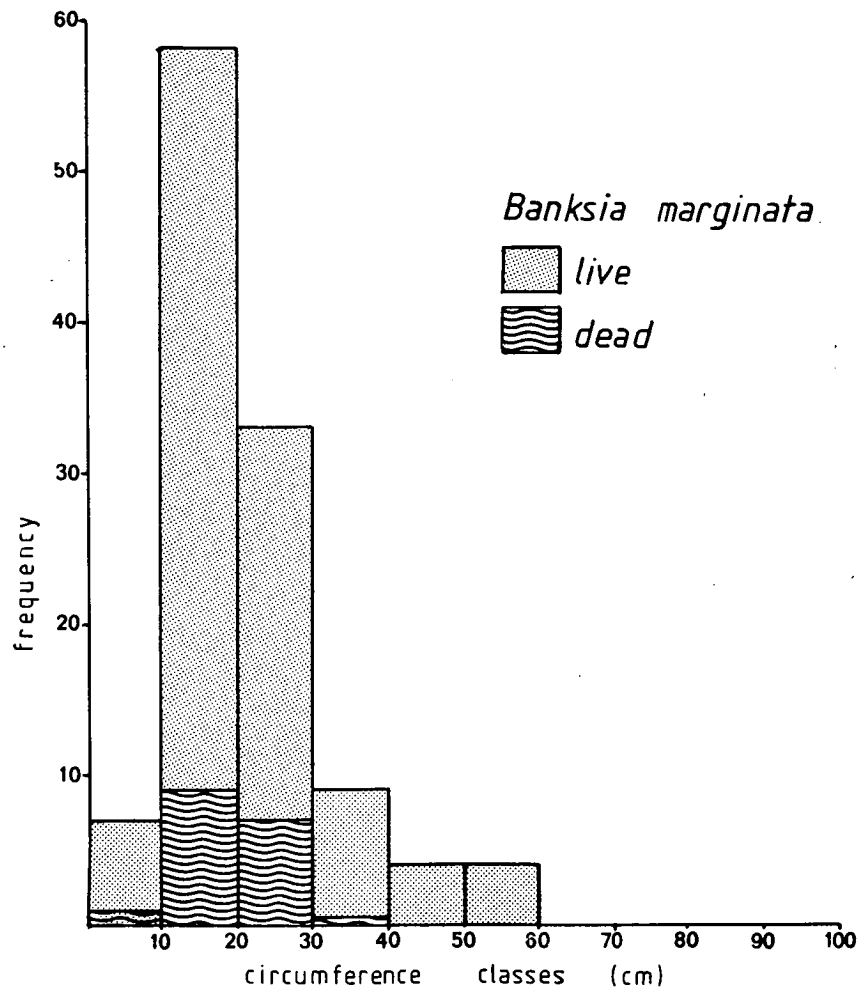
Figure 4·8   Frequency in circumference classes of live and dead *B. marginata* in a forest at Cape Tourville.

(a) *E. amygdalina*

trees

circumference classes (cm)

seedlings

height classes (cm)

(b) *E. tenuiramis*

trees

circumference classes (cm)

seedlings
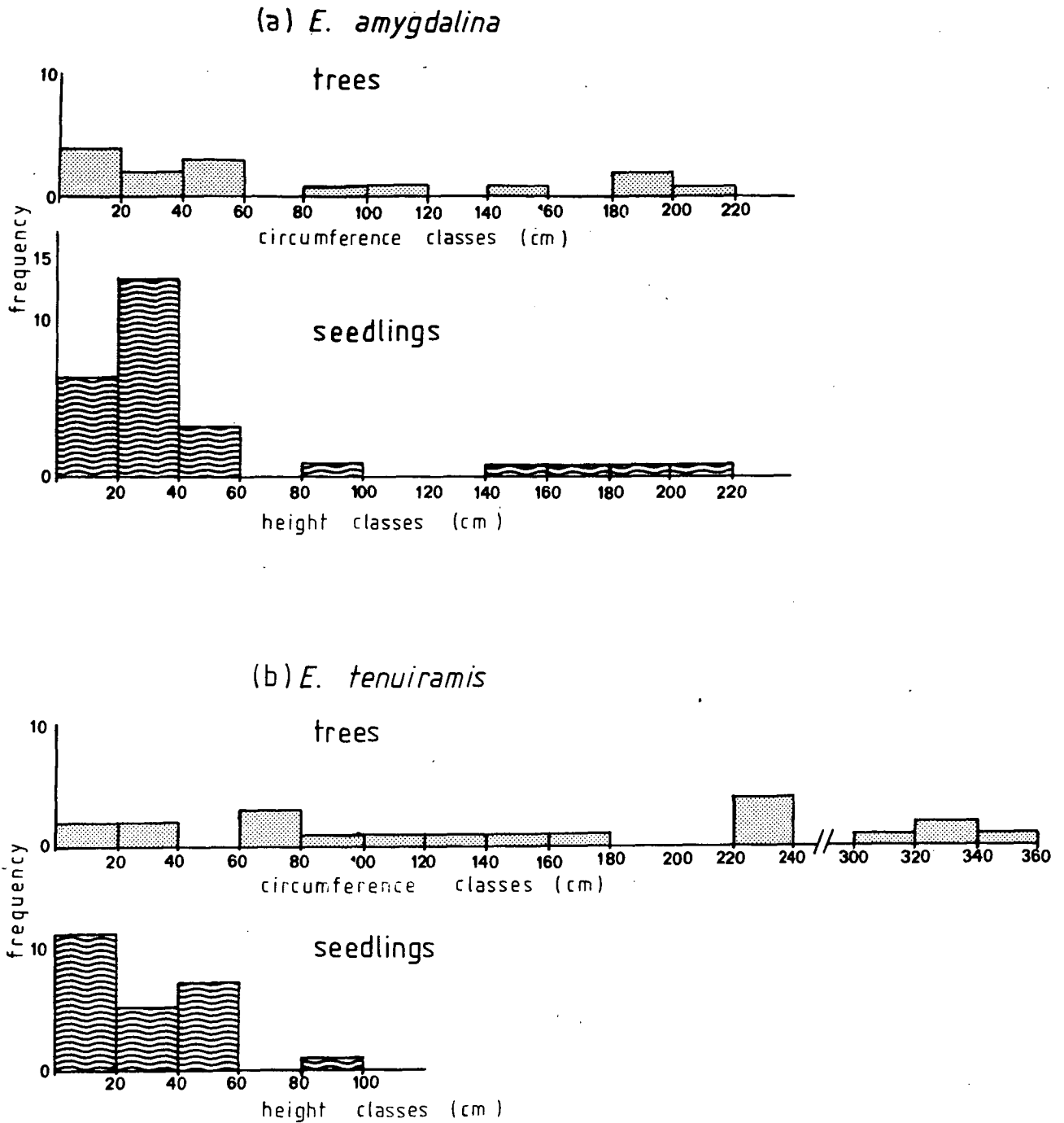
height classes (cm)

Figure 4·9 a & b Frequency of tree stems and seedlings in circumference and height classes respectively, for (a) *Eucalyptus amygdalina* and *E. tenuiramis*, in a forest at Cape Tourville.
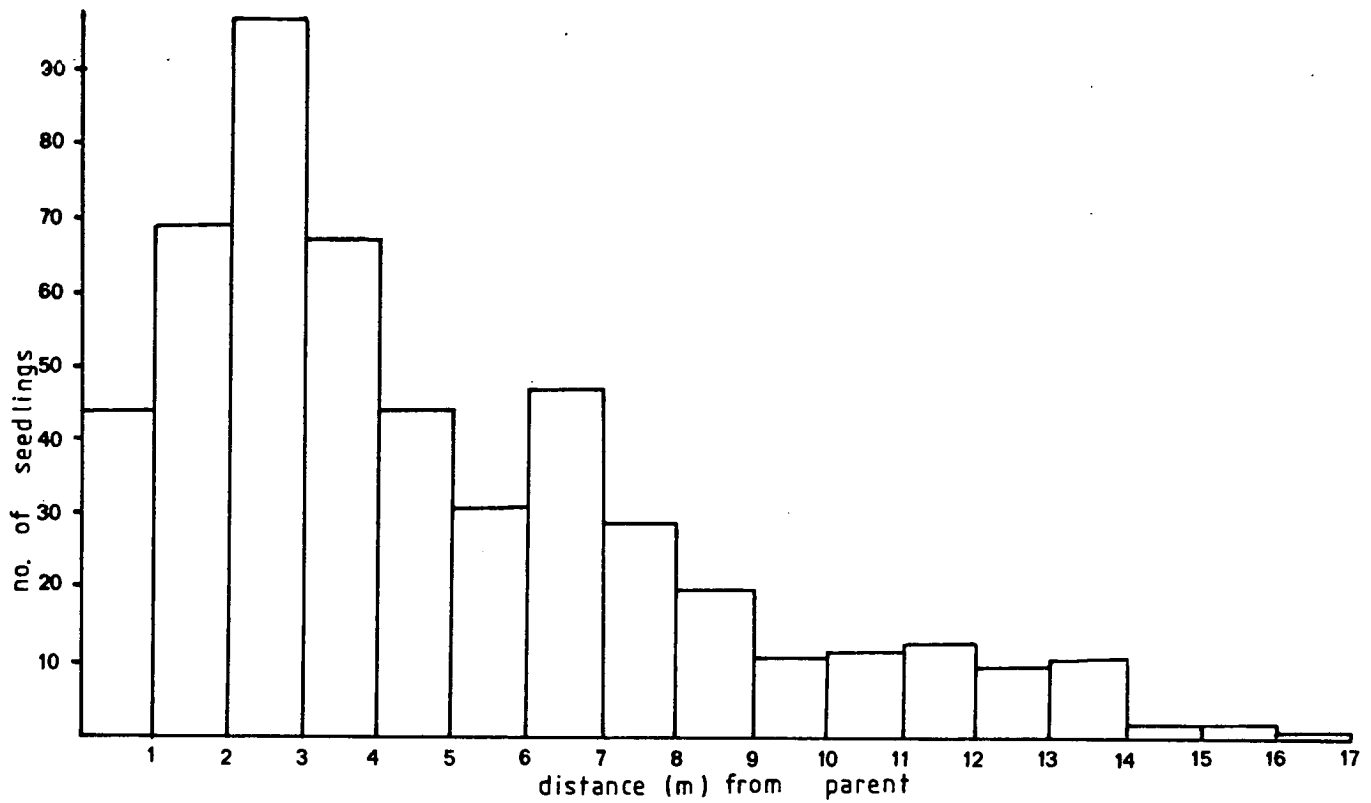
Figure 4·10 Frequency of total seedlings on all transects from all parents in one stand.
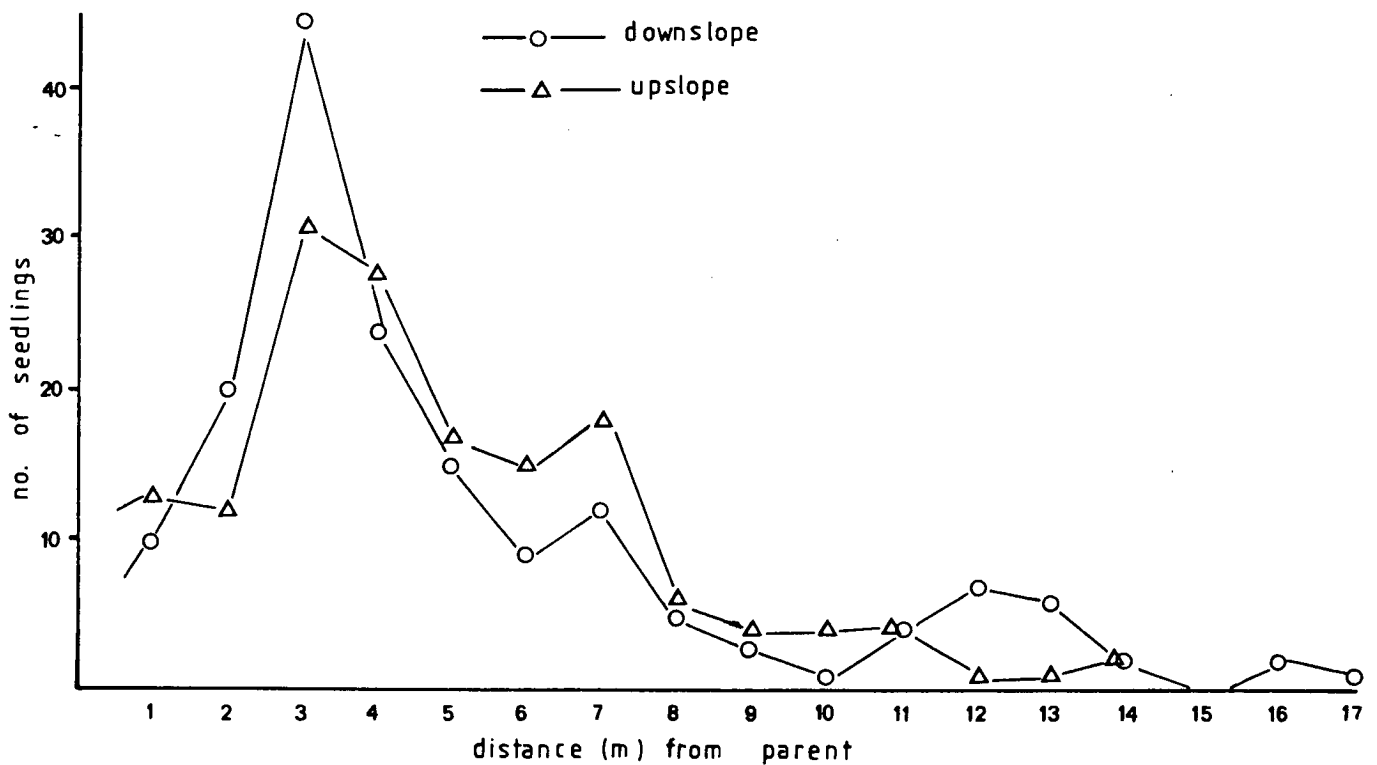
Figure 4·11 Frequency distribution of seedlings on all upslope and all downslope transects.
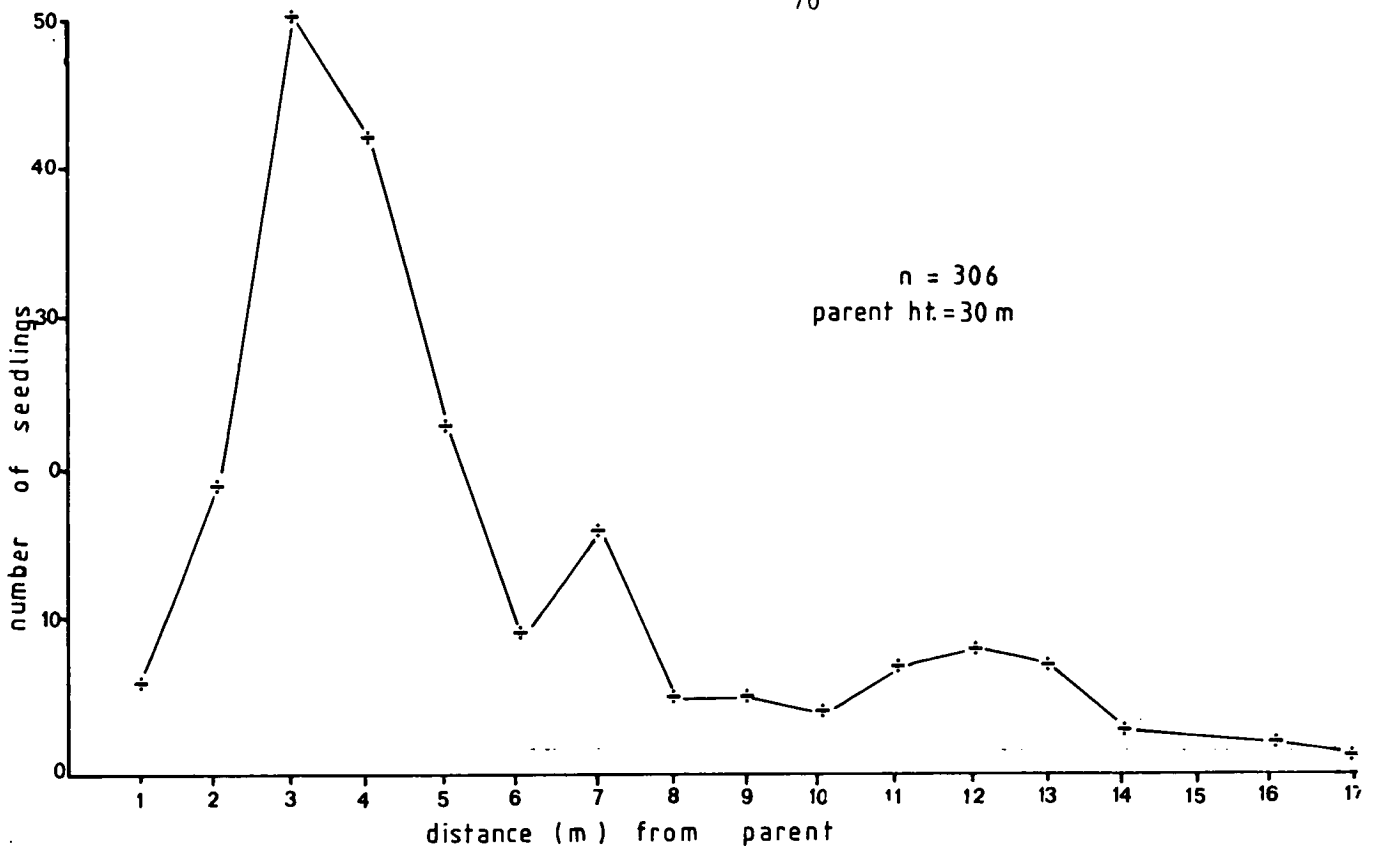
Figure 4·12 Seedling frequency and distance along combined transects from a putative parent 30 m ht.
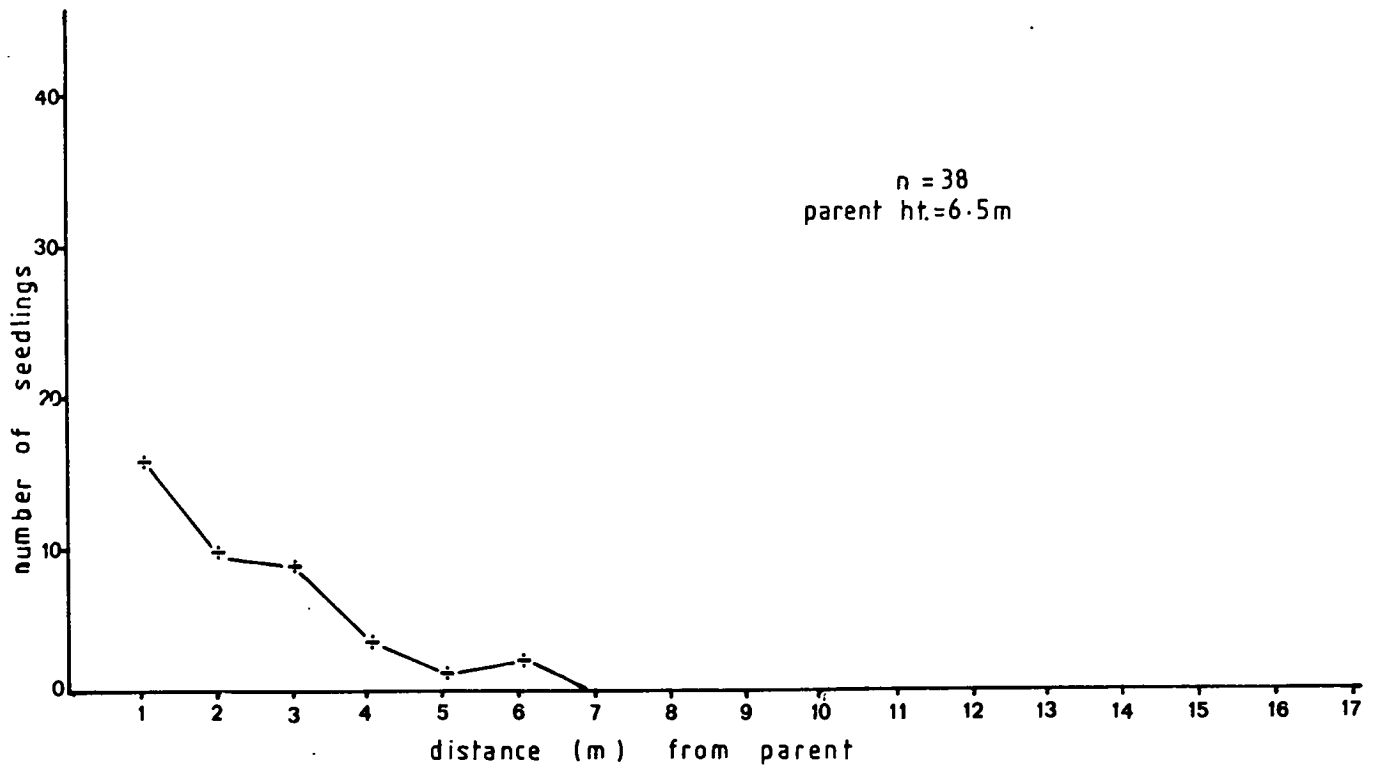
Figure 4·13 Seedling frequency and distance along combined transects from a putative parent 6·5 m ht.
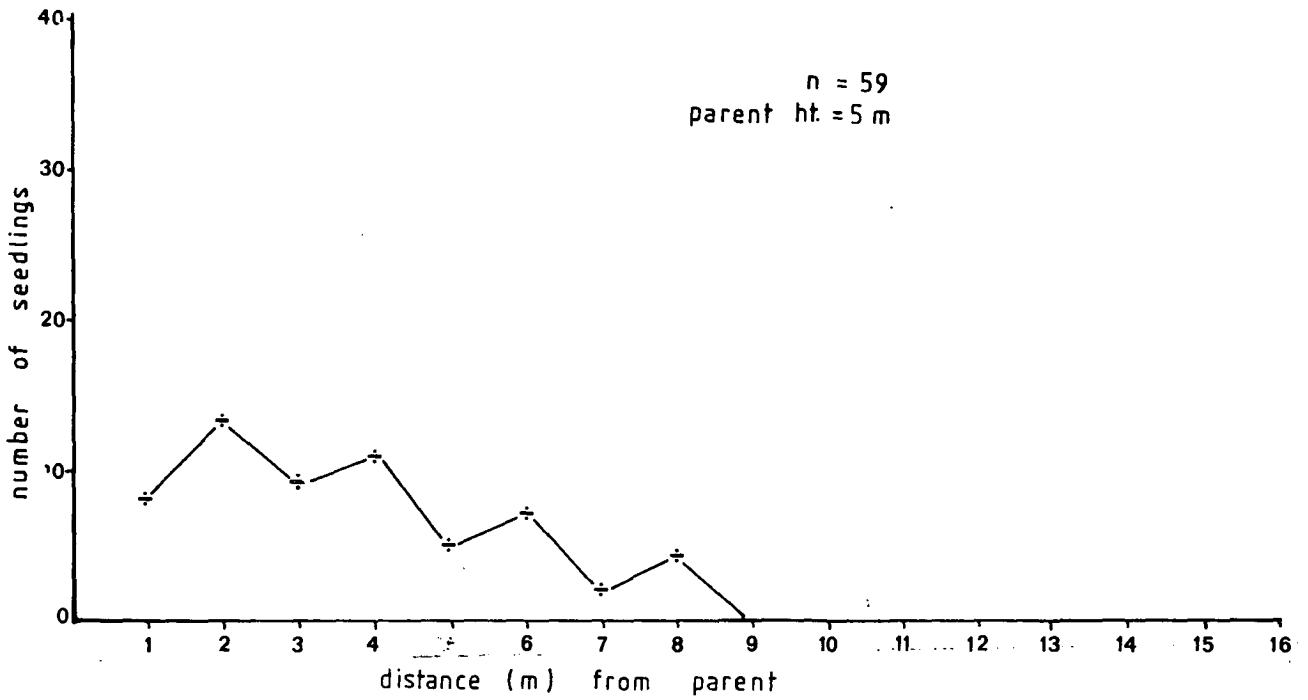
Figure 4.14 Seedling frequency and distance along combined transects from a putative parent 5m ht.
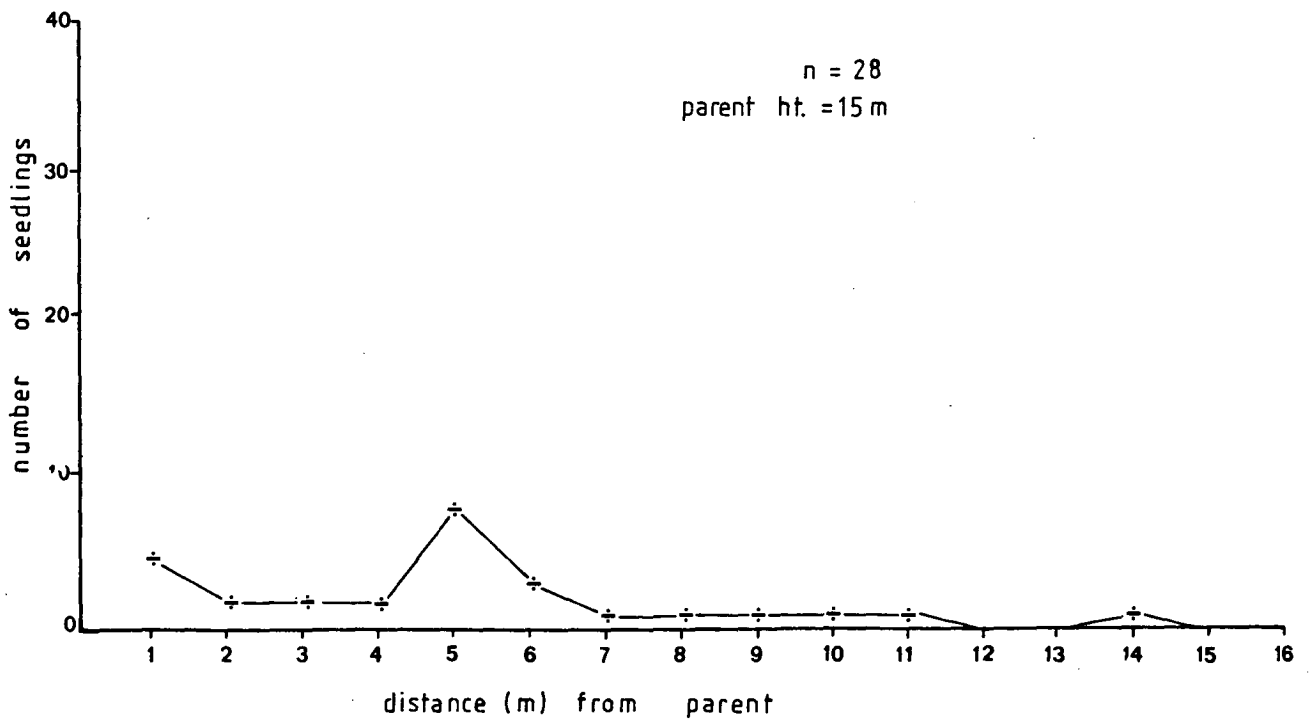
Figure 4.15 Seedling frequency and distance along combined transects from a putative parent 15m ht.

(ii) *C.oblonga*

Discs were cut from basal sections and polished, revealing clearly the annual rings. The frequency of sectioned individuals in different age group classes is shown as Figure 4.16.
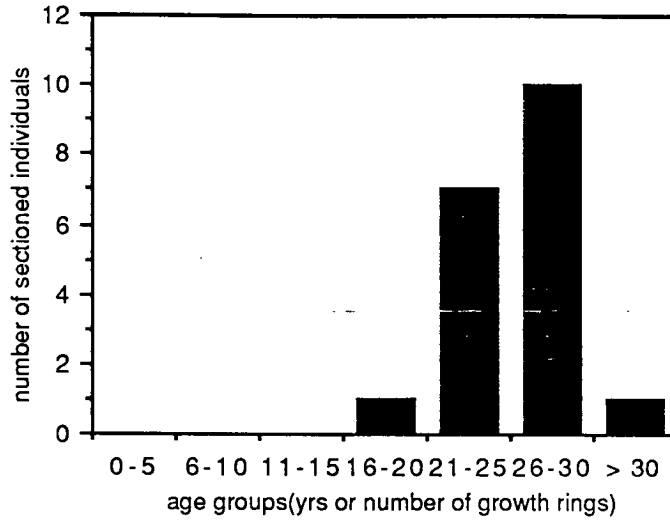
Figure 4.16

Frequency of stems in different age classes for Milford Hole *C.oblonga* data

The stand has a distinctly clumped age structure with most individuals around 28 years old or 23 years old. A scattergram showing height diameter relationships of trees (see Figure 4.17) has upper and lower boundaries to the scatter points which diverge away from the origin. The greater the heights of the trees the greater the difference in accrual of diameter increment between trees of similar height.
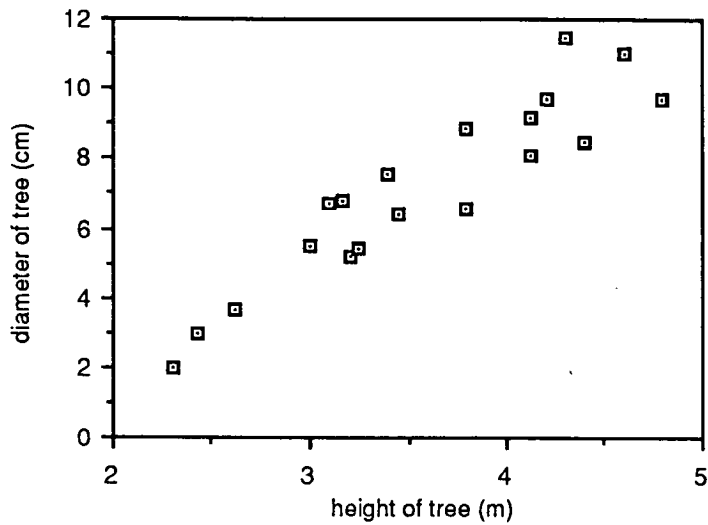
Figure 4.17

Scattergram of tree diameter against height for
Milford Hole *C.oblonga* data

Height of trees and number of seed cones were graphed (Figure
4.18). The two variables were highly correlated (correlation
coefficient = 0.783).

Figure 4.19 shows basal diameter plotted against number of
growth rings (age in years) which shows that diameter
increases at a declining rate with age (correlation
coefficient = 0.74).

The stem frequency in diameter classes for the transect at the
Apsley River is portrayed as a histogram (see Figure 4.20) and
shows a rapid decline in membership of older size classes,
particularly beyond 4.5 cm diameter.

The transect however, traverses two broad cohorts, the older
of which are up to 5 m high and appear fairly even aged.
Nodal counts on two *Banksia marginata* gave ages of 28 years
and 24 years. A younger cohort is associated with a *Banksia
marginata* which gives a nodal count equivalent to 11 years of
age.
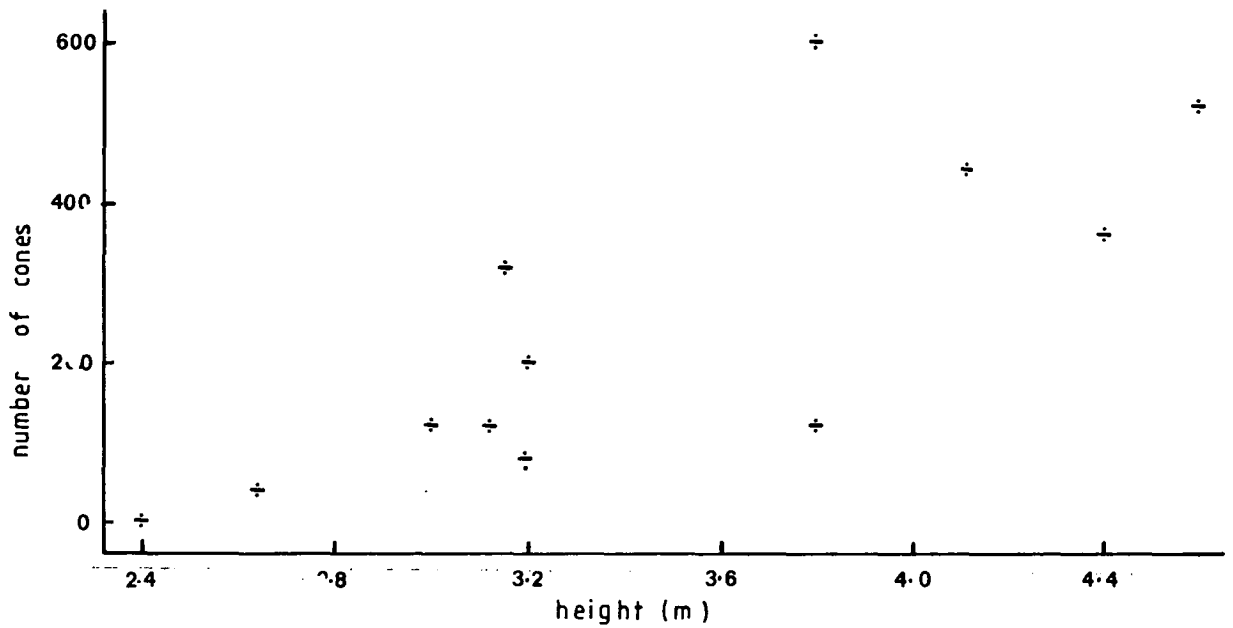
Figure 4·18 Height against number of cones for *C oblonga* data, Milford Hole. Correlation coefficient = 0·783
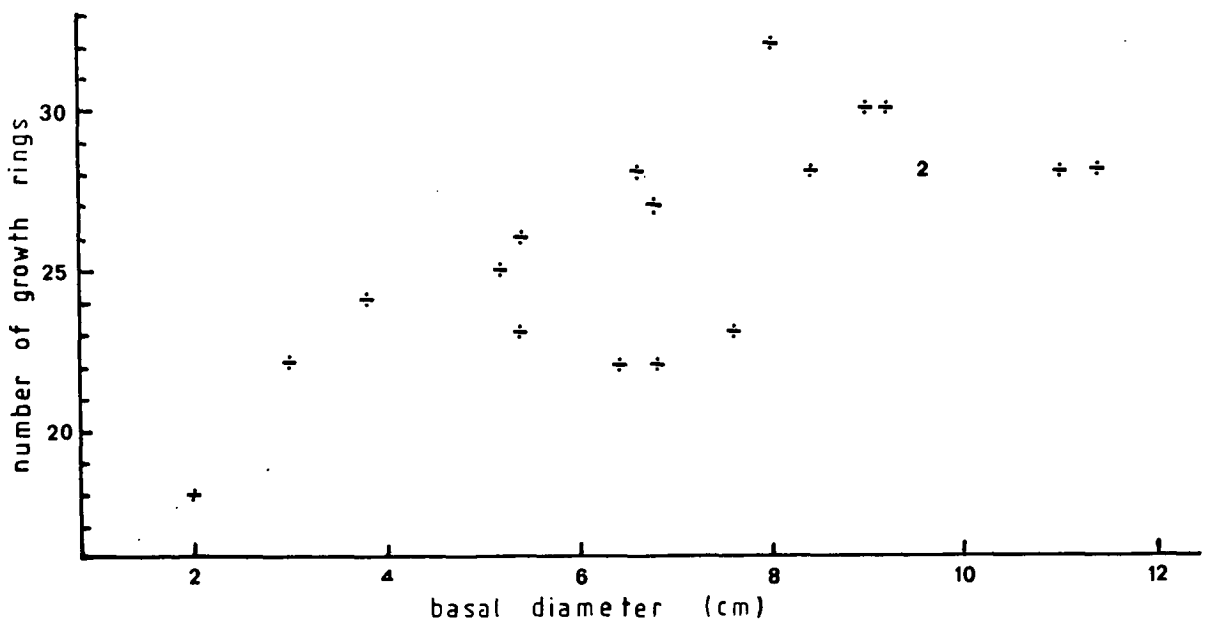
Figure 4·19 Basal diameter against number of growth rings for *C oblonga* data, Milford Hole. Correlation coefficient = 0·740
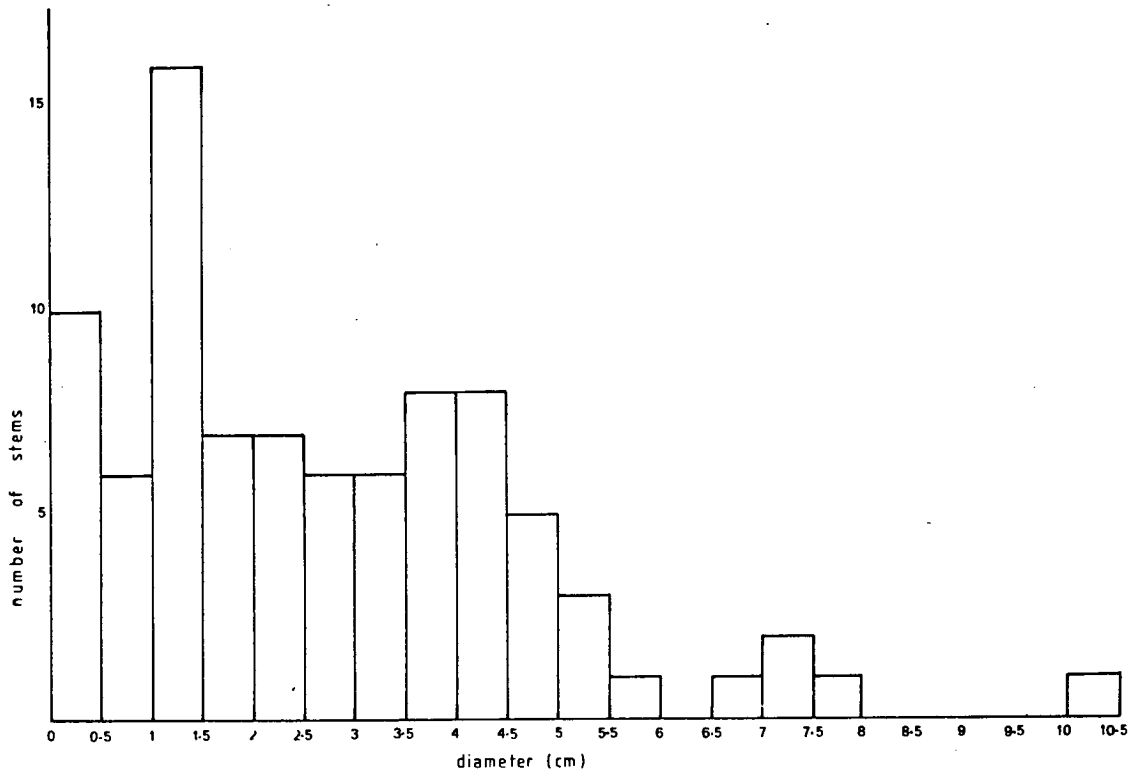
Figure 4·20 Numbers of *C. oblonga* stems in various basal diameter classes along a 49·5 m transect, Apsley River near Coles Bay Rd.

(iii) Vegetative reproduction : *C.rhomboidea* and *C.oblonga*

No evidence was discerned for vegetative reproduction in *C.rhomboidea*. Soon after planting, the *C.rhomboidea* cuttings began dying and after 20 days all were clearly dead (completely browned off). The *C.oblonga* cuttings began dying more slowly, but even after 150 days there were four survivors (completely green and supple foliage). Examination of exhumed cuttings at that stage showed incipient root development. It was apparent from field observation that all reproduction was from seed. *C.oblonga* however, appeared potentially analogous to *Lagarostrobos franklinii* in having a largely riverine distribution (with rare exceptions). The pattern of its distribution hinted at possible downstream propagation of foliage fragments or branch twigs, as has been observed with *Lagarostrobus franklinii*.

4.4 Discussion

Results indicate that *C.rhomboidea* is capable of continuous self regeneration as shown by the classic reverse 'J' curves in stands which are protected from heavy exotic animal grazing and high fire frequency. Confident assumptions about a particular stand based on single transects cannot be made but the basal diameter classes shown in the Piermont histogram (Figure 4.2) indicate a tendency to a reverse J curve effect but with a marked paucity of plants in the smallest measured class. This whole stand gives the appearance of a dense even aged stand with many suppressed individuals. Sheep graze the understorey and there are no seedlings which survive beyond 2 or 3 cm height. The histogram is consistent with this. Ogden (1985) says that "skewed size frequency distributions, with a predominance of small stems and progressively fewer in larger classes, can represent stable self-replacing 'climax' populations (size=age), or even-aged thinning hierarchies (size ≠ age)". Age estimates from many trees need to be gathered to decide

between these extreme possibilities. The other alternative is that an uneven aged natural stand not affected by grazing had established when trees now in the 4-6.9 cm were small seedlings. This may have been anywhere between ±20 and ±40 years prior to 1988 if the diameter/age graph of Cape Tourville trees was used as a guide.

At Rosedale Road, the site is a very rocky broken dolerite knoll amidst the forest that has probably traditionally been rough grazed by sheep. There are larger numbers of young trees in the <7 cm diameter classes. The site is such that many seeds would fall on the ground unlikely to support tree growth because of lack of soil. A high proportion of seeds may fall onto skeletal soil in narrow cracks where they may germinate and grow to a few centimetres height but then die through drought stress or insufficient soil. Once individuals were established however, they would have had a high chance of survival because the rockiness of the knoll provides good fire protection. The single stepped nature of the Rosedale data implicates sheep grazing effects at some stage. If this histogram is a reverse J curve then present age classes between 7 and 22 cm are deficient in *C.rhomboidea* individuals. Rough extrapolation from the Cape Tourville age/diameter data would indicate a deficiency of trees between ±50 and 70 years of age i.e. grazing may have been a significant factor on the block between the 1st and 2nd World Wars.

The role of grazing is significant. The events prior to this study allowed comparison of the effects of grazing. Sheep had run on Schouten Island until 1978 when they were removed by the lessee at the request of the National Parks and Wildlife Service. *E.rhomboidea* had previously occurred as scattered trees through the understorey of the eucalypt forest on the western part of the island and on the eastern part in gullies. No macropods occur on the island . After sheep were removed there was noticeably prolific regeneration of *Callitris* (pers.comm. H. Johnstone, Ranger, Freycinet National Park) on

the western part of the island. On Maria Island (where macropods are abundant), sheep were removed in 1982 and prior to this the grassy open forests (Brown and Bayly-Stark, 1979) of the western foothills of Mt Bishop and Clerk and Mt Maria had many scattered older trees of *C.rhomboidea*. After removal of the sheep regeneration of *Callitris* was notably abundant (pers.comm. A.Febey, former Ranger-in-Charge). This supports the view that sheep rather than native animals are the most deleterious grazers of *Callitris* seedlings, because sheep tend to chew off plants close to the ground while native animals nibble at them without destroying the whole plant.

Seedling *C.rhomboidea* are very susceptible to browsing. The seedlings are prickly to the touch and this is caused by leaves projecting at right angles to the stem. Decurrent leaves are developed as the seedling gains height (i.e. >10-20cm). This foliage dimorphism cannot be an effective defence against native browsing animals because chewed seedlings have been observed in many places. In numerous cases seedlings or young trees were observed growing in situations where browsing protection was provided by fallen limbs or branch litter. Howevever, unprotected seedlings in areas subject to sheep grazing are very rarely observed but at similar sites where there are only native browsers, seedlings may be common. Browsing defences could have naturally co-evolved with native browsers but do not appear to be effective against sheep.

The stand demography of *C.rhomboidea* is strongly related to fire history, browsing and physical disturbance of any particular stands. Continuous regeneration is commonly observed in natural stand in situations where eucalypts fail to regenerate. The species has serotinous cones from which seed is released after death of the tree or the branch containing the cones. A very few cones open and release seed at any time for reasons which are not apparent.

C.oblonga exhibits both pulse regeneration as shown in the St Pauls River data and continuous regeneration as observed in a number of stands and localities. It is clear from the Apsley River site that seedlings are unable to grow under the dense canopy provided by a mature stand of *C.oblonga* but once burnt the large store of seed locked in the stand will produce a new cohort which will show differential growth in the very competitive early stages of life, therefore giving the appearance of different age classes. Presumably once this new cohort achieves some height and high canopy coverage, the understorey will become depauperate in *Callitris* recruits as well as other species.

The stand examined on the lower Apsley is one of the best 'pure' stands in existence and occurs on flat alluvium. Almost equally good stands occur on the St Pauls River although there the canopy is often broken up. The examples of continuous regeneration are especially noticeable on the east coast rivers where the riparian environment is very variable and rugged. Seed would probably be carried downstream from flood damaged or dying trees where it lodges in suitable niches such as crevices in rocky floodplain terraces. Young trees of different ages are observed in such niches because there is little apparent competition for space and light.

Shading may be a significant factor determining seedling survival because uneven age stands of *C.oblonga* were only observed in open conditions such as on flood plain areas. In the few dense stands on good soil, no apparent seedling regeneration could be observed. At the Lower Apsley River site, no seedlings whatsoever occur under the older cohort of trees.

It is clear that both *C.rhomboidea* and *C.oblonga* are capable of continuous regeneration in particular circumstances. However, only C.rhomboidea seems capable of regenerating in shade. Both also regenerate as a result of disturbance such

as fire, and if there has been a large above ground seed bank, the new seedling cohort will be dense. For both species there are good positive correlations between seed cone production and age.

CHAPTER 5

SYNECOLOGY OF CALLITRIS COMMUNITIES

5.1 Introduction

The range of habitats of the two *Callitris* species has never been adequately described, although detailed field notes on *C.oblonga* habitats are contained in Moscal (1980-84). The only published references to the habitat of *C.oblonga* are brief observations of its occurrence on riverbanks or floodplains (for example Kirkpatrick, Brown and Moscal, 1980, Baker and Smith, 1910).

Duncan and Brown (1985) recorded *C.rhomboidea* in four eucalypt dominated communities and one *Allocasuarina* community while *C.oblonga* was reported in a different eucalypt community.

No comprehensive account of *Callitris* communities in Tasmania has been made because they have been incidentally recorded as part of broader studies (Duncan and Brown 1985, Kirkpatrick 1977) or mentioned in studies of restricted areas (for example Duncan and Duncan 1984, Harris and Brown 1980). Perhaps there has been a perception that the species are understorey or secondary layer species which could never form distinctive forests or dominate in pure Callitris formations like some western Tasmanian gymnosperms.

The aims of this chapter are:
(i)   to investigate the floristic variation within communities containing *Callitris* across the Tasmanian range of the two species,
(ii) describe and compare the environments of the two *Callitris* species across their Tasmanian ranges,
(iii) search for any unoccupied niches within sections of broad environmental gradients occupied by the two species.

5.2   Methods

(i)   Data   Collection

During the summers of 1986/87, 1987/88 and 1988/89, data were
collected from 126 10 metre by 10 metre quadrats containing
either *C.oblonga* or *C.rhomboidea*, throughout the Tasmanian
range of both species.   Sampling was stratified to aim for at
least one quadrat in each 10 km² grid square over the
distribution of the species.   Quadrats within each 10 km² were
allocated according to the "subjective without preconceived
bias" approach described in Mueller-Dombois and Ellenberg
(1974).   The uneven and highly variable nature of the
distribution of the two species meant that some grid squares
had many quadrats while others had few or none.   The
distribution information was refined during the course of
gathering quadrat data.

In each quadrat, presence of all vascular plants was recorded
in addition to observations on vegetation structure, fire
history and site conditions.   The site data recorded was:

slope: estimated according to classes, occasionally
            checked with a Suunto clinometer

landform: described and later assigned to one of 13 classes

altitude: taken from 1:100,000 or 1:25,000 Tasmap sheets to
            nearest 20m

drainage: described according to simple classes

aspect: measured with a Suunto compass or taken from the
            relevant Tasmap sheet. Later assigned to classes
            according to insolation levels

soil texture: described according to categories given in
            Corbett (1969)

pH: measured by CSIRO (Inoculo Laboratories) field
            testing kit

soil depth: described by simple classes

degree of fire protection: descriptive notation. Where
            possible, the time since the last fire was

estimated using node counts on Banksia marginata (Brown and Podger, cited in Bell 1983).

(ii) Numerical Analysis

(i) The floristic data set was stored on ECOPAK (Minchin, 1986). The data was subjected to a polythetic divisive classification analysis called TWINSPAN (Hill, 1979) which orders quadrats according to similarity of species compositions, then splits the quadrats into 2 groups which each consist of half the variation along an ordinal similarity-dissimilarity scale. Each group thus produced is then successfuly split in the same way. This splitting was carried out to the requested 6 levels of division.

(ii) A detrended correspondence analysis, DECORANA (Hill and Gauch, 1980) was carried out on species and quadrats to explore the relationships in the data. Ordination scores for quadrats were plotted against each other to gain some idea of the meaning of the axes, and the degree of sorting of groups along these axes. The species ordinations were not plotted but were used in their raw form to assess the environmental meaning of the axes.

(iii) An ordered percentage frequency table was prepared to show the importance of species in the TWINSPAN groups.

(iv) The groups were sorted in a one way analysis of variance using a Minitab program. The resulting population means were graphed within their 95 percentile limits.
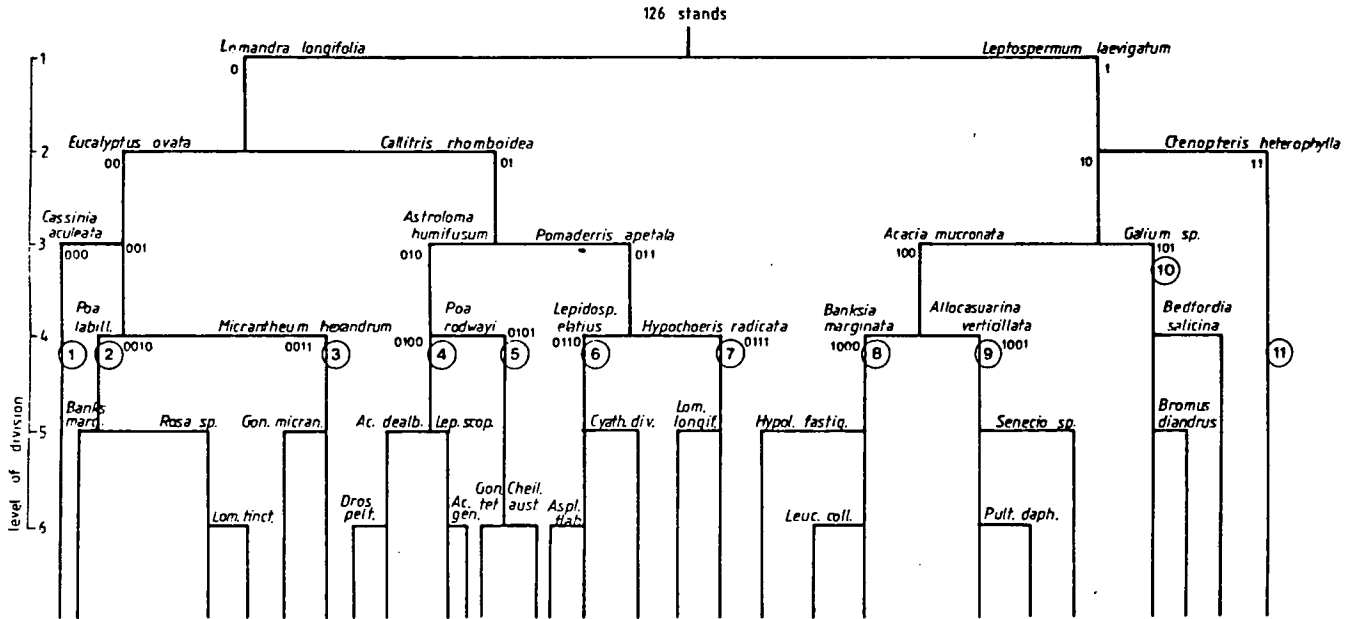
Figure 5.1 : Dendogram of the TWINSPAN classification of the 126 sample quadrats. Examples of the indicator species at each division are shown. The groups chosen for explanation are those circled numbers just below the fourth level of division, except group 10 which is below the third level of division. Species abbreviations are: *Poa labill* - *Poa labillardieri*, *Lepidosp.elatus* = *Lepidosperma elatius*, *Banks. marg.* = *Banksia marginata*, *Gon. micran* = *Gonocarpus micranthus*, *Ac. deal.* = *Acacia dealbata*, *Lept. scop.* = *Leptospermum scoparium*, *Cyath. div.* = *Cyathodes divaricata*, *Lom. long* = *Lomandra longifolia*, *Hypol fastig.* = *Hypolaena fastigiata*, *Lom. tict.* = *Lomatia tinctoria*, *Dros. pelt.* = *Drosera peltata*, *Ac.gen.* = *Acacia genistifolia*, *Gon. tet.* = *Gonocarpus tetragynus*, *Cheil. aust.* = *Cheilanthus austrotenuifolia*, *Aspl. flab.* = *Asplenium flabellifolium*, *Leuc. coll.* = *Leucopogon collinus*, *Pult.daph.* = *Pultenaea daphnoides var obcordata*.
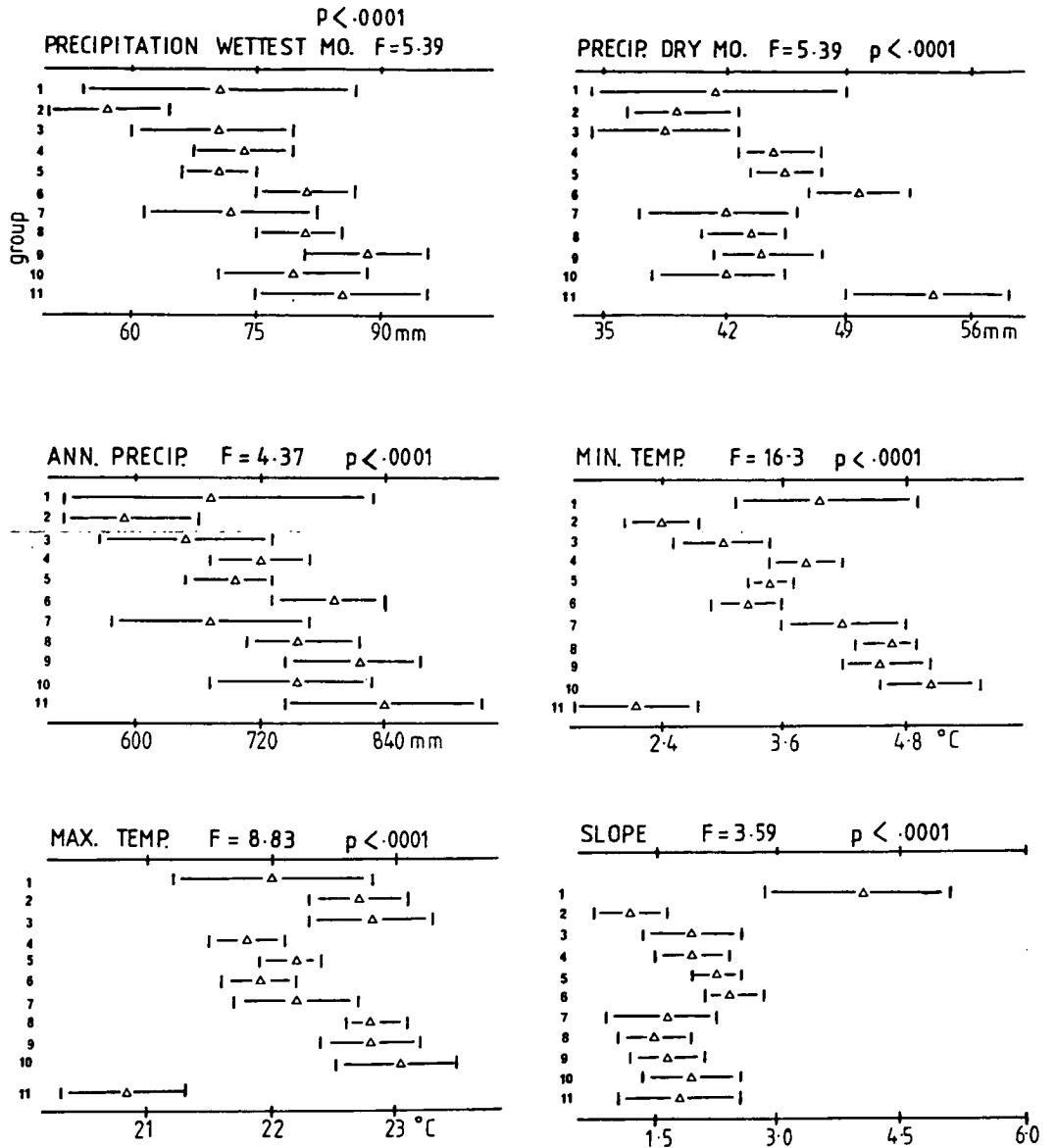
Figure 5.2 Results of a one way analysis of variance of 6 variables over 11 groups. The bars for each group represent the spread of samples in that group within the 95 percentile range. The greater the F score, the greater the discriminating power which the variable has in sorting groups. All probabilities are highly significant.
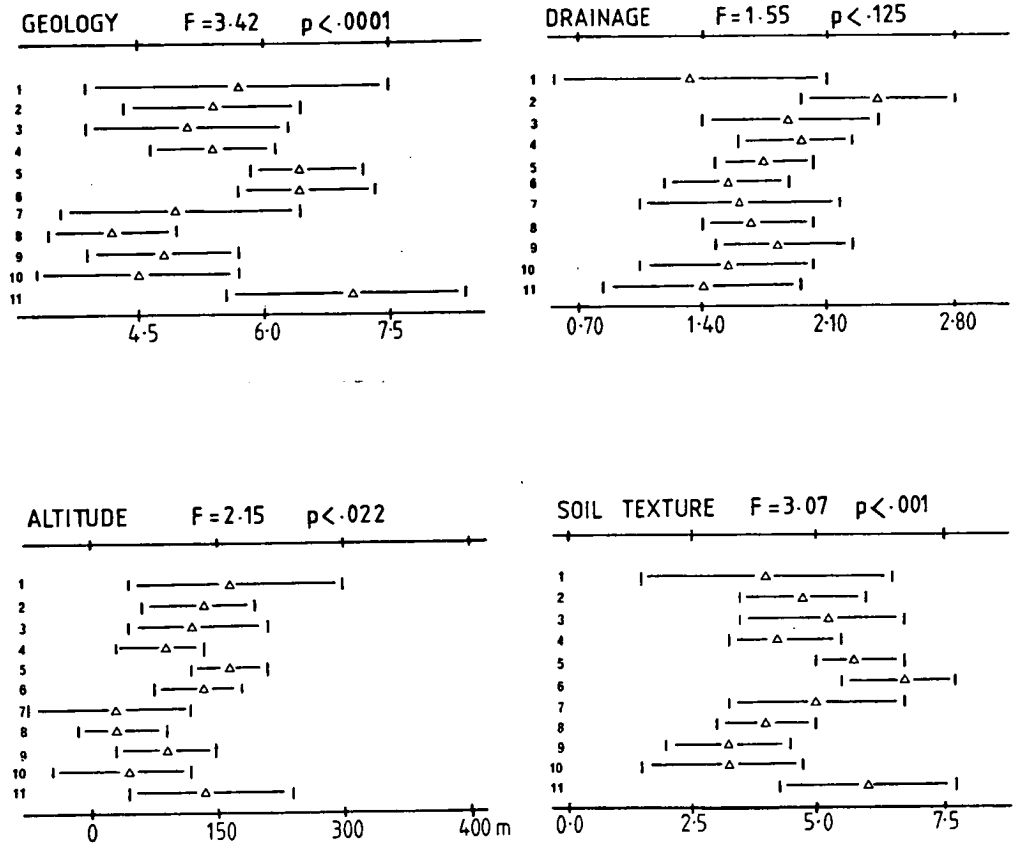
Figure 5.3 Results of a one way analysis of variance of 4 variables, over 11 groups. The bars for each group represent the spread of samples in that group within the 95 percentile range. The great the F score, the greater the discriminating power which the variable has in sorting groups. Note that drainage has the lowest probability value but is still important in discriminating group 2 from several other groups.

5.3 Results and Discussion

The TWINSPAN analysis produced a 6 level hierarchical classification (Figure 5.1). The groups chosen for detailed description as convenient classificatory groups are those resulting from the fourth level of division, except that group 10 was taken below the third level of division. The environmental basis of the main divisions is discussed in general terms below followed by descriptions of the selected classificatory groups.

At the first division, the data set was divided into mainland Tasmanian/inland sites on the left hand side of the division (0) and Furneaux/coastal quadrats on the right hand side, (1), which also contained a group of very wet sites. At the second level of division the left hand group of quadrats was divided into quadrats occurring on poorly drained (00) and well-drained sites (01) respectively while the right hand group was divided into quadrats in areas with high precipitation (11) and those in areas of low precipitation (10) The early separation of the wet group, indicated by *Ctenopteris heterophylla*, underlines the distinctiveness of this community which was called Group 11.

At the third level of division a small group (000) was split from the poorly drained set on the likely basis of higher pH, greater phosphate nutrification and greater numbers of weeds. This formed descriptive Group 1. The division of the "well-drained group" could be best explained by topography with the quadrats of rocky dolerite knolls, talus slopes and ridges and slopes with shallow soils on the left hand side (010). Some of the quadrats however, included deep well-drained sands or gravels near the coast.

The group of quadrats on the right hand side (011) of this division are floristic groups representing more subdued topographic situations such as valley bottoms and banks of small creeks.

On the right hand side of the diagram, the predominantly Furneaux Island flora included some floristic groups growing on coastal granite sites from the central east coast. The subsequent division of this group is probably best explained by pH with those species groups of lower pH on the left (100) with the other floristic group (101) having a higher pH and being characterised by generally shallower soils and rockier, more fire protected sites (descriptive Group 10).

At the fourth level of division the "poorly drained group" comprised mainly *C.oblonga* quadrats and split clearly on the basis of flora of floodplain sites (0010), indicated by *Poa labilliardieri* on the left hand side (descriptive Group 2) and flora of riparian sites (0011), indicated by *Micrantheum hexandrum* on the right side (descriptive Group 3). The generally well drained sites on the left hand side are split on the probable basis of drainage (0101, descriptive Group 5) and rockiness (0100, descriptive Group 4). The generally well-drained sites on the right hand side are split on the basis of distance from the coast and altitude with non coastal higher altitude quadrats on the left (011) indicated by *Lepidosperma elatius* (descriptive Group 6) and very coastal low altitude quadrats on the right (0111) indicated by *Hypochoeris radicata*. Deeper alluvium, sands and gravels typify descriptive Group 7 which also has a markedly higher incidence of alien species within quadrats, indicating a disturbance factor.

On the right hand side of the primary division of the dendrogram, the mainly Furneaux Group/granite quadrats are divided on the basis of fire protection, topography and soil depth or an interaction of these. Quadrats of descriptive Group 8 on the left (1000), indicated by *Banksia marginata*

generally occupy sandy coastal plains with generally more acid deeper soils and better local protection from fire than descriptive Group 9 quadrats on the right (1001), indicated by *Allocasuarina verticillata* which mainly had only slight fire protection and generally higher pH.

Each of the 11 groups is described in more detail below.

Group 1
Callitris rhomboidea (C.obliqua) under *Eucalyptus* and *Allocasuarina* woodlands and shrublands.

This community was sampled by 3 quadrats - one on Taillefer Rock, one on a sandy islet in Moulting Lagoon, and one on the St Pauls River. The only species occurring in all three quadrats was *Poa labillardieri*. Other common species were *Acacia dealbata, Cassinea aculeata, Holcus lanatus* and *E.viminalis*. The species lists of the quadrats indicate that disturbance may be a factor in defining this group. Exotic species are common and include *Rosa* sp., *Cirsium vulgare* and

Group 2

Callitris oblonga under *Eucalyptus ovata (E.viminalis, E.amygdalina)* woodlands.

This group is represented by 10 quadrats sited mainly on the St Pauls River but with one on the South Esk and one quadrat each at the Grange Rd and the Apsley River.

Apart from *C.oblonga, E.ovata* is the most frequent species indicating the generally poor drainage or long periods of waterlogging of the sites. Other common species are *Poa labillardieri, Lomandra longifolia, Schoenus apogon, Leptospermum lanigerum* and *Epacris impressa,* and, to a lesser extent, *Acacia dealbata* and *E.viminalis.* The endemic species recorded in this community include the *Lomatia tinctoria, Melaleuca pustulata, Acacia axillaris, Stenanthemum pimeleoides, Odixia angusta* and *Epacris gunnii.* Exotics recorded included *Crataegus monogyna, Ulex europaeus, Rosa* sp., *Leontodon taraxacoides* and the ubiquitous *Hypochaeris radicata.* These probably owe their presence to adjacent farmland and frequent disturbance by floods. The formations are mainly dominated by *E.ovata* in shrublands or woodlands but occasionally *E.amygdalina* and *E.viminalis* dominate. Understorey vegetation is often grassy, or sedgy, or sometimes shrubby.

The community is found on the immediate riparian zone where frequent flooding occurs. The sites are always flat areas on alluvium or on alluvium over dolerite and the soils are slightly acid, poor to moderately well drained and comprise silty or sandy loams and clays. The outstanding exception is the stand at Grange road which is unique because it is on dry lateritic gravels well away from any river.

Group 3

C.oblonga shrubland, scrub and woodland with *E.ovata, E.amygdalina* and *E.viminalis.*

This group was sampled by 7 quadrats, 4 of which were on the South Esk River and 2 on the Apsley River and one on the Swan River.

The most common species in the quadrats in this group apart from *C.oblonga* was *Ulex europaeus*. Other common species are *Micrantheum hexandrum, Pomaderris apetala, Gonocarpus micrantha, Bursaria spinosa* and *Callistemon pallidus*. This community has a high proportion of grasses including *Themeda triandra, Agrostis capillaris, Agrostis stolonifera, Poa sieberiana* and *Ehrharta distichophylla*. The sites are within highly disturbed patches of scrub in agricultural country. They are threatened by occasional firing and are subject to flooding and downstream distribution of weeds. This accounts for the high proportion of sites with *Ulex europaeus,* as well as other weeds being common, such as *Rubus fruiticosus, Hypochaeris glabra, Hypochaeris radicata and Plantago lanceolata*. *Acacia mucronata* is common and is also an indicator of disturbance. The seasonally waterlogged soil is indicated by *Eucalyptus ovata, Leptospermum lanigerum, Carex lynx* and *Melaleuca ericifolia*. Species which occassionally occur in this group include *Tasmannia lanceolata, Grevillea australis* and *Notelaea ligustrina*.

The formations are shrubland, scrub or woodland, dominated by *Eucalyptus ovata, E.viminalis, E.amygdalina, Acacia mearnsii, A.dealbata, Melaleuca pustulata* or *Hakea microcarpa*. The understorey is usually densely shrubby.

The community occupies the (still active) higher flood terraces or riverbanks on the larger rivers. Drainage is good, and the substrate comprises well drained sites, silty loam or light clay.
The group is related to Group 2 but is better drained than that group as it occupies higher flood terraces rather than the actual riparian strip.

Group 4

C.rhomboidea (C.oblonga) in *Eucalyptus* woodlands, shrubland and heath.

The community was sampled by 17 quadrats, 16 of which are *C.rhomboidea* quadrats and one of which is a *C.oblonga* quadrat. The community is distinguished by the frequent presence of *Astroloma humifusum*. The quadrats were located from Cape Hauy in the south to the Apsley River at Greenlawn in the north, and 40 kms inland to the St. Pauls River. Most quadrats are near the central east coast around Great Oyster Bay.

The most abundant species in the group are *Epacris impressa*, *Lomandra longifolia*, *Banksia marginata*, *Astroloma humifusum*, *Leptospermum scoparium*, *Pteridium esculentum* and *Acacia dealbata*. There are no species apart from *C.rhomboidea* and *Epacris impressa* with a fidelity greater than 6. A number of shrubs found in dry situations, wet gullies and wet gully margins are recorded, some possibly indicating a fire at a former wet forest site. Such species include *Gahnia grandis*, *Olearia stellulata* and *Olearia lirata*. There are few endemics. The group contains some typically coastal species such as *Helichrysum papillosum*, *H.costatifructum* and *Carpobrotus rossii*. The most common formation is woodland with *E.viminalis*, and *E.amygdalina* being the main emergent dominants. Others are *E.ovata*, *E.tenuiramis* and *E.globulus*. About a third of the quadrats in this group had grassy or sedgy understoreys while the remainder had heathy or shrubby understoreys.

This group occupies generally flat or gently sloping sites near the coast, except for the *C.oblonga* quadrat on the St. Pauls River. Most are situated on well insolated sites at varying altitudes. Bedrock is dolerite, granite, sandstone, mudstone or unconsolidated gravels or sands. Soils are acid loam or sand with light clay present at some sites.

The quadrats in this group had in common a lack of natural protection from fires and many sites showed signs of fairly high fire frequencies. The *C.oblonga* site is interesting in being one of the few sites containing *C.oblonga* which is totally removed from the influence of a watercourse. The site is on a highly-insolated, dry (on mudstone with very shallow soil) slope.

The sites in this group are either poorly protected by natural features at the site but persist as isolated large trees that have managed to escape lethal fires, but with no young cohorts; or *Callitris* stems occur where there is immediate local fire protection provided by large boulders. These sites represent part of the range of the species which is disappearing but only remain because tenuous localised fire protection has allowed them to remain. For example, Quadrat 99 was a *C.rhomboidea* stand between a fenceline and Banwell Road and was the only stand of pine in the locality-protected only because of the features of its roadside location.

Group 5

Callitris rhomboidea in *Eucalyptus globulus-E.viminalis-E.pulchella-E.amygdalina* woodlands of rocky dolerite slopes and knolls.

This group comprises 25 quadrats which are all central east coast sites from Rheban to the northern mainland limit of *C.rhomboidea* at the Denison Rivulet.

The sites all contain *Callitris rhomboidea* while other common species include *Astroloma humifusum, Lomandra longifolia, Lepidosperma elatius, Poa rodwayi, Bursaria spinosa, Hibbertia riparia, Lepidosperma lineare, Viola hederacea, Bossiaea prostrata* and *Gonocarpus tetragynus*. The highest percentage frequency of *Asterotrichion discolor* and the second highest frequency of *Bedfordia salicina* of any group, indicates the close relationship of this group to the wet gully dolerite group. The species *Correa reflexa, Notelaea ligustrina* and the drought adapted 'resurrection' fern *Cheilanthes austrotenuifolia* are typical of rocky dolerite knolls and dolerite talus slopes in eastern Tasmania. Another fern occassionally found in only marginally damp habitats, *Adiantum aethopicium*, sometimes occurs in this community.

A number of eastern Tasmanian endemics occur in these quadrats, such as: *Asterotrichion discolor, Melaleuca pustulata, Helichrysum lycopodioides, Clematis gentianoides, Leptospermum grandiflorum, Pimelea nivea, Spyridium obovatum var obovatum* and *Helichrysum scutellifolium*. The relatively high number of endemics in this group is consistent with the claim by Kirkpatrick and Brown (1984) that in eastern Tasmania "the number of endemic species is always greatest on the dolerite, and the number of endemic species is greatest on dolerite where the rock is most exposed; that is on exposed cliffs, rocky gorges and alpine plateaux. These sites are also generally fire protected."

The community is usually dominated by either *E.viminalis,* *E.pulchella,* *E.amygdalina* or *E.globulus* (in that order) or a combination of these. The "half-barked" *E.amygdalina* (Kirkpatrick and Potts, 1987) occurred at some sites. Most sites have a very open understorey which is sedgey, grassy and occassionally shrubby. *Poa rodwayi* is common.

This is a distinctive community which occurs almost exclusively on dolerite, where the landform is usually a dry rocky knoll, a talus or scree slope or a ridge top. The soils are generally very shallow, well drained loams and clay loams of neutral pH. The altitude of sampled sites ranges from 10m asl to 480m asl. The influential factors in distinguishing this community are its high degree of rockiness, dryness and relative lack of human disturbance. The group is closely related in environmental space to Groups 3,4,6 and 7.

Group 6
C.rhomboidea in woodlands and forests dominated by *E.globulus* *(E.viminalis, E.regnans, E.obliqua, E.ovata).*

This *C.rhomboidea* community was sampled by 16 quadrats which mainly occur on the central east coast with one Flinders Island quadrat. The group is indicated by the presence of *Lepidosperma elatius.*

The most common species in this community apart from *C.rhomboidea* and *Lepidosperma elatius* are *Pomaderris apetala,* *E.globulus, Acacia verticillata, Pteridium esculentum, Acaena novae-zelandiae, Coprosma quadrifida, Viola hederacea, Beyeria viscosa, E.viminalis* and *Bursaria spinosa.* Other species occurring in at least 74% of the quadrats are *E.obliqua,* *Dianella tasmanica, Asplenium flabellifolium, Banksia marginata, E.pulchella, Exocarpos cupressiformis, Zieria arborescens, Olearia viscosa* and *Clematis aristata.* Numerous other shrubs were recorded in some of the quadrats. Many of these species are typical of wet gullies in eastern Tasmania. Occassionally there had been a sufficient absence from fire

and sufficient shading for a number of ferns to become established such as *Hymenophyllum peltatum, H.rarum, Blechnum wattsii, Ctenopteris heterophylla, Rumohra adiantiformis, Histiopteris incisa* and *Pellaea falcata.* 'Species of note are *Elaeocarpus reticulatus* which occurred in the Flinders Island quadrat and *E.regnans* which dominated a quadrat in a gully near Taranna. A number of typical eastern Tasmanian dolerite endemics occurred in quadrats including *Asterotrichion discolor, Spyridium obovatum var obovatum, Odixia angusta, Cyphanthera tasmanica* and *Bedfordia linearis.*

The community occurs as low/tall open forests and woodland although 2 samples comprised tall open shrubland and closed scrub. *E.globulus* is the most common dominant eucalypt but other dominant eucalypts are *E.viminalis, E.ovata, E.obliqua* and *E.regnans.* In one site, *C.rhomboidea* is the emergent dominant.

This community occurs on very rocky talus slopes in steep gullies generally inland from the coast. Often the community is found at the base of steep gullies and on creek banks. The bedrock is invariably dolerite except on Flinders Island where the community occurs amongst granite boulders. The soils are usually loams but sometimes clayey, well drained with a slightly acid to neutral pH. The very rocky nature of this group of sites means a low fire frequency. This group is the inland version of Group 11. If fire were excluded for long enough *Callitris* would form closed canopy forests as has happened in a couple of locations near the coast.

Group 7
Callitris rhomboidea in *Eucalyptus* and *Allocasuarina* forests and woodlands.

This group was sampled by 5 quadrats which are scattered in the farming districts from the Rheban district to Cranbrook. One quadrat was from Palanna on the northern end of Flinders Island.

The most persistent species apart from *C.rhomboidea* is *Oxalis corniculata*. Other species which frequently occur are *Acaena novae-zelandiae*, *Bursaria spinosa* and *Pomaderris apetala*. Other common species recorded were *Banksia marginata*, *Diplarrena moraea*, *Senecio sp. Myoporum insulare* and *Arctotheca calendula*. The community is characterised by the presence of *Hypochaeris radicata* and the large number of exotic species recorded in this group strongly suggests disturbance as the most distinguishing variable. Exotics include *Holcus lanatus*, *Rumex acetosella*, *Cupressus macrocarpa*, *Vinca major*, *Crataegus monogyna*, *Iris foetidissima*, *Anagallis arvensis*, *Rubus fruiticosus* and *Ulex europaeus*. The proportion of endemic species remaining in this community is small but include *Spyridium obovatum var obovatum*, *Eucalyptus amygdalina* and *E.pulchella*. There is a strong coastal element among the taxa recorded for the community due to 2 coastal quadrats. These species include *Myoporum insulare*, *Bulbine semibarbata*, *Acacia sophoraea* and *Tetragonia implexicoma*. *Cassinea aculeata*, a disturbance indicator is also often present.

The community occurs as grassy or shrubby low (open) woodlands or low open forest dominated by combinations out of the following species: *E.amygdalina*, *E.viminalis*, *E.pulchella*, *E.globulus* ssp. *globulus*, *E.globulus* ssp. *pseudoglobulus* and *Allocasuarina verticillata*.

The environments occupied by this community are flat or gently sloping and include : a beach dune in a seaside picnic area, a riverbank alongside a house and a road, a river floodplain near a bridge and houses, and a World War II gun emplacement. Apart from the disturbance factor there are no other distinguishing features of this group. Its quadrats were located on very well drained deep soils, mostly on alluvium, sands or gravels, with a pH varying from highly acidic to neutral.

The quadrats are not particularly protected from fire by natural features but *Callitris* survive as older cohorts or scattered individuals. Younger age classes are usually missing even though very small seedlings a few cms high may be present.

This community is common throughout the East Coast and Flinders Island and probably represents a transitional phase preceding extinction of Callitris at particular sites. Once the mature specimens senesce or are killed, the future of *Callitris* at that site may be left to the last generation of seedlings which may disappear like their immediate forebears or else might only survive through fortuitous circumstances.

Group 8
Callitris rhomboidea under *E.globulus, E.nitida (E.tenuiramis)* woodlands, forests and shrublands, or *C.rhomboidea-Leptospermum-Acacia* scrub.

This *C.rhomboidea* group is characterised by the presence of *Banksia marginata*, and has been sampled by 17 quadrats all having very coastal locations mostly on Flinders Island and Passage Island. Two quadrats occurred in eastern Tasmania, near Bicheno and at Cape Tourville.

The most commonly occurring species are *Acacia mucronata, Banksia marginata, Leptospermum scoparium, L.glaucescens, L.laevigatum, Allocasuarina monilifera* and *Lepidosperma* sp. There is a very low proportion of ferns and mesophyllous shrubs but a high proportion of low-nutrient adapted coastal heathland species such as *Dillwynnia* spp, *Hypolaena fastigiata, Epacris impressa, Isopogon ceratophyllus, Boronia pilosa, Hakea teretefolia, Xanthosia pilosa, X.tridentata, Amperea xiphoclada* and *Pultenaea daphnoides* var *obcordata*. These species are typical of acid sandy heaths and acid granitic soils. There is relatively little disturbance in this community so exotic species numbers are low.

Eucalyptus globulus dominated woodland mostly comprised this group with some *E.nitida* woodlands, and in one case *E.tenuiramis* tall open shrubland. *C.rhomboidea* also commonly co-occurred with Acacia, Leptospermum and Banksia marginata in closed heath or closed scrub formations. The understorey within this community is typically shrubby or heathy.

The climax vegetation on these sites may well be almost pure *Callitris rhomboidea* forest such as occurs in patches near Camerons Inlet. The group 8 community is the most widespread of the *Callitris* groups on Flinders and Cape Barren Island on the flatter plains and gentle slopes, especially where fire protection has been provided in the lee of lagoons and creeks or where sources of ignition have been remote. The prominence of scrub and shrubland formations for this group indicates a recovery stage since fire but is a foreboding indication of the longer term direction of seral change.

The community is common on flat coastal sandy plains or low hills and is distinguished by well drained deep sandy acid soils. The bedrock is mostly granite except in two quadrats at Wingaroo and Carnacs Flat there was a limestone basement. The surficial soil however was granite derived sands and pebbles which had a low pH therefore the limestone was not having any noticeable effect on plant communities. Soils were invariably gritty, silty or sandy loams or sands.

The group is most closely related to group 9 but does not exhibit as extreme coastal conditions.

Group 9

C.rhomboidea scrub, woodland and forest in the Furneaux Group.

This *C.rhomboidea* community has *Allocasuarina verticillata* present in most quadrats. The community occurs on the coasts of Flinders and Cape Barren Islands and on Long Island and Deal Island amidst scrub which is infrequently burnt. There were 13 quadrats in this group. The most frequent species

within this group are *Allocasuarina verticillata, Acacia mucronata, Leptospermum laevigatum, Pultenaea daphnoides var obcordata* and *Melaleuca ericifolia*. Other common species are *Lepidosperma elatius, Leptospermum scoparium, Pteridium esculentum, Lepidosperma concavum, Clematis aristata* and *Kunzea ambigua*. Some quadrats contained species of interest in the Tasmanian context including *Elaeocarpus reticulatus, Phyllanthus gunnii* and *Lasiopetalum baueri* all of which have their main Tasmanian distributions on the Furneaux Group. Apart from bracken, the only ferns recorded were *Histiopteris incisa, Dicksonia antarctica* and *Microsorum diversifolium*. Typical coastal species such as *Poa poiformis* and *Rhagodia candolleana* occur also.

This group exhibits a diverse community structure. Of the stands sampled, there were 2 closed scrub, 3 low closed forest, 1 low open forest, 1 low woodland, 1 open heath, 2 closed heath, 1 tall open shrubland and 1 tall open forest. (The structure at another site was not recorded). In only a few cases were *Eucalyptus globulus, E.nitida* or *E.viminalis* emergent dominants. In most cases, *Callitris* was mixed with *Kunzea, Melaleuca, Leptospermum* or *Allocasuarina* in the canopy layer. The understorey was usually shrubby or heathy, but sometimes grassy with occasional sedges.

The community occurs on coastal and island plains very close to the influence of the sea. Bedrock is mostly granite but where recent limestone does occur it is masked by siliceous granite-derived soil or acid sands. Soils are mostly loams, sandy loams or sand with variable but generally acid pH and are reasonably well drained.

This community is most closely related to group 8 but exhibits signs of slightly more disturbance (more exotic species) than that group.

Group 10

Callitris rhomboidea island scrub and heath, Furneaux Group

This very distinctive community was taken between the third and fourth level of division and is represented by 7 quadrats all of which are on Outer Islands in the Furneaux Group, namely Badger, Babel, Tin Kettle, Vansittart and Big Dog Islands.

The most frequently recorded species were *C. rhomboidea* and *Leptospermum laevigatum*. Other species which commonly occurred include *Leucopogon parviflorus*, *Dodonaea viscosa*, *Bromus diandrus*, *Crassula sieberana*, *Rhagodia candolleana*, *Polycarpon tetraphyllum* and *Poa poiformis*. There is a strong coastal element in these species and other typical Furneaux Island coastal species include *Tetragonia implexicoma*, *Senecio lautus* and *Zygophyllum billardieri*. Some exotics are present. Some of these species present indicated extremely xeric conditions, i.e. *Crassula sieberana*, *Polycarpon tetraphyllum* and *Zygophyllum*.

This group is never associated with any eucalypts, and the *Callitris* is mostly co-dominant in scrub or heath formations with *Leptospermum laevigatum*, *Kunzea ambigua*, *Melaleuca ericifolia*, *Allocasuarina verticillata* and *Leucopogon parviflorus*.

The quadrats are on flat to steep sites mainly on granite but with one quadrat on dolerite and another on limestone. The sandy and loamy soils have a pH varying from acid to neutral and are very well drained. The sites are all markedly well protected from fires by natural physical features. The group is the lowest altitude one and has the more drought prone and drier sites than those of any other group. This group is most closely related to 8 and 9.

Group 11

Callitris rhomboidea low closed forest, and in woodlands with *E.globulus, E.delegatensis, E.obliqua (E.viminalis)*. A ferny or mesophyllous shrubby understorey is typical.

This group has been sampled by 5 quadrats scattered throughout the central east coast. The group is a *C.rhomboidea* group whose most consistent species are ferns, mesophyllous shrubs or plants characteristic of wet gullies or rainforest. The more commonly recorded pteridophytes were *Asplenium flabellifolium, Ctenopteris heterophylla, Microsorum diversifolium, Rumohra adiantiformis, Lycopodium varium* and *Hymenophyllum peltatum*. Common shrubs recorded were *Beyeria viscosa, Bedfordia salicina, Pomaderris apetala, Pimelea drupacea, Helichrysum antennarium, Coprosma quadrifida* and *Zieria arborescens*. A number of other ferns recorded included *Dicksonia antarctica, Grammitis billardieri, Hymenophyllum flabellifolium* and *Pellaea falcata*. Many of the understorey species are characteristic of rainforest (Jarman, Brown and Kantvilas, 1984). The trees *Phyllocladus aspleniifolius, Anopterus glandulosus* and *Atherosperma moschatum* which were recorded in this group are characteristic trees of western Tasmanian rainforests. As with group 5, this group had a high number of endemics typical of dolerite, including *Bedfordia linearis, Epacris marginata, Olearia argophylla, Cyathodes glauca* and *Pimelea nivea*.

This group contains *C.rhomboidea* low closed forest and open scrub but the *Callitris* also occurs under *E.globulus, E.delegatensis, E.obliqua* and *E.viminalis*. The understorey is usually shrubby although the low closed forest on Cape Bernier has an open understorey with more than 85% ground cover of moss, and has abundant epiphytic and lithophytic ferns and liverworts.

This group occurs on extremely rocky slopes or benches often surrounded partly by cliffs and in areas of dolerite topples or blockfields. The locations are invariably outstandingly

well protected from fire and it appears clear that absence of fire for long periods has ensured the character of these climax and near-climax C.rhomboidea forests. The community is well represented on structural benches on the east coast formed by horizontally bedded sandstones and other sediments extending beyond dolerite cliffs. These shelves have been obscured by dolerite blockfields eroded from the cliffs above. Such benches occur along the east coasts of Tasman Peninsula, Cape Bernier and Maria Island. The low number of quadrats reflect the difficulty of access to these sites.

5.3.3 Summary Discussion

The environment attributes of quadrat samples show that C.rhomboidea ranges widely across soil type, drainage classes, bedrock lithology, slope, aspect and landform type. C.rhomboidea occurs on soils with a texture which varies from clay to sand and on soils with a pH as low as 3 and as high as 8.5. Most samples ranged between 3.5 and 7. Soil depth varied widely under stands of C.rhomboidea. At one extreme trees grow in crevices on granite cliffs and at the other extreme on deep loams and deep coastal sands. The species is represented on the following lithologies: dolerite, granite, mudstone, sandstone, limestone and unconsolidated sediments.

Almost every type of habitat throughout the range of the species has stands of Callitris rhomboidea. The species does not occur on very swampy ground but specimens are occassionally to be found on floodplains. However, such specimens are uncommon. The species is found on every landform and every aspect within its range. Landforms on which it occurs include: islands, cliffs, coastal plains, coastal sandspits, ridge crests, gully slopes, rocky knolls, river banks, talus slopes and beach dunes. Slopes vary accordingly, from flat to near vertical. The altitude ranges from sea level to 575m.

There are a large number of sites where *C.rhomboidea* would be fire protected by virtue of its physical surroundings such as a talus slope with no understorey. There is no topographic or edaphic constraint why *C.rhomboidea* could not expand across the landscape throughout its range and gradually occupy almost every type of habitat, except very wet sites where it seems to be at a competitive disadvantage.

C.oblonga does not show the same diversity in habitat because it is found mainly in riparian and floodplain habitats and has adaptations which give it the best competitive advantage in these habitats. Some stands grow on atypical sites. A single specimen grows on consolidated sand dunes in *E.viminalis* woodland, a short distance from a tidal lagoon. Another stand grows on almost lateritic soils at a very dry site totally removed from any riverine habitat. The most remarkable stand occurs on a drought prone mudstone slope with skeletal soil, well above the highest flood level of the St. Pauls River. This stand is now isolated from the river by a strip of native grassland but the *Callitris* probably represents a portion of an old contiguous stand which extended from the river and was slowly migrating upslope until clearing and burning left this small stand as a local relict.

Both species were recorded in a very wide diversity of plant communities (see Appendices 2 and 3). Floristic groups as described from the Twinspan classification are mainly either *C.rhomboidea* groups or *C.oblonga* groups. Only in a few cases do *C.oblonga* and *C.rhomboidea* share similar sets of associated species. Part of the reason for this is an environmental differentiation according to drainage. *C.oblonga* is mostly associated with species of poorly drained environments, this being the only edaphic factor which tends to preclude *C.rhomboidea*. There is a huge floristic diversity in *Callitris* plant communities. There were 368 species of vascular plants recorded which is about 14% of the total Tasmanian flora. A glance at the species list (Appendix 1) indicates flora characterising coastal salt spray zone,

rainforest, wet sclerophyll, dry sclerophyll and riparian environments. The only broad category of environments with species unrepresented are alpine and sub alpine.

The species also represent changes in vegetation over almost the broadest latitudinal range in the State. The one way analyses of variance show that the floristic data set in the Twinspan varied in the same direction as annual precipitation and minimum temperature therefore these must explain much of the variation in the floristic data set.

CHAPTER 6

COMPARATIVE AUTECOLOGY OF *CALLITRIS RHOMBOIDEA* AND *CALLITRIS OBLONGA*

6.1   INTRODUCTION

Callitris rhomboidea and *C.oblonga* have partly overlapping distributions (see Chapter 3). *C.rhomboidea* is confined to the east coast of Tasmania and the eastern Bass Strait Islands where the climate is mild. *C.oblonga* extends along inland river valleys where diurnal seasonal temperature fluctuations are more pronounced. It extends along valleys where cold air drainage is likely to produce heavy frosts. There is some overlap in the distribution of the two species along some east coast rivers but *C.rhomboidea* occupies a riparian niche in these instances. This distribution pattern suggests that climate may be a major factor determining the broad relative distribution of *Callitris* species especially as Chapter 5 demonstrates that site factors do not seem to play a direct role. Both species are restricted to a narrower range of habitats than each could potentially occupy (Chapter 5). Observation in the field suggested that climate, fire, and, perhaps, palaeoenvironmental factors are implicated in their present distributions.

The role of fire is important in considering the ecology of *Callitris* but there has been little work carried out on this aspect. Workers elsewhere in Australia (Clayton-Greene 1981, Bowman *et al* 1988) have established that a feedback loop apparently exists involving soil type and texture, type of understorey and its packing density, fire intensity, stand density and survival of the stand.

Clayton-Greene (1981) found that many *Callitris columellaris* (*C. glaucophylla*) resprouted in the axils of scale leaves on terminal branchlets after fire. This was despite complete defoliation due to crown scorch. Resprouting after fire was not observed during this study although resprouting showing the same pattern described by Clayton-Greene occurred in both

Tasmanian *Callitris* species after apparent death (total browning off) from frost damage.

In has previously been claimed that the distribution of *C.rhomboidea* within particular districts has been influenced by the availability of fire protected topographic niches (e.g. Harris and Kirkpatrick 1982). Bowman and Wightman (1985) support this as being a more widespread *Callitris* pattern in their description of a small scale vegetation pattern at Gunn Point in Northern Australia, where the distribution of *Callitris* coincides with steep fire protected slopes. A probable change in fire regime has most likely caused the retreat of *Callitris* forests on the Arnhem Land Plateau (Bowman et al m.s.). Cullen (1989) reports a tendency for *Athrotaxis* survival on the Central Plateau to be concentrated in fire protected sites.

The role of fire is thought to be the present major moulding influence on the distribution pattern of both species. This proposition was tested by systematic observation throughout the range of the species in Tasmania The Furneaux Islands were used as a 'natural laboratory' to provide *a posteriori,* evidence for the hypothesis that fire has eliminated much *C.rhomboidea* throughout its range. The response of *C.oblonga* to fire was also examined.

It has been shown (see Chapter 4) that fire regime is a major influence on the demography of *C.rhomboidea* stands. Examination here of the factors affecting the interaction of fire and *C.rhomboidea* will therefore assist in interpreting demographic characteristics at different sites. In particular, observations relevant to the phenomenon of *Callitris* stands 'repelling' fires was noted. Clayton-Greene (1981) described the effects of a fire which burned through *Eucalyptus* forest with associated stands of *Callitris columellaris.* Litter and especially grasses were found to be significant in carrying fire, and in the understorey of *C.columellaris* where there was very little litter build up and

a lack of understorey grasses, fires were shown to be self extinguishing. Bowman and Wilson (1988) claim both higher moisture content and a sparser litter layer in *Callitris* forest caused it to be less flammable that *Eucalyptus* forest in the Northern Territory.

No previous observations have been made on the role of fire in relation to *C.oblonga*. The species appears to distinctly favour a riparian habitat. The role of climate and fire in determining the relative distributions of *C.rhomboidea* and *C.oblonga* is examined in this chapter.

6.2 The Role of the Major Factors

6.2.1 Climate

6.2.1.1 Methods

1. To determine a broad descriptive account of their climatic range the distribution of the two species was overlain by a map of Gentilli's (1972) climatic zones.

2. A climatic model was generated using the computer program BIOCLIM (Busby 1986) in order to:

    (i) describe climatic envelopes for the present day ranges of *C.rhomboidea* and *C.oblonga*, and
    (ii) to identify areas of the State which could be climatically acceptable for the two species.

The BIOCLIM model requires as input the latitude, longitude and altitude of representative sites. The program was run separately for each species. Attributes of representative sites are shown in Table 6.1. The representative sites are then matched to climatic values at those particular sites according to a generalised climatic surface for the State. The model then extrapolates to other points on that climatic surface. Points on the predictive map are marked according to

how closely they match the parameters within the profile. Points matching all 16 parameters within the total range are plotted as ' - ', points matching all 16 parameters within the 90 percentile (5 to 95 per cent) range are plotted as '+', points matching 13 to 15 of the parameters within the interquartile range (25 - 75 percentile) as '0', and points matching all 16 parameters within the interquartile range as $ (Busby, 1986). Therefore the best predictors of climatically suitable areas, in increasing order, are those points labelled '+', '0' or S

3. Relative mortality of the two species was tested in a frosting experiment. Characterisation of frost resistance can be a complex procedure wihich should ideally test a number of parameters (Sakai and Larcher 1987) so this experiment is preliminary.

(i)   Seeds of *C.rhomboidea* from Apslawn and of *C.oblonga* pooled from two sites at Grange Road and Benham, were germinated and grown on in pots with a standard commercial potting mix;

(ii) Seedlings were removed from the glasshouse and hardened outdoors for 53 days from 19 January 1987;

(iii) The seedlings of each species were allocated randomly to experimental or control groups. 28 seedlings were in each of the 4 groups;

(iv) Control groups remained in the glass house throughout the experiment. Experimental groups of seedlings of both species were subject to 0° temperature for approximately 2 days and then were subsequently subjected to the following temperatures in a Sanyo controlled temperature cabinet for a specific number of hours -4° (4 hours) 9 days interval then -5° (3 hours) 19 days interval -6° (3 hours) 11 days interval -8° (3.5 hours) 42 days interval -10° (3.5 hours) 7 days interval -12° (3 hours) 6 days interval -14° (3 hours). This frost regime was chosen because it was expected to transect the critical frosting

survival levels for foliage, of the two species (also
see data from Sakai *et al* 1981).

(v) Easily visible necrosis of the seedling tip was
scored as a mortality and was allocated to a
mortality score for that particular experimental
temperature.

4. During a drought period, observations were made of both
species throughout their edaphic ranges, to detect drought
stress.

6.2.1.2   Results and Discussion

C.rhomboidea occurs throughout four of Gentilli's Tasmanian
climatic zones: humid warm, moist subhumid warm, dry subhumid
warm and humid cool. *C.oblonga* occurs within moist subhumid
warm, dry subhumid warm, moist subhumid cool and dry subhumid
cool.

The BIOCLIM program produced predictive maps for the
distributions of *C.rhomboidea* (Figure 6.1) and *C.oblonga*
(Figure 6.2).

The efficiency of BIOCLIM as a predictor of range can be
limited by an incomplete input of sites representing the
complete range of the species. This is not a problem in this
case because it is considered that the distributions of the
Callitris species have been very accurately mapped and input
is represented by samples from throughout their ranges. A
more serious problem is that the effect on species
distribution of any palaeoenvironmental event such as a
glaciation cannot be accounted for. Therefore, a species may
not be occupying its complete potential climatic range because
it may have been forced into refugia. If this were the case,
the predicted points will only lay within areas that fall
within the climatic envelope which is calculated on the basis
of the extant distribution. Also, where a prediction falls
within the interquartile range (designated by '0') for 13 to

15 of the total 16 parameters, it may be that any of the remaining 1 to 3 parameters may be the critical limiting ones for the species. The model is slightly coarse because of the generalisations made within the program in fitting a climatic surface over the whole State.

The prediction for the potential climate range of *Callitris rhomboidea* is shown in Figure 6.1. Broadly, potential climatic range of the species is predicted for a large part of south eastern Tasmania and a small portion of north eastern Tasmania. The best predictors occur nowhere more than about 25 km inland. These areas include country west of the Derwent River around the Huon Valley, Sandfly, Kingston, Hobart and New Norfolk. East of the Derwent River, the districts from Tea Tree to Richmond, Forcett to Kellevie and around Nugent; and the country between Runnymede, Buckland and Woodsdale are predicted as suitable. North of the present limit of *C.rhomboidea* on mainland Tasmania, areas of suitable climate right on the coast are predicted in the immediate districts of Chain of Lagoons, St Helens and Eddystone Point. The north east between St Helens and Musselroe Bay and from about the Great Musselroe River eastwards to the coast is, as would be expected, climatically suitable habitat (at the lowest level of prediction).

These areas seem apparently suitable for the species if subjectively judged, because most would have mild maritime influenced climates except for some sites in the western and perhaps inland eastern areas of prediction. During the last glacial period however, many of the predicted sites listed above would have been much colder and possibly more exposed to katabatic winds. The areas west of the Derwent River and the lower Midlands sites south of Tunbridge would have been alpine with a 6° reduction in summer temperature (Kirkpatrick, 1986). There has been no post-glacial expansion of the species to occupy its wider predicted suitable habitat.

Interestingly, the present disjunction in the distribution between the Douglas River and Clarke Island is partially reflected in the predictive map. This means that the disjunction could be partly explained by existing climatic factors as well as palaeoenvironmental factors. The lack of *C.rhomboidea* on apparently suitable sites in the far north east may require palaeoenvironmental or anthropogenic explanation as there is presently no apparent natural or non human induced factor which would bar the existence of *Callitris* from this region.
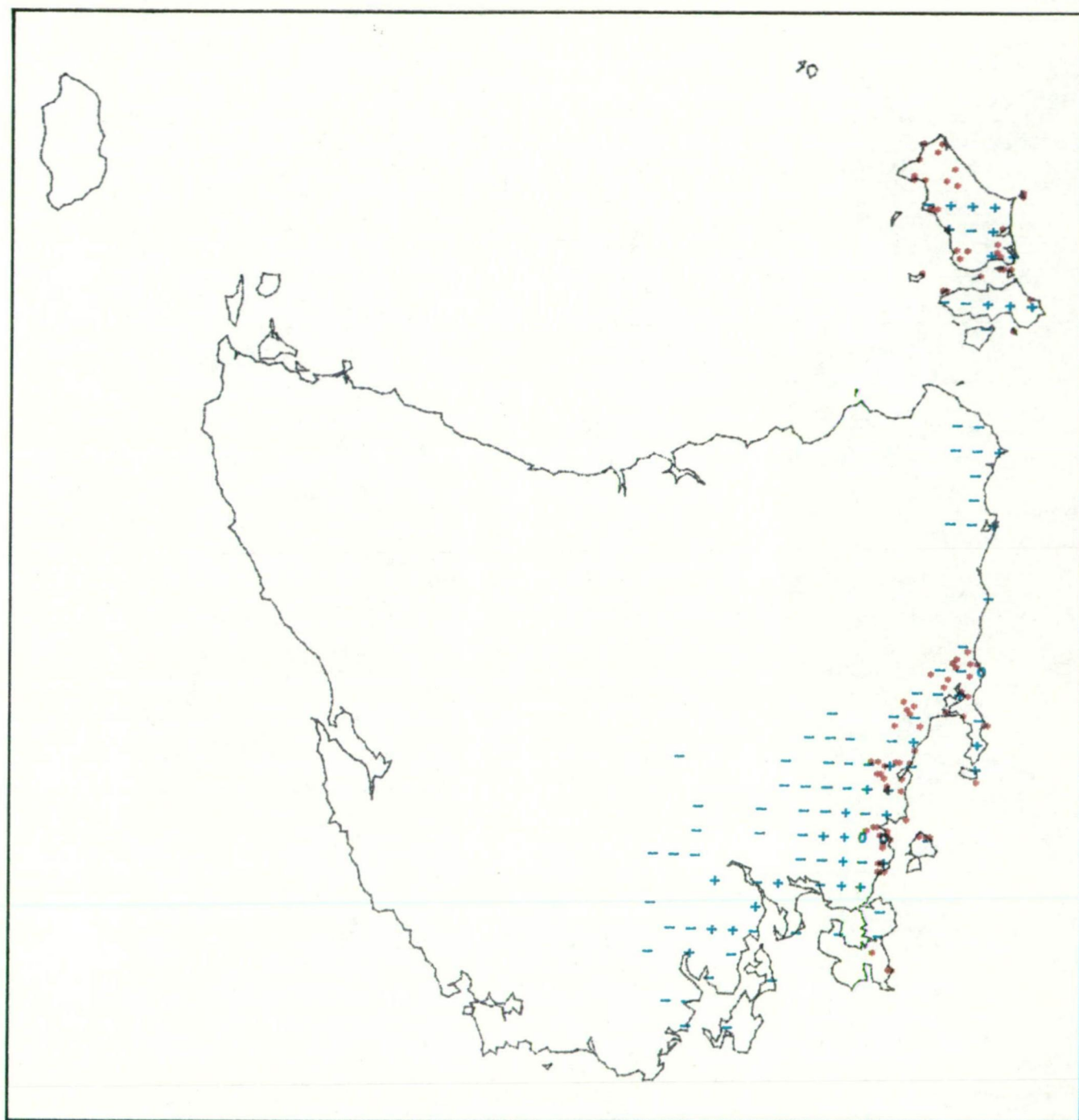
Figure 6.1 Predicted climatic ranges of *C.rhomboidea* at different levels
of confidence: '-'= points matching all 16 parameters within
the total range, '+'= points matching all 16 parameters within
the 90 percentile range, and '0'= points matching 13 to 15 of
the parameters within the interquartile range. Red dots show
the location of input sites.

Figure 6.2 Predicted climatic ranges of *C.oblonga* at different levels of
         confidence: '-'= points matching all 16 parameters within the
         total range, '+'= points matching all 16 parameters within the
         90 percentile range.   Red dots show the location of input
         sites.

Table 6.1 Climatic profiles for *C.rhomboidea* and *C.oblonga* based on
synthetic estimates over their present Tasmanian range.
Explanation of parameters:

TANN	annual mean temperature
TMNCM	minimum temperature of the coolest month
TMXWM	maximum temperature of the warmest month
TSPAN	annual temperature range
TCLQ	mean temperature of the coolest quarter
TWMQ	mean temperature of the warmest quarter
TWETQ	mean temperature of the wettest quarter
TDRYQ	mean temperature of the driest quarter
RANN	annual mean precipitation
RWETM	precipitation of the wettest month
RDRYM	precipitation of the driest month
RWETQ	precipitation of the wettest quarter
RDRYQ	precipitation of the driest quarter
RCLQ	precipitation of the coolest quarter
RWMQ	precipitation of the warmest quarter

C. rhomboidea

CLIMATE PROFILE:

	TANN	TMNCM	TMXWM	TSPAN	TCLQ	TWMQ	TWETQ	TDRYQ	RANN	RWETM	RDRYM	RCVAR	RWETQ	RDRYQ	RCLQ	RWMQ
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
MEAN	12.4	3.9	22.3	18.4	8.4	16.5	11.3	13.7	747.	78.	45.	15.9	218.	154.	204.	158.
S.D.	1.0	1.0	0.8	0.7	1.0	1.0	1.7	3.7	108.	12.	6.	3.7	37.	21.	44.	20.
MIN VALUE	8.9	1.4	18.8	17.2	5.1	12.8	7.1	8.2	603.	61.	37.	11.0	166.	123.	146.	123.
5 PERCENTILE	10.5	2.4	20.8	17.5	6.5	14.6	8.6	8.6	622.	65.	40.	11.8	174.	133.	150.	134.
25 PERCENTILE	11.8	3.0	22.0	17.8	7.8	16.1	10.2	9.2	667.	69.	41.	13.1	187.	140.	165.	144.
50 PERCENTILE	12.5	4.0	22.4	18.1	8.6	16.4	11.0	15.6	728.	76.	43.	14.1	218.	147.	200.	154.
75 PERCENTILE	13.4	4.9	22.9	18.8	9.4	17.5	13.1	17.3	772.	80.	48.	19.5	232.	164.	225.	166.
95 PERCENTILE	13.6	5.3	23.0	19.9	9.7	17.7	13.5	17.5	945.	96.	58.	21.9	274.	195.	271.	195.
MAX VALUE	13.7	5.3	23.1	20.3	9.8	17.8	13.7	17.6	1180.	131.	68.	24.1	378.	228.	378.	228.

C. oblonga

CLIMATE PROFILE:

	TANN	TMNCM	TMXWM	TSPAN	TCLQ	TWMQ	TWETQ	TDRYQ	RANN	RWETM	RDRYM	RCVAR	RWETQ	RDRYQ	RCLQ	RWMQ
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
MEAN	12.0	2.8	22.8	20.0	7.7	16.3	9.6	13.6	617.	61.	40.	12.8	171.	130.	163.	136.
S.D.	0.6	1.0	0.5	1.4	0.9	0.4	2.4	3.4	64.	9.	3.	3.6	23.	16.	24.	19.
MIN VALUE	11.3	1.5	22.3	18.0	6.8	15.7	6.8	9.0	559.	53.	38.	10.3	153.	115.	143.	115.
5 PERCENTILE	11.3	1.5	22.3	18.0	6.8	15.7	6.8	9.0	559.	53.	38.	10.3	153.	115.	143.	115.
25 PERCENTILE	11.5	1.9	22.4	18.7	7.0	16.1	7.5	9.4	563.	55.	38.	11.0	157.	118.	152.	118.
50 PERCENTILE	11.5	2.4	22.6	20.2	7.0	16.3	9.5	16.0	599.	60.	40.	12.2	164.	129.	157.	136.
75 PERCENTILE	12.6	3.8	23.1	21.2	8.5	16.7	11.0	16.1	624.	62.	41.	13.0	171.	136.	159.	147.
95 PERCENTILE	12.8	4.3	23.5	21.9	8.9	16.8	13.7	16.3	723.	75.	46.	13.7	217.	156.	202.	162.
MAX VALUE	12.8	4.3	23.6	22.0	8.9	16.9	13.7	16.9	787.	89.	51.	26.8	240.	178.	240.	178.

The north east coastal disjunction may be a relict of the last glaciation when periglacial conditions dominated the north east mountains (Caine 1983). With a northwesterly wind system then prevailing (Bowden 1983), the effect of katabatic winds would surely have pushed the treeline well out to the east. Some support for this is provided by Macphail and Moscal (1981) who attempt to explain the presence of alpine plants in the Douglas River valley as glacial relicts. If *C. rhomboidea* was hugging the Pleistocene shoreline because it could only survive within the ameliorating effects of a maritime climate, then its subsequent landward migration may not have kept pace with the post glacial sea level rise.

If *C. rhomboidea* had managed to recolonise the far north eastern corner of Tasmania then at least 8,000 years (see Cosgrove 1985) of Aboriginal burning across this gently undulating landscape may have eliminated it.

The predictive map for *C. oblonga* presents a fairly tightly restricted area of climatically suitable sites (Figure 6.2).

Outside the present distribution of the species, climatically suitable habitat was predicted in the district between Little Swanport and Swansea and inland as far as the headwaters of the Buxton River and Meredith River. The species is not known from this area at present but interestingly, Milligan (n.d. c1855) mentioned that the species occurred on the Meredith River.

It is surprising that suitable areas were not predicted over some more inland areas but perhaps this is due to the coarseness of the model. In any case, the predicted range for *C. oblonga* is much smaller than for *C. rhomboidea* because *C. oblonga* presently occurs within a relatively narrow climatic envelope.

Both *Callitris* species do not occupy their full climatic range as can be inferred from the gaps in selected cumulative

frequency graphs produced by BIOCLIM, shown in Figure 6.3 a to d. A species difference in spread of samples (Fig. 6.3 a and b) is quite pronounced in terms of one parameter (precipitation of the driest month). There are large gaps within the range of *C.oblonga* which are not represented by sample locations, in spite of wide sampling. Again, the annual mean temperature profiles (Fig. 6.3 c and d) show distinct clumping and a large gap in the case of *C.oblonga*. In the case of *C.rhomboidea*, gaps occur at the lower end and in the central area within the sampled temperature regime.

The tables of the synthetic climate estimates (see Table 6.1) show that the temperature ranges experienced by the *C.oblonga* sites is an average of two degrees higher than the *C.rhomboidea* sites. Other slight differences between the species occurs (see Table 6.1) but the most interesting aspect is an intraspecific difference within the continental *C.oblonga* group and the east coastal group. Sites 19, 3, 18, 17, 16, 21, 2 and 1 belong to the latter group. All except one group have climatic attributes more closely resembling those of *C.rhomboidea* sites than other *C.oblonga* sites.

The frosting experiment showed differences in the mortality patterns between the two species at cold temperatures. Figure 6.4 shows that a temperature of around -5°C may be a critical barrier to *C.rhomboidea*. Areas experiencing very severe frosts, however infrequent would prove inimical to the colonisation by *C.rhomboidea*. This supports a climatic explanation for confinement of the species to areas of milder climate.

C.oblonga, on the other hand, showed that while temperatures of -5°C could kill seedlings, some seedlings remained alive at temperatures below -10° and -12°. Seeds however were pooled from an east coast provenance and an inland valley provenance, which might explain the pattern of the graph. It may well be that the 'coastal' provenances and the 'inland' provenances of *C.oblonga* have differing thresholds for frost survival.

C.rhomboidea   C.oblonga
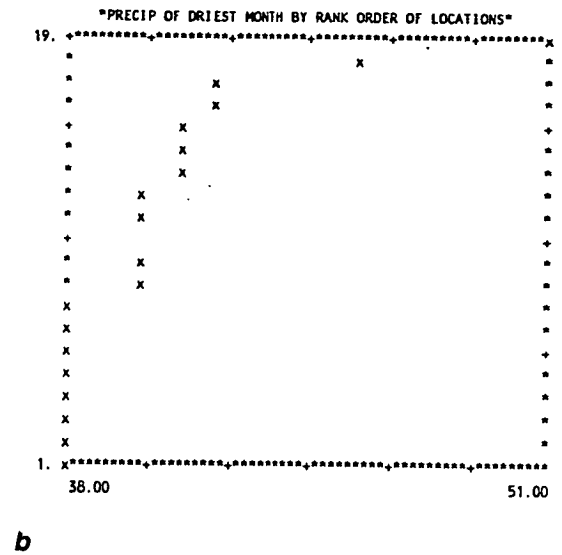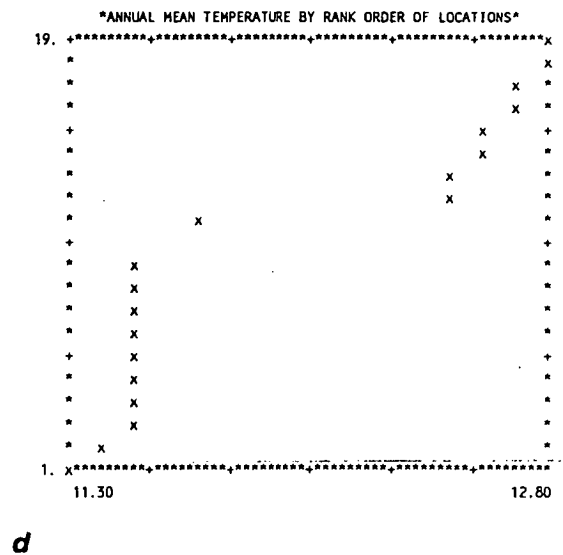
Figure 6.3 a to d. Cumulative frequency distributions of sample locations according to two climatic variables. Number of samples shown on the vertical axis. Rainfall in mm on horizontal axis in a and b. Horizontal axis in c and d represents degrees Celsius. Multiple sample points are denoted by 'M'. Graphs for C.rhomboidea are on the left and for C.oblonga on the right.
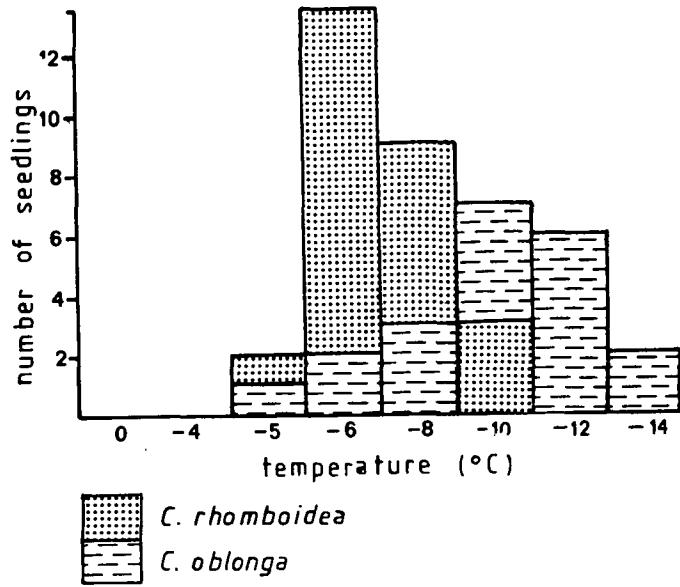
Figure 6·4 Mortality of seedlings of *C. rhomboidea* and *C. oblonga* following exposure to a range of low temperatures.

Sakai et.al. (1981) found the freezing resistance of leaf, bud, cortex and xylem of *C.oblonga* was -10°C, -15°, -15° and -15° respectively. This is consistent with the data presented here.

Close observation was made throughout field sampling, on the drought tolerance of *C.rhomboidea* and *C.oblonga*. The best measure of drought tolerance is observation in the field (Davidson and Reid, 1980) and the present study coincided with a Tasmanian drought (see Tasmanian Yearbook 1987, Govt. Printer, Hobart). No trees of either species were observed to suffer drought stress. This is despite the occurrence of *C.rhomboidea* in extremely xeric edaphic and topographic situations. The occurrences of *C.oblonga* in the atypical non riverine stands where in one case the substrate is skeletal soil on mudstone on a well insolated slope (see Plate 4.2) similarly showed no stress. The only drought deaths observed were of tiny seedlings on dried out mossy substrates over unweathered bedrock. The future of such seedlings may have been doubtful regardless of a drought.

The observed tolerance to drought stress is compatible with the distribution of the species' cogeners in semi arid environments throughout Australia. Possible physiological bases for drought tolerance are provided by the sunken and obscured nature of stomates on the leaves of many species (Venning 1979) which may slow the transpiration rate; and the presence of outgrowths in transfusion tracheids in *C.rhomboidea* and *C.oblonga* which may play a role in maintaining the shape of water transporting cells under water stress conditions (Gadek and Quinn, 1988).

6.2.2 The Role of Fire

6.2.2.1   Methods

Fire induced patterning of *C.rhomboidea* communities : the case
of the Furneaux Island group:

1. Vegetation patterning in the Furneaux Group was examined
    since the Aboriginal burning factor could be discounted.
    Aborigines had not occupied the Furneaux Group for at
    least several thousand years prior to first European
    occupation in the region in 1797 (Orchiston and Glenie,
    1978). This historical examination of vegetation pattern
    allowed consideration of the effects of fire on a broad
    scale in relation to *Callitris*. Historical references
    were sought, and the distribution of *Callitris* in all the
    islands of the Furneaux Group noted.

2. An area of approximately 266 km^2 on the north eastern
    plains of Flinders Island was mapped to show the
    patterning of the vegetation, in relation to fire shadow
    effects.

Observations on stand fire history and site vulnerability to
fire

1. In December 1987 a 44m transect of contiguous 1 x 1m
    quadrats was placed perpendicular to a fire boundary
    dating from November 1982. This site at Camerons Inlet on
    Flinders Island is on flat coastal sands. The frequency
    of individual stems for each of all the species was
    recorded for each quadrat and the data plotted as a
    histogram.

2. In December 1987 a 100m straight transect was laid out
    through a 'fire-shadow' closed scrub behind a lagoon near
    Wingaroo, Flinders Island. The transect was aligned to
    cross multiple age fire boundaries. The line was surveyed

on a bearing of 193° using a Suunto hand held compass and levelled with a dumpy level and staff. The structure of the vegetation was recorded in detail, and canopy and understorey species noted. Different canopy height classes of vegetation were aged using either branch node counts on *Banksia marginata* (Brown and Podger, cited in Bell 1983) or counting growth rings of *Leptospermum glaucescens* severed at the base (Jarman, Kantvilas and Brown, 1988). Where vegetation structure or topography changed, a soil profile was exposed down to a clay layer. Zonation of the profile was described in terms of : texture, according to a descriptive scale ranging from sand to clay (Corbett, 1969) and colour according to a Munsell soil colour chart. The pH of the Al horizon was measured with a C.S.I.R.O. field soil pH testing kit (Inoculo Laboratories). The information resulting from this transect was drawn as a profile diagram.

3. At Cape Tourville, a transect of 15 5 x 5m quadrats was placed in a *Eucalyptus tenuiramis-E.amygdalina (C.rhomboidea)* woodland perpendicularly traversing an apparent old fire boundary. The absolute frequency of all species in the ground stratum was recorded and subsequently graphed.

4. Observations on stand fire history and degree of site vulnerability to fire, were made for both *C.oblonga* and *C.rhomboidea* while gathering the quadrat information throughout the Tasmanian ranges of the species.

6.2.2.2   Results   and   Discussions

6.2.2.2.1 Fire   induced   patterning   of   *C.rhomboidea*
            communities   :   the   case   of   the   Furneaux
            Group

Islands in the Furneaux Group were not occupied by Aboriginal
people at the time of European settlement and so there were
probably no human-induced influences such as fire, on the
vegetation in the millenia prior to European settlement.
Aboriginal sites attest to occupation in the Group (e.g.
Orchiston and Glenie 1978, Harris 1988) but the most recent
dated Aboriginal occupation site is 6,520± 130BP, for a site
at Palanna (Orchiston and Glenie 1978).

This is consistent with the migration of Aboriginal humans
back and forth on the Tasmanian Peninsula during the last Ice
Age when sea levels would have been low enough to expose the
Bassian Plain.   As sea level rose around 14,000-8,000 years
BP, the incidence of Aboriginal visits to areas which became
isolated by greater stretches of water became fewer.   The
hiatus in human occupation then lasted for about 6,500 years.

The Islands therefore provide an interesting illustration of
post-European firing on a pre-European climax vegetation which
had been without anthropogenic fire for thousands of years.

The Outer Islands of the Furneaux Group are the oldest areas
occupied by Europeans in Southern Australia.   Settlement began
soon after the rescue of survivors of the *Sydney Cove*
shipwreck in 1797 on Preservation Island.   Islands were
occupied by sealers but land was quickly cleared for timber,
firewood and gardens.   For example, Munro set up on
Preservation Island in 1822 (Murray-Smith 1979) when this
island was presumably wooded and six years later the island
had probably been converted to grassland and shrubland with
only a relict patch of trees at the western end (Campbell

1828). By 1832 it seems even these trees had gone. (Backhouse cited in Plomley 1987).

The earliest historical reference to the vegetation (Campbell 1828) suggests that many of the islands greater than about 50 hectares (but depending on degree of exposure of the island) were originally covered in forests, almost certainly with a component of *C.rhomboidea*.

Descriptions of some of the islands in 1828 (many islands had already been settled for 30 years) included the following examples (Campbell, 1828):

Cape Barren Island: "the whole island is well wooded, the trees being the same as those generally found in Van Diemens Land, pine trees of a small size grown here but in no great quantities".
Vansittart Island: "it is well wooded"
Flinders Island: "trees abound of the common sort peculiar to Van Diemens Land, also small pine trees are interspersed along the sides of the hills".
Babel Island: "well covered with trees"
Outer Sister Island: "well covered with wood".

Many of the islands had presumably already changed as a result of fires but the above descriptions indicate how tree dominated vegetation was much more prominent on islands that are today partly or wholly reduced to tussock grassland, shrubland or sedgeland communities. The 'pines' referred to above are *C. rhomboidea*. The comment on their scarcity on Cape Barren Island by 1828 may indicate that the present local vernacular term for this species ("Cape Barren Pine") may date back to the earliest sealing days and reflect a greater abundance. *C. rhomboidea* on Cape Barren Island is today mainly reduced to relict stands behind their protective lagoons on a narrow strip of the east coast of the island and in a few mountain gullies.

Callitris sites on the Outer Islands can be associated with topographic features which have lent protection from fires. *Callitris* is likely to be an indicator of those sites containing vegetation least disturbed since European settlement. A descriptive list of all known *C. rhomboidea* sites on the Outer Islands follows:

1. **Passage Island** A more remote island, on which the *Callitris* is associated with an infrequently burned shrubland or scrub. The stands were probably retreating until more conservative management techniques, including less burning, were adopted by the lessee at the request of the National Parks and Wildlife Service.

2. **Long Island** The *Callitris* is associated with infrequently burned shrubland or scrub, on the north eastern ridge of the island. The ground is very rocky in parts and this may have provided local protection for the seedlings.

3. **Tin Kettle Island** Two small stands are confined to the eastern extremity of the island. The smaller stand is almost on coastal rocks. The larger southern stand has at its western side a sloping cliff of bare bedrock which has acted as a firebreak. Reefs and rocky shallows would prevent access by boats to this shore.

4. **Badger Island** The stand is confined to the head of a small bay at the extreme north eastern corner of the island. To landward are tors of bedrock and steep slopes acting as firebreaks. Reefs would prevent boat access to this shore.

5. **Vansittart Island** The *Callitris* are confined to a strip of coastal scrub on the east coast on a vegetated series of old dunes. To landward is a disconnected string of lagoons and swampy ground occupying a swale which has acted as a firebreak.

6. **Great Dog Island** *Callitris* forms a dense stand with occasional emergent eucalypts and an understorey characterised by mosses, ferns and some shrubs. This forest, in a topographic amphitheatre abuts the shore and

its landward margins grade quickly into tall closed scrub and then *Poa* tussock grassland.

7. **Babel Island** The *Callitris* occupy cliff slopes on the eastern slopes of the mountains from Eagles Nest running to the north and also the rocky steep northern slopes overlooking the most northerly plain. A few specimens occur with *Bursaria spinosa* and *Allocasuarina verticillata* on the southern ridge leading onto Mt Capuchin.

8. **Inner-Sister Island** The few *Callitris* trees are associated with *Allocasuarina verticillata* woodland on the summit of a rocky ridge.

Few of the Outer Islands are now wooded. Even the larger islands which have patches of remnant woodland or forest are mostly occupied by tussock grassland or shrubland.

There must have been devastating fires on Flinders as well as other islands by the late 1820s. As we know the population had been more widespread in the sealing boom years prior to 1810 and it must have been in that period that the vegetation was changed dramatically. In 1872 the total population was only 227 in the islands and apart from the Aboriginal settlement at Wybalenna which commenced in 1832, there were very few people on Flinders Island. By 1832 the vegetation on Flinders Island must have been heavily fired. A description by Backhouse (in Plomley 1987) of December 1833 said:

> "we crossed the tier of granite hills that runs along the eastern [sic] side of this island, and which is covered with common and blue gum, small pine (*Callitris pyramidalis* ?) to the grass tree plains that extend here from a few miles (perhaps five) from the west coast to the east coast. The soil of these plains is very poor and sandy; low gum trees are scattered with low scrub among the grass trees which are *Xanthorrhoea arborea* or the noble size. ....All the trunks are charred from burning the scrub."
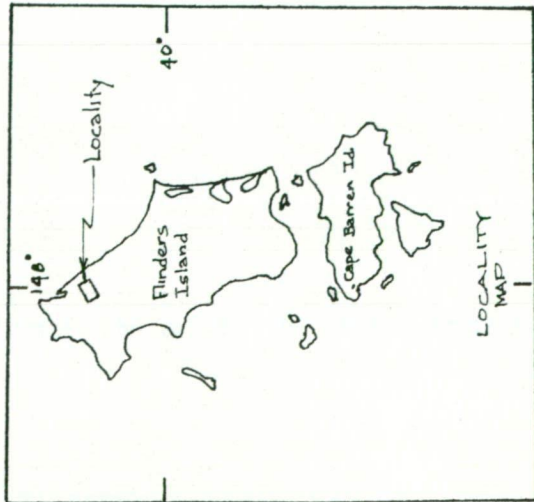
Figure 6·5

VEGETATION STRUCTURE OF PORTION
OF NORTHERN FLINDERS ISLAND.

Key:
- lagoons
- sedgeland-heath mosaic
- closed scrub
- eucalypt woodland (mainly E. nitida)
- eucalypt forest
- estuarine complex
- coastal sand dune complex
- Gahnia dominated sedgeland

LOCALITY MAP

Flinders Island
Cape Barren Id.
Locality
40°
148°

information from aerial photographs dated 23·1·92.

grid north
1km approx. scale
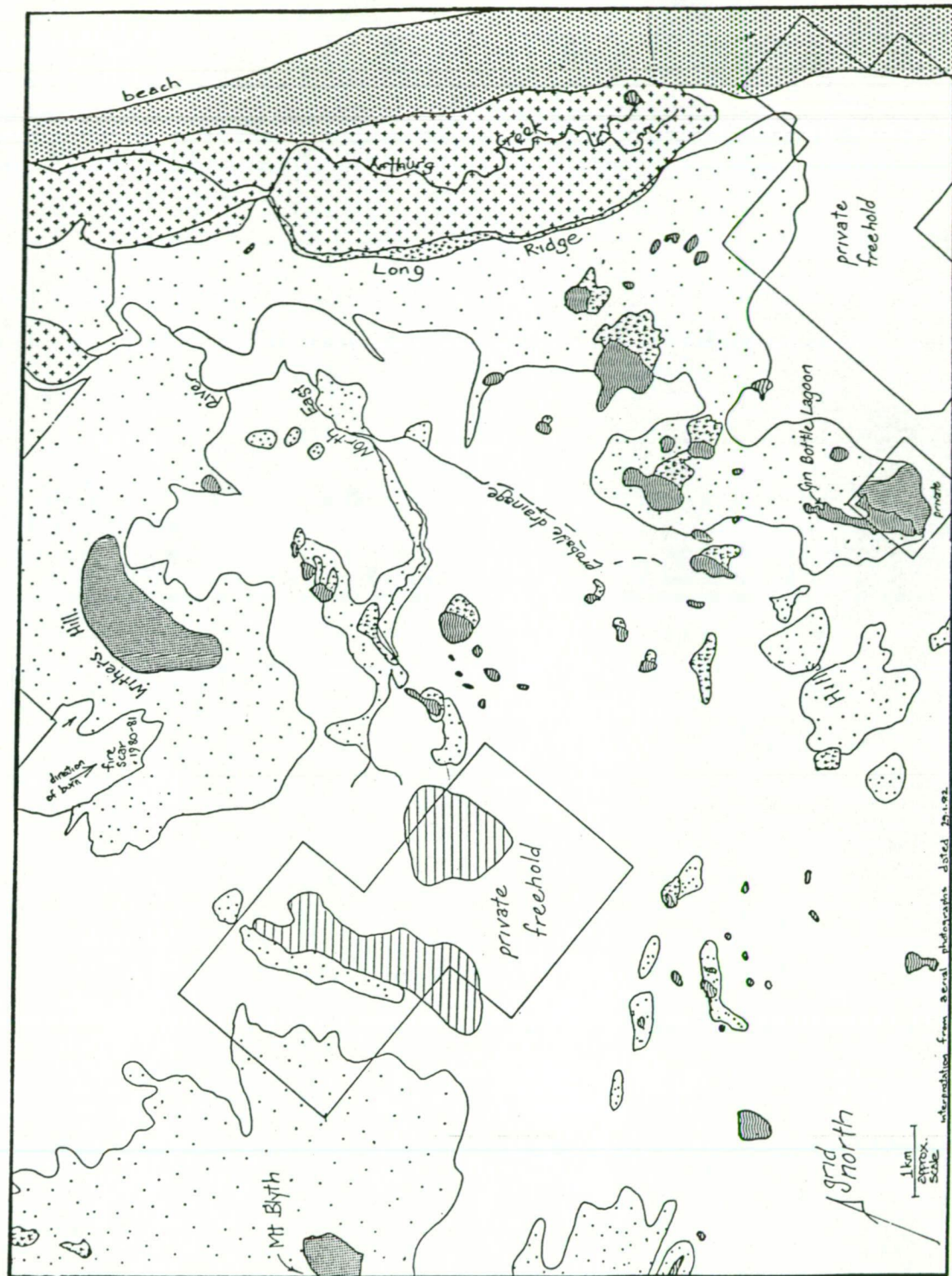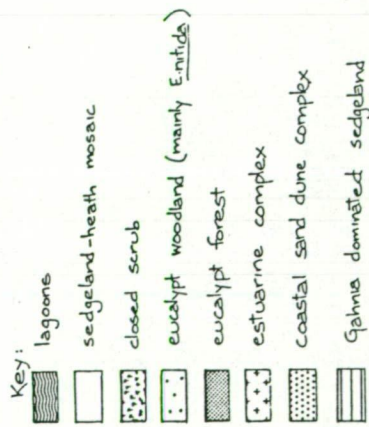
Plate 6.1 A fire killed *C.rhomboidea* downwind of a fire shadow woodland near Wingaroo, Flinders Island. The protective lagoon is on the right beyond the trees. Note the epicormic regrowth on the eucalypts in the background on the left.

Plate 6.2 Fire erodes the edge of a fire shadow scrub on the northern plain, Flinders Island.

Species key: Am = *Acacia mucronata*, Av = *A verticillata*, Bm = *Banksia marginata*, Cr = *Callitris rhomboidea*, En = *Eucalyptus nitida*, Ev = *Eryngium vesiculosum*, G = *Gahnia sp*, Le = *Lepidosperma elatius*, Lg = *Leptospermum glaucescens*, Me = *Melaleuca ericifolia*, P = *Poa sp.*, Pe = *Pteridium esculentum*, Sr = *Selliera radicans*.

SOIL PROFILES:

A

pH 6 , 7·5YR 2/0
light clay loam,
gradational

clay mottled with
10YR 5/8

B

pH 8   7·5YR 2/0
black loamy clay

clay 10YR 3/1 mottled with
10YR 4/6, with small quartz
pebbles (2mm diam)

C

Ao fibrous humus
       7·5YR 3/4
pH 6   10YR 3/1
sandy loam
sand with quartz pebbles
(2mm diam) 10YR 5/2
clay mottled 10YR 4/6

D

pH 4.5   7·5YR 2/0
sandy loam

sand with rounded quartz
grains (2mm diam)

gritty sand
clay 10YR 4/6

10cm scale

LOCATION FURNEAUX MAP 1:100,000 GR 844886   12-12-'87

FIGURE 6·6 TRANSECT BEHIND A LAGOON NEAR WINGAROO
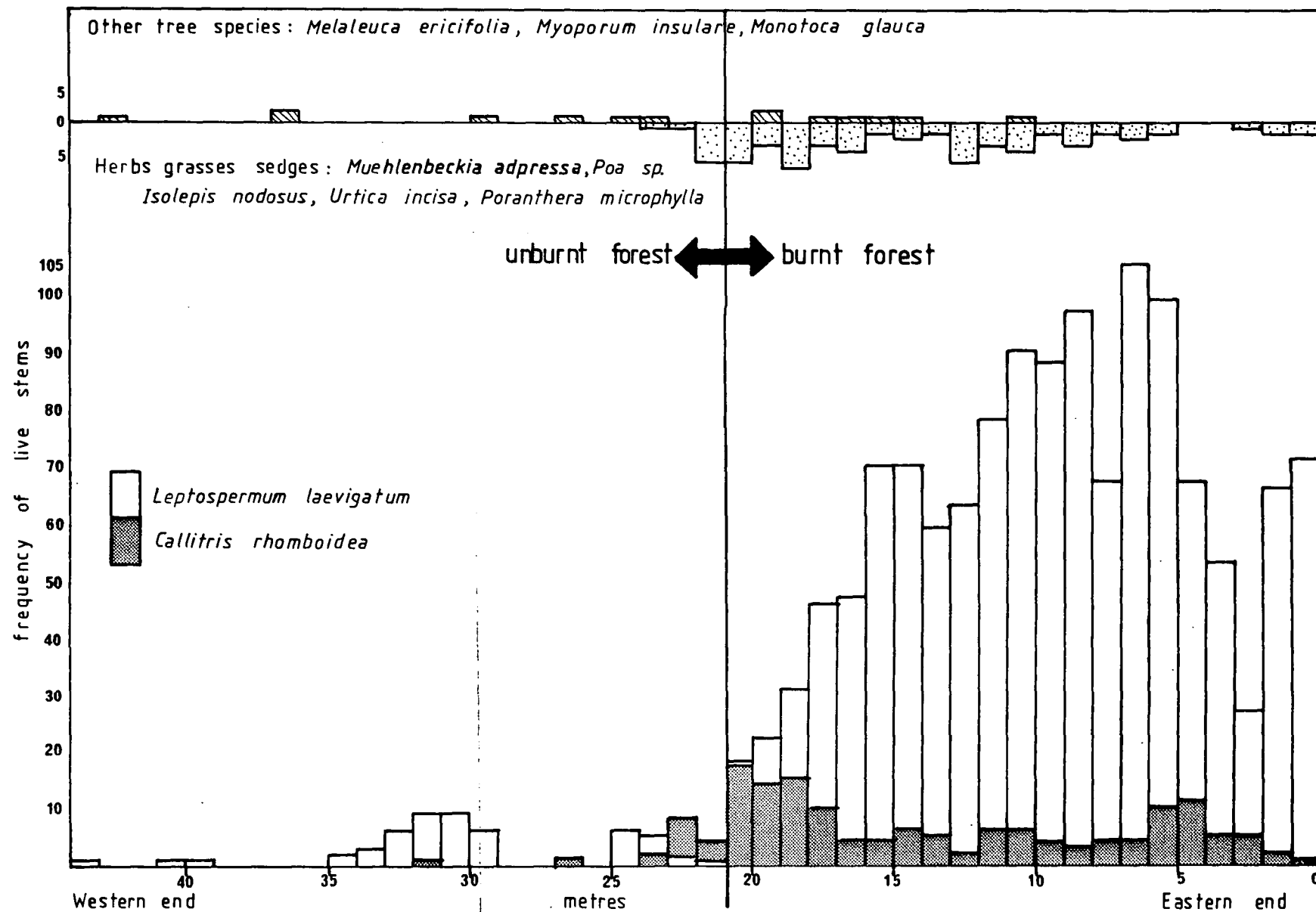
Figure 6·7   Frequency of species along a transect from burnt to unburnt *Callitris* forest, Camerons Inlet.

Callitris rhomboidea clearly occupies fire shadow areas on these plains. There is no apparent edaphic barrier to *Callitris* colonization of much of these plains, which would be the logical outcome if there were no fires. The fire shadow effect is demonstrated in Figure 6.5 which was mapped from aerial photographs. This shows patches of closed scrub on the southeastern sides of the lunette bordered lagoons. The fire direction is parallel to the prevailing wind direction and is easily visible in the pattern of fire scars in the region. Plate 6.2 shows the effects of a fire which has converted a *Callitris* dominated closed scrub to bracken. Plate 6.1 shows an isolated *C. rhomboidea* specimen which occurred downwind of a *Callitris* scrub. Fires subject to a change of wind occasionally burn back into the edge of the closed scrub. The evidence indicates a decline in *C.rhomboidea* throughout the Furneaux Group since first European settlement resulting from a fire frequency which has been too high for the species.

6.2.2.2.2 Observations on stand fire history and site vulnerability to fire

To examine possible edaphic effects along a transect from tall *Callitris* closed-scrub to heathland, soil profiles were examined along a levelled transect. This shows (Figure 6.6) *Callitris* as occurring in the formation which has remained unburned for more than 40 years. In heath which was not protected by the lagoon, the last fire had occurred about 6 years prior to December 1987 and there were no *Callitris* nor any downers or stumps. In a formation within the fireshadow of the lagoon a fire about 35 years old created a closed scrub in which *Melaleuca ericifolia* has regenerated and now dominates. Charred *Callitris* downers indicate their former presence in the formation. A drainage channel with a distinctive species assemblage is coincident with the <40 year fire boundary. The understorey in the ±35 year stand was notably marked by an absence of grasses, bracken or other plants.

This reinforces the observation described by Clayton-Greene (1981) of a high intensity fire dying almost immediately on reaching a dense *Callitris* stand. This was explained by the almost total lack of fuel on the floor of the stand and the higher density packing of *Callitris* litter compared with that in a eucalypt forest.

Clayton-Greene's observations are supported by the results of a transect at Cameron's Inlet (Figure 6.9). Relative frequency of *C.rhomboidea* and associated species across a fire boundary at Camerons Inlet showed a low number of *C.rhomboidea* stems compared with *Leptospermum laevigatum* within the unburnt forest except right at the edge adjacent to the burnt area. Here there is a clumping of *C.rhomboidea* and a virtually bare understorey. In the burnt area the frequency of *Leptospermum laevigatum* stems generally outnumbers *C.rhomboidea* stems in most quadrats by a ratio of about 16:1, except near the fire boundary where there is a sharp increase in frequency of *C.rhomboidea* stems with a corresponding decrease in *L.laevigatum* stem frequency. Particularly relevant is the almost non-existent ground stratum that was evident in the unburnt vegetation while the burnt area had an average of 3.4 herb/grass/sedge individuals per m^2.

The Camerons Inlet transect further supports the critical factor of litter density and absence of grasses. The unburnt stand was almost totally devoid of ground cover species including herbs, sedges and grasses. The only exception was in the 3 quadrats adjacent to the boundary and the ground species in this area totally comprised *Muehlenbeckia adpressa*, a frequent coloniser of bare sandy areas near coasts. This species was probably a post fire adventive which was taking advantage of bare ground plus higher light levels in the unburnt vegetation next to the boundary.

Although the exact meteorological and other conditions at the time of the Camerons Inlet fire are unknown, it is clear that the fire was burning in a westerly direction at this

particular site, and may have been travelling slowly. The fire boundary is adjacent to a portion of tall closed scrub which contains a higher proportion of *C.rhomboidea* than other parts of the unburnt scrub containing mostly *Leptospermum laevigatum*. The relative rates of regeneration of *C.rhomboidea* and *Leptospermum laevigatum* on the burnt portion of the transect may also indicate a higher relative pre-fire density of the latter species. The cause of the exact location of the fire boundary at this site may have been in response to a patch of *C.rhomboidea* and its lack of loosely packed litter.

The unburnt vegetation at the site comprises *Callitris rhomboidea* (8-10m height) co-dominant with *Eucalyptus globulus* and *Leptospermum laevigatum*. In the burnt area the eucalypts had not been killed despite complete defoliation by the fire. Occasional single trees of *Leptospermum laevigatum* had escaped immolation and remained standing. All *C.rhomboidea* had been killed but the highest proportion of dead standing stems were of this species whereas most of the windthrow appeared to be *Leptospermum laevigatum* and *Monotoca glauca*. The *C.rhomboidea* stags were riddled with borer (family Cerambycidae) so that eventually they will be weakened enough to blow over.

The regrowth was patchy, presumably reflecting the prefire distribution of parent species as well as microvariation in substrate condition for seeds. *Acacia mucronata* formed some patches and was up to 3m in height. *Leptospermum laevigatum* was very dense in patches as was *Pteridium esculentum*. The estimated median height of the regrowth was about 1m but *C.rhomboidea* appeared to have an estimated median regrowth height of ± 50cm. *C.rhomboidea* regrowth was also patchy, particularly concentrated where a group of windthrown stems had provided protection from browsing. The tallest *C.rhomboidea* seedling observed was 1.8m in height and bore female cones from two seasons.

Plate 6.3 *C.oblonga* on the St. Pauls River showing the accumulation of flood debris against the *Callitris* trees, which increases the risk of the trees being burnt.

Plate 6.4 Fire has burned to the edge of these *C.oblonga* trees near Milford Hole on the St. Pauls River. The largest tree visible may be ±32 years old.
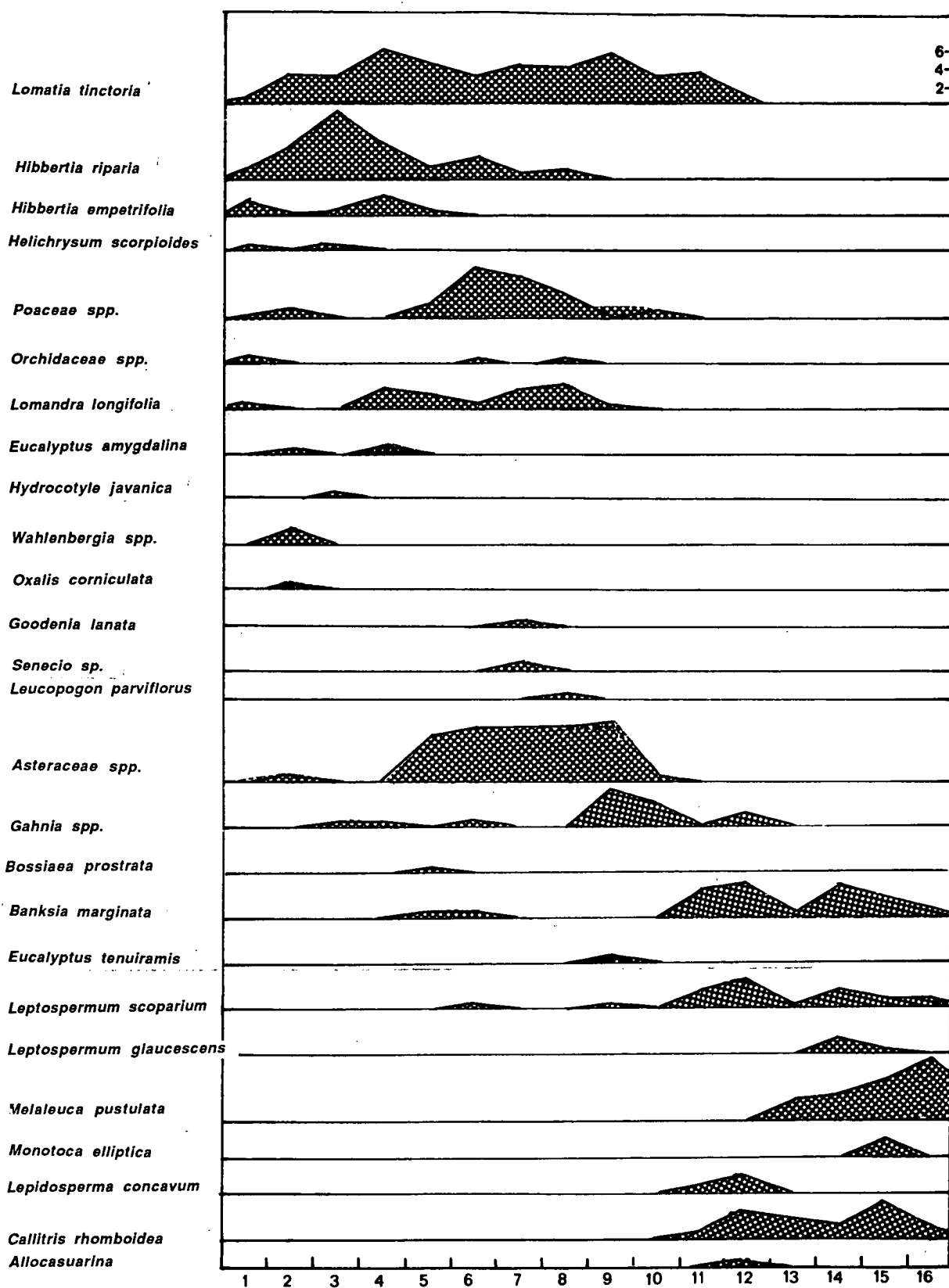
Figure 6.8 Cape Tourville : Absolute frequency of ground stratum species in contiguous 5 x 5m quadrats

C.rhomboidea is clearly a fire susceptible species which has a defence against fire induced elimination at a particular site, at two levels. The first defence is the serotinous cones which comprise woody cone scales fused together and completely enclosing the naked seeds. Although individual trees are killed outright, the woody cones resist burning and open after the tree is killed. In many burnt stands which contained *C.rhomboidea* it was common to see the dead trees still standing. This characteristic which may allow some small competitive advantage in post-fire seed distribution, could be due to insufficient fire intensity at the site of the tree to allow burning through of the trunk. Lack of understorey fuel around the immediate area of the trunk may act to reduce this very local fire intensity.

Individuals however, are normally killed outright by fire, after which cones open and seed falls to the ground. Low intensity ground fires do not necessarily kill *C.rhomboidea* unless the tree is ringbarked by fire. At a number of sites, occasional larger trees bore fire scars. For example, at Q.100, on a steep rocky hillslope with very little ground layer vegetation, one large live *C.rhomboidea* contained a deeply burnt fire scar hollow at its base on the upslope side. Cambial death would normally occur easily because the outer bark and phloem layer of *C.rhomboidea* is only about ±4 mm.

At the second level of defence, *C.rhomboidea* can be protected from fire death by the usual absence of loosely packed litter and grass species beneath stands of the trees. The greater the density of *C.rhomboidea* the more pronounced this effect. This ground fuel loading factor has been discussed by Clayton-Green (1981) and Bowman et al (1988). Their conclusions also appear to hold for *Callitris rhomboidea* within the Tasmanian context.

The Cape Tourville transect data show a marked absence of ground cover species corresponding to the *C.rhomboidea* sites. The transect crossed an old fire boundary resulting from a

fire which probably occurred about 1972. The age was derived from counts of *Banksia marginata* nodes (Podger and Brown, cited in Bell, 1983). The *C.rhomboidea* at the site have existed there for at least 50 years. This stand of *Callitris* has survived during a fire in the surrounding vegetation. Given the uniform soils and lack of topographic variation across the transect it must be assumed that ground stratum characteristics had a bearing on fire survival.

Absolute frequency data of species in contiguous 5x5m quadrats at Cape Tourville (figure 6.8) shows an apparent association of *Allocasuarina littoralis*, *Allocasuarina monilifera*, *Lepidosperma concavum*, *Melaleuca pustulata*, *Leptospermum glaucescens*, *Leptospermum scoparium*, *Banksia marginata* and *Monotoca elliptica*. All of these except for *Lepidosperma* are tall shrubs or trees or have the potential of being so. Herbs and small ground plants, notably including grass species were not recorded in the quadrats which contained *Callitris rhomboidea*.

The geomorphic factor in fire protection is considerable. The greatest proportion of *C.rhomboidea* occurs in fire protected situations such as steep gullies, cliffs, talus slopes and so on. The distribution of the pine across diverse substrates and geological types (see Chapter 5) and in almost all landform situations throughout its range indicates no autoecological obligation to these protected sites (gully, cliff, talus). Such sites are simply the last refuges of a species which has most likely been in retreat for some time. On flat plains and areas across which fires can easily sweep, there is least pine. The exception is Flinders Island which has been discussed in a previous section (6.2.2.1). Pine on flat lands on mainland Tasmania occurs either in dense stands or as scattered old large individuals. This is the result of many fires which have eliminated pine which has been sparsely distributed amidst the more flammable eucalypt forest. The pine existing in the denser stands has therefore had a competitive advantage over pine in sparser stands. In areas

of high fire frequency (i.e. much of the lowland east coast of Tasmania) where very little ground fuel is allowed to accumulate, the larger individual pines may continue to survive, particularly if at their base there is immediate local protection such as a ground cover of boulders.

In fact there is some possibility that a fire frequency induced shift in vegetation types may have occurred on the east coast. It is possible to imagine rainforest as being more extensive in the past except on drier areas such as ridges and other areas which might be more prone to drought. As the rainforest has retreated before a higher fire frequency, the *Callitris* has migrated into former rainforest niches while *Callitris* itself was being displaced by *Eucalyptus* and other species of *Myrtaceae*. This hypothesis is not able to be supported here by other than inferential evidence. At Mt Bishop and Clerk, on Maria Island for example, pure *Callitris* forest exists contiguously with *Phyllocladus aspleniifolius* - *Atherosperma moschatum* rainforest. In terms of structure and floristic composition, the two vegetation types are distinctive. Of interest however, is the occurrence within the rainforest of *Callitris rhomboidea* trees (Plate 6.5). Fire has probably allowed the invasion of the species into the regenerating rainforest in a situation where no seed source from eucalypts are present. A logical progression from this hypothesis is a forest dominated by *C.rhomboidea* with rainforest species in the understorey. This is the case at a nearby location (Q.105) where *C.rhomboidea* dominates over an understorey which includes shrubs such as *Tasmannia lanceolata*, *Phyllocladus aspleniifolius* and *Anopterus glandulosus* as well as ferns including *Hymenophyllum* spp., *Ctenopteris heterophylla*, *Lycopodium myrtifolium* and *Rumohra adiantiformis*.
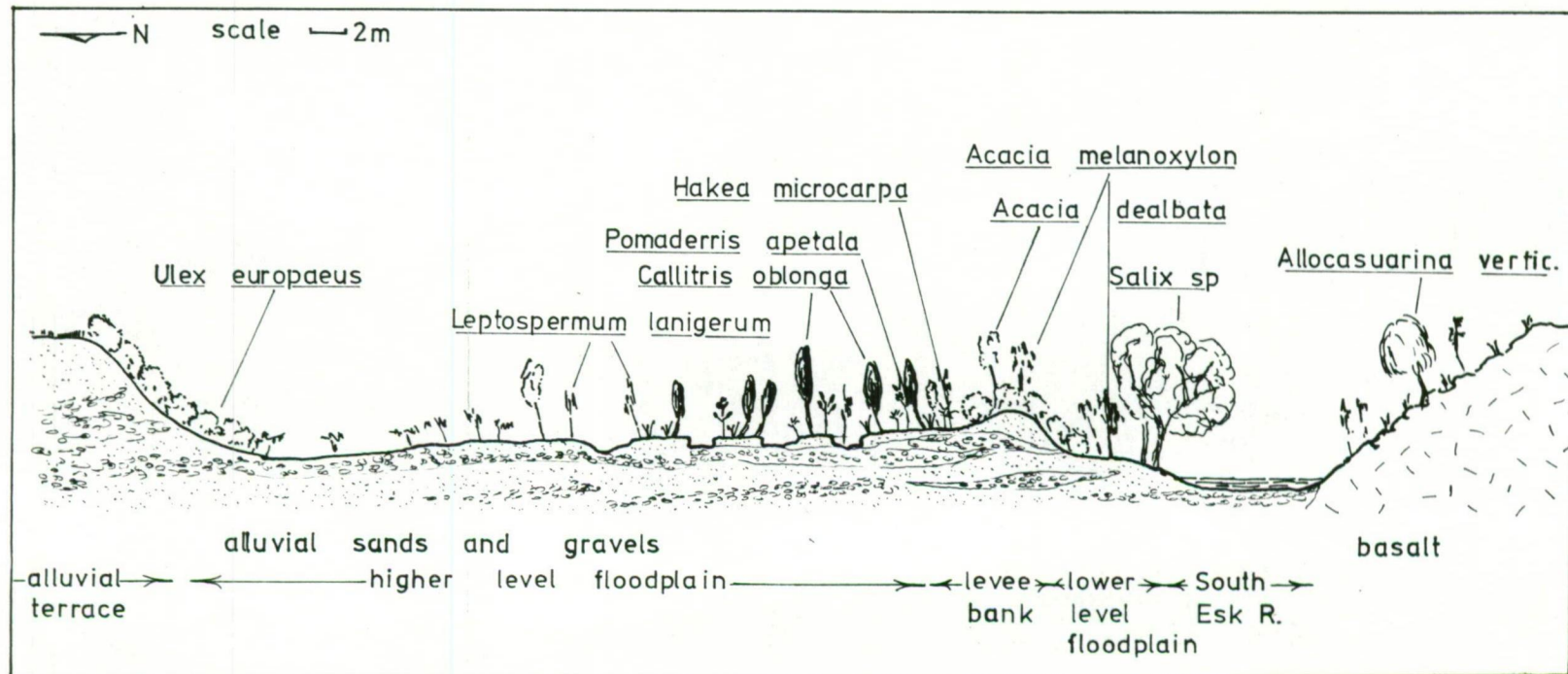
Figure 6.9 A sketched profile of Llewellyn (St Pauls
1:100,000 map 469705) on the South Esk River showing *C.oblonga*
on a topographically fire protected site due to anastomosing
flood channels.

There are three hypotheses at the Mt Bishop and Clerk site:

1. The *C.rhomboidea* and associated species are invading the rainforest, probably due to competitive advantage following fire.

2. The boundary is stable with some intermixing on either side.

3. The rainforest is invading the *C.rhomboidea* site.

Some combination of 1 and 2 seems most likely. The third scenario is probably prevented by a fire frequency just high enough to maintain the *Callitris* at that site. The rainforest species have greater protection from fire on the talus field

It can be seen that while individual trees are susceptible to being killed by fire, their ability to occupy diverse topographic situations has enabled many stands to flourish in fire-protected niches. On flat areas, survival is encouraged by clumping in stands where suppression of a grassy understorey by densely packed litter can occur. Observations by other workers on mainland *Callitris* species therefore hold for *C.rhomboidea*.

C.oblonga is mainly confined to riparian habitats which were often observed to be very fire protected locations such as on banks between anastumosing flood channels (figure 6.9), and on riparian strips backed by cliffs or very steep slopes. Some stands contain large accumulations of flood debris and often *C.oblonga* in dense regrowth stands occurred with flammable myrtaceous and proteaceous species and grasses. A portion of a stand at Milford Hole which was burnt in September 1986 was examined four months later and no regeneration was evident.

C.oblonga shares some similar attributes to *C.rhomboidea* such as serotinous cones, thin bark and high susceptibility to fire death. Additional characteristics which may influence fire behaviour and post-fire recovery are the dense foliage clumped in a tight 'pencil' like crown, multi-stems, small height, and

woody cones which are mostly attached to the main stems with very few on lateral branches.

In dense stands of larger trees it is apparent that densely packed leaf litter and shading would probably preclude any understorey grasses or shrubs. The benefit this may have in suppressing fire is offset by accumulations of flood debris (Plate 6.3), which is noticeably greater on river stretches downstream of agricultural and logging areas. Pre-European flood debris accumulation may have been less significant but this is only speculative. In some dense riparian stands, gorse *(Ulex europaeus)* intrudes.

Observations through the range of *C.oblonga* suggest that moisture availability is not a controlling factor in distribution to the same extent as fire. Three stands are known which occur well above flood plains, (in one case on a very dry rocky bank) and form an understorey to grassy eucalypt woodland. One of these stands has good regeneration while another is subject to heavy browsing pressure.

It is clear that both Tasmanian *Callitris* species have suffered a decrease in range through fire.

Plate 6.5 *C.rhomboidea* (the darker trees) occurring on a dry ridge near Mt Bishop and Clerk on Maria Island. Scattered trees have colonised burned rainforest on the talus slope in the foreground. The shrubs are mainly *Phyllocladus aspleniifolius, Atherosperma moschatum* and *Tasmannia lanceolata*

Plate 6.6 The St Pauls River looking east towards the Eastern Tiers in the right far distance. Milford Hole is in the foreground. Most of the shrubby flats along the river would once have been occupied by *C.oblonga*. The light grey shrubs on the edge of the paddock on the right are gorse *(Ulex europaeus)*. Some *C.oblonga* is arrowed.
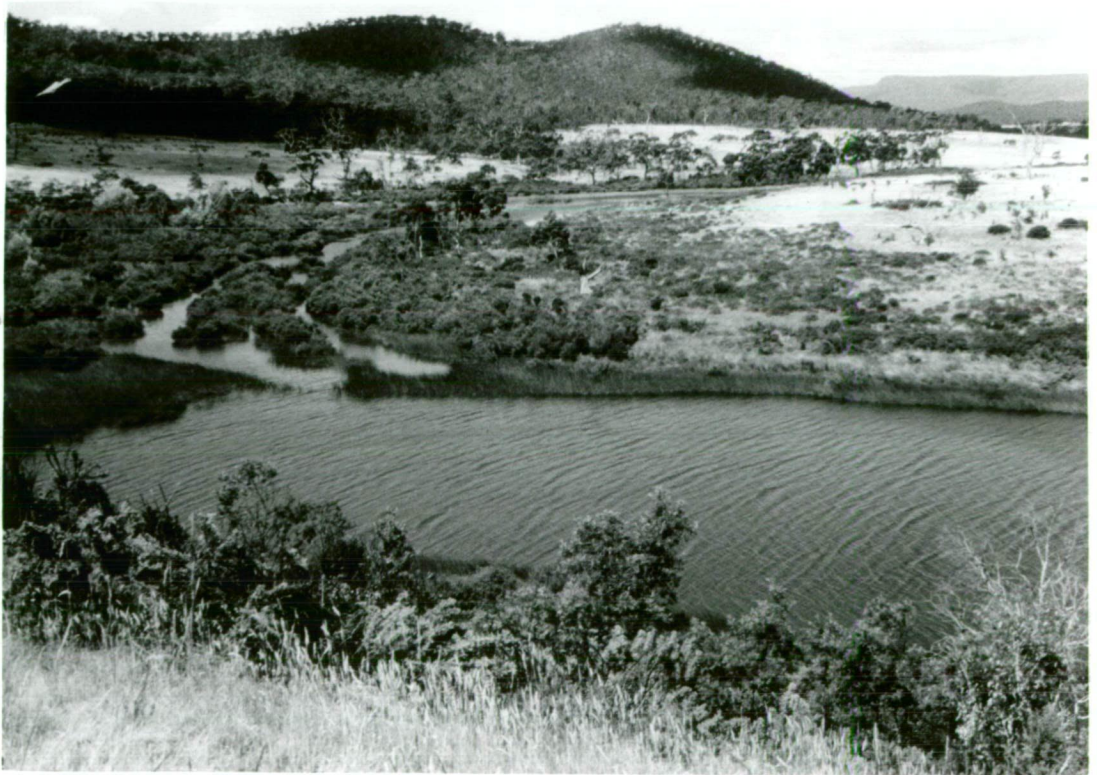
Plate 6.7 Severe stem deformation on *C.rhomboidea* on a talus slope near Marshall Creek. Fire scars occur on both upslope and downslope sides of the trunk.

Plate 6.8 Some of the lower branches on these two *C.rhomboidea* have been burnt by fire. Lower Apsley River.

CHAPTER 7

DISCUSSION

This study set out to answer major questions as to why *Callitris* is where it is in the Tasmanian landscape and what role has been played by environmental constraints, disturbance constraints, constraints resulting from changing climate, and the migration ability of the species, in determining the distribution of the species.

Direct gradient analyses (see Chapter 5) of quadrats show both species, in particular *C.rhomboidea*, to range widely across edaphic and topographic gradients. Both *C.oblonga* and *C.rhomboidea* occur in a wide range of plant communities (see Appendices 2 and 3) but rarely occur in wet sclerophyll forest or rainforest. Their catholic tastes in environments conforms with the view of Page and Clifford (1981) who claimed that conifers had a wide ecological amplitude which helped to explain their persistence. The only sites not favoured by *C.rhomboidea* are those subject to waterlogging. However, this is only a localised factor. One of the two major *C.oblonga* floristic groups is separated from *C.rhomboidea* groups by slope and drainage because it occurs on flat, poorly drained sites. These are not considered to be independent controlling variables but happen to coincide with floodplain and riparian habitats.

Constraints by current disturbance are obviously important. The continuing process of agricultural clearing, clearfell logging and sheep and rabbit grazing have caused decline of both species. The most important disturbance factor is burning.

Grazing by sheep and possibly rabbits has been an important factor in preventing regeneration in some areas. Sheep and rabbits graze close to the ground and therefore have a more deleterious effect than native macropods. The effect of grazing is most obvious on 'sheep runs' where seedlings

regenerate only in the protection of fallen *Callitris* trees which then provide a 'cage' for their progeny.

Competition from exotic plant species has contributed to the decline of *C.oblonga*, particularly in the farming areas. Along much of the South Esk, St. Pauls and Apsley Rivers, gorse thickets are dense and quick growing. The gorse is periodically burned and its formidable regeneration capacity quickly obliterates slow growing competitors like *C.oblonga*. On the South Esk River, willow (*Salix* sp.) is also a problem for *C.oblonga* because it forms dense copses and obliterates otherwise suitable habitat for *C.oblonga*. *C.rhomboidea* has no apparent weed competitors preventing its regeneration.

Fire is the most influential factor presently shaping the distributions of the species. The advent of man into the landscape no doubt caused an increase in fire frequency, which probably increased further in many areas after European settlement. This is supported by historical sources (discussed in Chapters 3 and 6). Both species are adapted to fire because they hold seed in woody serotinous cones on the tree, and old trees can have massive banks of stored seed. High fire frequency shifts stand age structure to younger classes with consequent reduction in the above ground seed bank. If any two fires are closer together than ±4 years, then *Callitris* can become extinct at that site.

C.oblonga is probably more disadvantaged by fire because its linear distribution is more prone to edge effects (like fire), and limited seed dispersal other than by downstream movement. In fact the present pattern of *C.oblonga* distribution strongly suggests downstream spread of propagules. The upstream limits of *C.oblonga*, on the Swan River, Apsley River, St. Pauls and others have probably been descending downstream at least since Aboriginal burning commenced. The riparian environment is difficult in competitive terms because good soil and high moisture availability lead to high germination and early survival rates for many species, after a fire. The resulting

high fuel level makes the vegetation more fire prone, particularly where there is a shift from mesophyll shrubs to sclerophyll shrubs.

The effect of frequent fires is to produce a tendency towards restriction of both species to fire protected habitats such as cliffs, rocky knolls and the base of deep gullies for *C.rhomboidea*. For *C.oblonga* the tendency is for restriction of the species to portions of flood plain protected by meander loops or anastomosing channels, cliffs, rocky benches or other landforms which can physically protect *C.oblonga* from fire death. This fire imposed pattern could distort the view of the habitat requirements of the two species and their relationships with other vegetation. Other evidence supports the view that *C.oblonga* is principally a riparian species and fire has probably only reinforced this distribution pattern. *C.rhomboidea* on the other hand occurs across a broad range of topographic and edaphic situations but it has declined in flatter areas where there is no protection from fire.

It is proposed here that a fire induced shift and displacement process occurred across the landscape in eastern Tasmanian forests. This vegetation change was probably initiated when man arrived in eastern Tasmania at least 8,000 years ago (Cosgrove, 1985) and possibly 30,000 years ago (Cosgrove, 1989). *C.rhomboidea* most likely occupied the interfluvial ridges on the Eastern Tiers, the rocky dolerite knolls scattered along the east coast lowlands, sand ridge crests and any edaphically dry situation, probably in association with a sclerophyllous component on the most insolated and dry sites and on acid nutrient-poor sites.

The valleys and south facing slopes most likely carried more extensive patches of rainforest whose margins retracted towards the base of gullies as fire frequency increased, presumably after the arrival of Aboriginal man. The prolific germination of *C.rhomboidea* seedlings after fire would have ensured the survival of the species but as fire frequency

increased, *Callitris* would have tended to decrease in numbers on the more fire prone ridges, and migrated downslope to occupy the former habitat of retreating rainforest. This speculation is supported by the differential post-fire response of rainforest species and *Callitris* vegetation, and also by the apparent post-fire invasion of rainforest on Mt Bishop and Clerk.

This process would explain the situation occassionally found in the Eastern Tiers where there may be abundant *C.rhomboidea* on the south facing slope of a gully, often with a mesophyllous shrubby understorey and one or only few large individuals on the north facing slope. The more highly insolated slope suffers a high fire frequency because there is less moisture availability for shrubs (Kirkpatrick and Nunez 1980) and there is a higher production of more flammable grasses and litter (Jackson 1968, Kirkpatrick and Nunez, 1980). The situation becomes a self perpetuating cycle involving frequent burning which precludes the survival of young *Callitris*. The less insolated slope usually has a much lower fire frequency and has mesophyllous shrubs. Once *Callitris* has colonised such a site (perhaps originally at the expense of rainforest) it can successfully perpetuate itself through continuous and gap phase regeneration.

C.oblonga is at greater risk from fire whilst it is a component of dense regenerating shrubland or scrub. Once *C.oblonga* becomes dominant and forms a closed canopy the understorey layer ceases to exist and only fine leaf litter remains therefore greatly reducing fire risk. There are very few extant stands which have reached this condition. Flood debris accumulations provide some potential fire risk.

Fire has affected the broad distribution pattern of the two species. In areas of the south east coastland lowlands, where there are few topographic refuges, *C.rhomboidea* has become locally extinct. One such area is the area between Bream Creek and the northern end of the Forestier Peninsula where

the conifer has been eliminated through clearing and a high fire frequency.

The great disjunction in the north east of the State has most likely been caused by anthropogenic burning, where fires have been able to sweep unimpeded across the flat lowlands of the north east. This corner seems ideally suited for *C.rhomboidea* habitat in both climatic terms (see Chapter 6) and edaphic terms. The conifer occurs in identical habitat across Banks Strait on Clarke, Cape Barren and Flinders Island. The crucial difference is that the Furneaux Islands had no human occupation for ±8,000 years whereas north east Tasmania has had human occupation for at least the last ±8,000 years, and probably longer. Since human re-occupation of the Furneaux Islands in the nineteenth century, the decline of *C.rhomboidea* has been taking place. This region is probably one of the best places in Australia for examining the impact of man on vegetation.

Fire may be the major contributory cause of the large disjunction in north eastern Tasmania but it does not explain the confinement of *C.rhomboidea* to the east coast when there is plenty of apparently suitable habitat in south eastern Tasmania; or why *C.oblonga* is confined to only two major rivers in the northern Midlands.

Palaeoclimatic factors may also have contributed to the north east disjunction but they almost certainly help to explain the importance of the Eastern Tiers as a barrier to westward migration of *C.rhomboidea* during the Last Glacial.

Kiernan (1983) suggests a decrease in temperature during the Last Glacial of 5°C to 7°C which would most likely depress the treeline to ±100m and would put the treeline in the north east, very close to the present coastline during the Last Glacial (Kirkpatrick, 1986). During the height of the glacial (±25k to ±18k years B.P.) the western slopes and summit of the Eastern Tiers would have been a periglacial landscape with a

precipitation shadow and a milder climate to the east. The north eastern mountains would also have been subject to a severe periglacial climate which influence would have extended beyond those mountains in the form of cold air drainage and even katabatic winds. Against this background there would still have been temperature oscillations. The killing frosts of approximately 150 years periodically (Paton 1988) would have presumably been more severe. Minimum temperature was most likely the determinant of the *Callitris* treeline. Aridity would not be expected to be a limiting factor because of the morphological adaptations of *Callitris* to extremely xeric environments (see Chapters 2 and 5, and Clayton-Green 1981).

If *C.rhomboidea* had been on the coast (i.e. Seymour to Ansons Bay) between the Pleistocene and present shorelines, its landward migration may not have kept pace with the post-glacial rise of sea level.

Neither *C.rhomboidea* nor *C.oblonga* seeds appear to be bird dispersed. The seeds are winged, and if there is strong prevailing wind when seed is released it may carry for some distance, perhaps up to 100m. Using age-diameter and seed-fall distance data from Chapter 4, and assuming a step-wise dispersal from trees (6.5m height, basal diameter equivalent to 42 year old tree) of 9m, a minimum migration rate for *C.rhomboidea* is 220m/1k years. This figure should be increased 10 fold to account for the likely instances of seed or cones being blown from the tree in a gale. This would therefore give a distance of only 22 km during the 10,000 years since deglaciation. Based on the architecture of the tree, a migration rate across land for *C.oblonga* would be much less. Seed of both species would be carried much greater distances down rivers, a more likely scenario for *C.oblonga*. Downstream spread of propagules would not assist *C.rhomboidea* in a landward migration.

The extent of *Callitris* forests on the Pleistocene Tasmanian Peninsula may not have been much different in its general pattern. *C.rhomboidea* would have remained confined to the east of the Eastern Tiers because of its susceptibility to very low temperatures. *C.rhomboidea* is also likely to have occupied the flat country in the far north east. The distribution of *C.oblonga* may have been different. It is feasible that it could have survived along rivers, even inland, during the Last Glacial but if this were so then stands would be expected on a number of tributaries of the South Esk and St. Pauls Rivers. On the western side of the Tiers, the conifer occurs only on the St. Pauls River and the South Esk River below the confluence in a linear distribution traversing over 120 km. Only an isolated stand occurs near the mouth of Rosiers Creek a short distance upstream of the St. Pauls/South Esk junction. On the eastern side of the Tiers, the present distribution of *C.oblonga* is mostly associated with rivers whose headwaters are very close to the headwaters of the St. Pauls River. The pattern strongly suggests downstream distribution from a Last Glacial refuge in the Eastern Tiers between Mt St John and Snow Hill.

This study has shown that the broad relative patterns of distribution of the two *Callitris* species in Tasmania are largely determined by past and present climatic factors with differential frost tolerance being the critical factor. The apparent freezing resistance of *C.oblonga* foliage in this study is consistent with results reported in Sakai et al (1981). *C.rhomboidea* is more frost prone.

C.oblonga has probably always been a species of broad inland river valleys subject to cold air ponding, or deep gullies subject to cold air drainage from the higher parts of the Eastern Tiers. The relatively low frost tolerance of *C.rhomboidea* helps to explain its confinement to the milder maritime climate of the East Coast and the Furneaux Group.

C.oblonga is well adapted to a riparian niche because it is frost tolerant, it has a strong lateral root system to provide stability in floods, it can survive in an almost prostrate habit where it is subject to powerful floodwaters and it is tolerant of waterlogged ground. *C.rhomboidea* on the other hand has a wide environmental niche but it rarely overlaps with *C.oblonga* habitat, it would not be as capable of growing on floodplain environments as it does not grow well on poorly drained areas.

Both conifers are well adapted to a xeric environment where fire is an occasional factor. Continuous regeneration of *C.oblonga* in the absence of disturbance has not been proven but in reality disturbance occurs frequently through mechanical damage to trees during floods. There is episodic seed release by this mechanism. *C.oblonga* only grows in conditions where light is available so it is readily able to colonise the many niches in floodplain and riparian environments. *C.rhomboidea* is capable of gap phase and continuous regeneration and is more shade tolerant than *C.oblonga*. *C.rhomboidea* is not a 'disturbance obligate'. The Eastern Tasmanian habitats of *Callitris* have been tectonically stable environments for a long period of geological time. The soils are generally deep and fertile unlike much of the oligotrophic environments of the south west where soils have been glacially removed. *C.rhomboidea*, like *Athrotaxis* is a gap phase regenerator and could survive in disturbance environments.

The ecophysiological differences (frost tolerance, shade tolerance) between *C.oblonga* and *C.rhomboidea* appear analagous to those separating *Athrotaxis selaginoides* and *A.cupressoides*. The most important difference is in seed production because *'Athrotaxis'* produces most of its seed in 'mast years' whereas *Callitris* accumulates seed in fire resistant cones on the tree.

C.oblonga and *C.rhomboidea* have suffered the neglect of ecologists and land managers alike. *C.oblonga* is Tasmania's rarest conifer which is vulnerable to burning and clearing. It is inadequately reserved, at present occurring only in a private reserve (Tasmanian Conservation Trust Inc.) on the lower Apsley River. It is essential to protect the stands in the higher reaches of the rivers as it is these stands which can provide seed to areas further downstream. To allow seed to establish downstream, efforts should ideally be made to preserve some natural habitat free of gorse, willow and other weeds. Clearing and burning riparian vegetation is undesirable for *C.oblonga* and for other reasons. Some enrichment planting of suitable sites on private land on some of the major rivers with nearest provenance seed should be undertaken.

C.rhomboidea, although locally abundant throughout its range is a conifer in decline through mans' activities. The planting of the species in agricultural areas with local provenance seed should be actively encouraged. Where the conifer occurs in State Forest there should be no clear felling. Selective logging of stands within State Forest is more preferrable because this would assist regeneration without destroying older cohorts. Although the species is adequately reserved in Tasmania, it has declined so rapidly in many areas that some important provenances may be extinguished. For these reasons all the remaining stands of *Callitris* in the Outer Islands in the Furneaux Group should be protected.

The gymnosperms of the more xeric environments of the Southern Hemisphere comprise a high proportion of Cupressaceae species. These conifers are adapted to drier environments and regnerate well after fire. There is now wide evidence for the decline of even these conifers because of frequent burning and other factors associated with human settlement. *Callitris* has the capacity to regenerate and survive but the anthropogenic decline of the two species has parallels in a wider retreat of

Southern Hemisphere xeric conifers in the Cape Province of
South Africa, eastern south island New Zealand and eastern
Patagonia. Our responsibility in Tasmania is to preserve our
ancient gymnosperms so they can survive further millenia.

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APPENDIX 1

Vascular plant species recorded from quadrat samples throughout the Tasmanian range of *C.rhomboidea* and *C.oblonga*. Nomenclature follows Buchanan et al. (1989) except for *Olearia archeri* Lander and *Cupressus macrocarpa* Hartw.

DICOTYLEDONS

AIZOACEAE   (FICOIDEAE)
Carpobrotus rossii (Haw.) Schwantes
Tetragonia implexicoma (Miq.) Hook.f.

APIACEAE   (UMBELLIFERAE)
Daucus glochidiatus (Labill.) Fischer et al.
Hydrocotyle sp.
Hydrocotyle hirta R.Br. ex A.Rich
Hydrocotyle sibthorpioides Lamk.
Xanthosia pilosa Rudge
Xanthosia tridentata DC.

APOCYNACEAE
Vinca major L.

ASTERACEAE   (COMPOSITAE)
Arctotheca calendula (L.)M.Levyns
Bedfordia linearis (Labill.) DC.
Bedfordia salicina (Labill.) DC.
Brachyscome aculeata (Labill.) Less.
Brachyscome decipiens Hook.f.
Brachyscome parvula Hook.f.
Brachyscome rigidula (DC.) G.Davis
Cassinia aculeata (Labill.) R.Br.
Cirsium vulgare (Savi) Ten.
Gnaphalium collinum Labill.
Helichrysum antennarium (DC.) F.Muell. ex Benth.
Helichrysum apiculatum (Labill.) D.Don
Helichrysum costatifructum R.V.Smith
Helichrysum dendroideum Wakef.
Helichrysum lycopodioides (Hook.f.)Benth.
Helichrysum obcordatum (DC.) Benth.
Helichrysum scorpioides Labill.
Helichrysum scutellifolium (Hook.f.)Benth
Hypochoeris glabra L.
Hypochoeris radicata L.
Lagenifera stipitata (Labill.) Druce
Leontodon taraxacoides (Vill.) Merat
Leptorhynchos squamatus (Labill.) Less.
Odixia angusta (Wakef.) Orch.
Olearia argophylla (Labill.) Benth.
Olearia ericoides (Steetz) Wakef.
Olearia lepidophylla (Pers.) Benth.
Olearia lirata (Sims.) Hutch.
Olearia myrsinoides (Labill.) F.Muell.ex Benth.
Olearia archeri Lander
Olearia persoonioides (DC.) Benth.

Olearia phlogopappa (Labill.) DC.
Olearia stellulata (Labill.) DC.
Olearia viscosa (Labill.) Benth.
Senecio sp.
Senecio gunnii (Hook.f.) Belcher
Senecio hispidulus A.Rich
Senecio lautus Forst.f. ex Willd.
Senecio linearifolius A.Rich
Senecio minimus Poiret
Senecio quadridentatus Labill.
Sonchus sp.
Sonchus asper (L.) Hill
Sonchus oleraceus L.

BRASSICACEAE   (CRUCIFERAE)
Cardamine sp.
Rorippa sp.

CAMPANULACEAE
Wahlenbergia sp.
Wahlenbergia gracilenta Loth.
Wahlenbergia gymnoclada Loth.

CARYOPHYLLACEAE
Cerastium fontanum Baumg.
Polycarpon tetraphyllum (L.) L.
Silene sp.

CASUARINACEAE
Allocasuarina littoralis (Salisb.) L.Johnson
Allocasuarina monilifera (L.Johnson) L.Johnson
Allocasuarina verticillata (Lam.) L.Johnson

CHENOPODIACEAE
Rhagodia candolleana Moq.

CLUSIACEAE   (GUTTIFERAE)
Hypericum gramineum Forst.f.

CONVOLVULACEAE
Dichondra repens Forst. & Forst.f.

CRASSULACEAE
Crassula sieberiana (Schult.& Schult.f.) Druce

CUNONIACEAE
Bauera rubioides Andrews

DILLENIACAEAE
Hibbertia aspera DC.
Hibbertia empetrifolia (DC.) Hoogl.
Hibbertia hirsuta (Hook.) Benth
Hibbertia prostrata Hook.
Hibbertia riparia (R.Br.ex.DC.)Hoogl.
Hibbertia serpyllifolia R.Br.ex DC.

DROSERACEAE
Drosera peltata Thunb.

ELAEOCARPACEAE
Elaeocarpus reticulatus Smith

EPACRIDACEA
Acrotriche serrulata (Labill.) R.Br.
Astroloma humifusum (Cav.) R.Br.
Astroloma pinifolium (R.Br.) Benth.
Cyathodes divaricata Hook.f.
Cyathodes glauca Labill.
Cyathodes juniperina (Forst.)Druce
Epacris gunnii Hook.f.
Epacris impressa Labill.
Epacris lanuginosa Labill.
Epacris marginata Melville
Epacris paludosa R.Br.
Epacris tasmanica W.M.Curtis
Leucopogon collinus (Labill.)R.Br
Leucopogon ericoides (Smith) R.Br.
Leucopogon parviflorus (Andrews) Lindley
Lissanthe strigosa (Smith) R.Br.
Monotoca elliptica (Smith) R.Br.
Monotoca glauca (Labill.) Druce

ESCALLONIACEAE
Anopterus glandulosus Labill.

EUPHORBIACEAE
Amperea xiphoclada (Sieber ex Sprengel) Druce
Beyeria viscosa (Labill.) Miq.
Micrantheum hexandrum Hook.f.
Phyllanthus australis Hook.f.
Phyllanthus gunnii Hook.f.
Poranthera microphylla Brongn.
Ricinocarpus pinifolius Desf.

FABACEAE   (LEGUMINOSAE)
Acacia axillaris Benth.
Acacia dealbata Link
Acacia genistifolia Link
Acacia mearnsii DeWild.
Acacia melanoxylon R.Br.
Acacia mucronata Willd. ex Wendl.f.
Acacia myrtifolia (Smith) Willd.
Acacia sophorae (Labill.)R.Br.
Acacia stricta (Andrews) Willd.
Acacia suaveolens (Smith) Willd.
Acacia terminalis (Salisb.)Macbr.
Acacia verniciflua A.Cunn.
Acacia verticillata (L'Herit.) Willd.
Aotus ericoides (Vent.) G.Don
Bossiaea cinerea R.Br.
Bossiaea prostrata R.Br.
Daviesia ulicifolia Andrews
Dillwynia cinerascens R.Br.ex Sims
Dillwynia glaberrima Smith

Dillwynia sericea A.Cunn.
Glycine clandestina J.Wendl.
Gompholobium huegelii Benth.
Goodia lotifolia Salisb.
Hovea lanceolata Sims
Hovea linearis (Smith) R.Br.
Indigofera australis Willd.
Platylobium formosum Smith
Platylobium triangulare R.Br.
Pultenaea daphnoides J.Wendle
  var obcordata (Andrews) Benth.
Pultenaea gunnii Benth.
Pultenaea juniperina Labill.
Pultenaea pedunculata Hook.
Pultenaea stricta Sims
Sphaerolobium vimineum Smith
Trifolium dubium Sibth.
Trifolium repens L.
Ulex europaeus L.
Vicia sp.

GENTIANACEAE
Centaurium erythraea Rafn

GERANIACEA
Geranium potentilloides L'Herit.ex DC.
Geranium solanderi Carolin
Pelargonium inodorum Willd.

GOODENIACEAE
Dampiera stricta (Smith) R.Br.
Goodenia elongata Labill.
Goodenia lanata R.Br.
Goodenia ovata Smith

HALORAGACEAE
Gonocarpus micranthus Thunb.
Gonocarpus tetragynus Labill.
Gonocarpus teucrioides DC.

LAMIACEAE   (LABIATAE)
Ajuga australis R.Br.
Mentha diemenica Sprengel
Prostanthera lasianthos Labill.
Prunella vulgaris L.

LAURACEAE
Cassytha glabella R.Br.
Cassytha melantha R.Br.
Cassytha pubescens R.Br.

MALVACEAE
Asterotrichion discolor (Hook.) Melville

MONIMIACEAE
Atherosperma moschatum Labill.

MYOPORACEAE
Myoporum insulare R.Br.

MYRTACEAE
Baeckea ramosissima A.Cunn.
Callistemon paludosus F.Muell.
Calytrix tetragona Labill.
Eucalyptus amygdalina Labill.
Eucalyptus delegatensis R.Baker
Eucalyptus globulus Labill.
Eucalyptus nitida Hook.f.
Eucalyptus obliqua L'Herit.
Eucalyptus ovata Labill.
Eucalyptus pulchella Desf.
Eucalyptus regnans F.Muell.
Eucalyptus tenuiramis Miq.
Eucalyptus viminalis Labill.
Kunzea ambigua (Smith) Druce
Leptospermum glaucescens S.Schauer
Leptospermum grandiflorum Lodd.
Leptospermum laevigatum (Gaertner) F.Muell.
Leptospermum lanigerum (Aiton) Smith
Leptospermum scoparium Forst.& Forst.f.
Melaleuca ericifolia Smith
Melaleuca gibbosa Labill.
Melaleuca pustulata Hook.f.
Melaleuca squarrosa Donn ex Smith

OLEACEAE
Notelaea ligustrina Vent.

ONAGRACEAE
Epilobium sp

OXALIDACEAE
Oxalis corniculata L.

PITTOSPORACEAE
Billardiera longiflora Labill.
Billardiera procumbens (Hook.) E.Bennett
Billardiera scandens Smith
Bursaria spinosa Cav.
Pittosporum bicolor Hook.

PLANTAGINACEAE
Plantago lanceolata L.
Plantago varia R.Br.

POLYGALACEAE
Comesperma volubile Labill.

POLYGONACEAE
Muehlenbeckia adpressa (Labill.) Meissner
Rumex acetosella L.
Rumex brownii Campdera

PRIMULACEAE
Anagallis arvensis L.

PROTEACEAE
Banksia marginata Cav.
Grevillea australis R.Br.
var linearifolia Hook.f.
Hakea lissosperma R.Br.
Hakea sericea Schrader & Wendl.
Hakea teretifolia (Salisb.) Britten
Lomatia tinctoria R.Br.
Persoonia juniperina Labill.
var juniperina

RANUNCULACEAE
Clematis aristata R.Br. ex DC.
Clematis gentianoides DC.
Ranunculus sp.

RHAMNACEAE
Pomaderris apetala Labill.
Pomaderris elliptica Labill.
Pomaderris pilifera Wakef.
Spyridium microphyllum (F.Muell.ex Reisseck) Druce
Spyridium obovatum (Hook.)Benth.
Spyridium vexilliferum (Hook.) Reisseck
Stenanthemum pimeleoides (Hook.f.)Benth.

ROSACEAE
Acaena echinata Nees
Acaena novae-zelandiae Kirk
Crataegus monogyna Jacq.
Rosa rubiginosa L.
Rubus fruiticosus L.
Rubus parvifolius L.

RUBIACEAE

Coprosma hirtella Labill.
Coprosma quadrifida (Labill.) Robinson
Galium australe DC.
Galium ciliare Hook.f.
Galium gaudichaudii DC.

RUTACEAE
Boronia anemonifolia A.Cunn
Boronia citriodora Gunn ex Hook.f.
Boronia pilosa Labill.
Correa lawrenciana Hook.
Correa reflexa (Labill.) Vent.
Eriostemon verrucosus A.Rich
Phebalium bilobum Lindley
Phebalium squameum (Labill.) Engl.
Zieria arborescens Sims

SANTALACEAE
Exocarpos cupressiformis Labill.
Exocarpos syrticola (F.Muell.ex Miq.) Stauffer
Leptomeria drupacea (Labill.) Druce

SAPINDACEAE
Dodonaea viscosa Jacq.

SCROPHULARIACEAE
Veronica calycina R.Br.
Veronica formosa R.Br.

SOLANACEAE
Solanum laciniatum Aiton
Solanum nigrum L.

STACKHOUSIACEAE
Stackhousia monogyna Labill.

STERCULIACEAE
Lasiopetalum baueri Steetz
Lasiopetalum micranthum Hook.f.

STYLIDIACEAE
Stylidium graminifolium Swartz

THYMELAEACEAE
Pimelea drupacea Labill.
Pimelea flava R.Br.
Pimelea humilis R.Br.
Pimelea nivea Labill.

TREMANDRACEAE
Tetratheca labillardierei J.Thompson
Tetratheca pilosa Labill.

URTICACEAE
Australina pusilla (Desf.ex Poiret) Gaudich.
Urtica incisa Poiret

VIOLACEAE
Viola sp
Viola hederacea Labill.

WINTERACEAE
Tasmannia lanceolata (Poiret) A.C.Smith

ZYGOPHYLLACEAE
Zygophyllum billardieri DC.

MONOCOTYLEDONS

CENTROLEPIDACEAE

Centrolepis strigosa (R.Br.) Roemer & Schultes

CYPERACEAE
Baumea juncea (R.Br.) Palla
Carex breviculmis R.Br.
Carex iynx Nelmes
Carex longebrachiata Boeck.
Eleocharis acuta R.Br.
Gahnia graminifolia Rodway
Gahnia grandis (Labill.) S.T.Blake
Gahnia microstachya Benth.
Gahnia radula (R.Br.) Benth.
Gahnia trifida Labill.
Isolepis cernua (Vahl) Roemer & Schultes
Isolepis nodosa (Rottb.) R.Br.
Isolepis subtilissima Boeck.
Lepidosperma concavum R.Br.
Lepidosperma elatius Labill.
Lepidosperma laterale R.Br.
Lepidosperma lineare R.Br.
Lepidosperma longitudinale Labill.
Schoenus apogon Roemer & Schultes
Tetraria capillaris (F.Muell.) J.Black

HYPOXIDACEAE
Hypoxis glabella R.Br.

IRIDACEAE
Diplarrena moraea Labill.
Iris foetidissima L.
Patersonia fragilis (Labill.) Ashers. & Graebner

JUNCACEAE
Juncus pallidus R.Br.
Juncus pauciflorus R.Br.
Luzula sp.
Luzula novae-cambriae Gondoger

LILIACEAE
Arthropodium minus R.Br.
Bulbine bulbosa (R.Br.) Haw.
Bulbine semibarbata (R.Br.)Haw.
Dianella revoluta R.Br.
Dianella tasmanica Hook.f.

ORCHIDACEAE
Caladenia sp.
Caladenia catenata (Smith) Druce
Dendrobium striolatum Reichb.f.
Pterostylis longifolia R.Br.
Thelymitra sp.

GYMNOSPERMS

CUPRESSACEAE
Callitris oblonga A.& L.Rich.
Callitris rhomboidea R.Br. ex A.& L.Rich
Cupressus macrocarpa Hartw.

PHYLLOCLADACEAE
Phyllocladus aspleniifolius (Labill.) Hook.f.

PTERIDOPHYTES

ADIANTACEAE
Adiantum aethiopicum L.

ASPIDIACEAE
Polystichum proliferum (R.Br.) C.Presl.

ASPLENIACEAE
Asplenium flabellifolium Cav.

BLECHNACEAE
Blechnum nudum (Labill.) Mett.ex Luerss.
Blechnum wattsii Tind.

DAVALLIACEAE
Rumohra adiantiformis (Forst.f.) Ching

DENNSTAEDTIACEAE
Histiopteris incisa (Thunb.) J.Smith
Pteridium esculentum (Forst.f.) Cockayne

DICKSONIACEAE
Dicksonia antarctica Labill.

GRAMMITIDACEAE
Ctenopteris heterophylla (Labill.) Tind.
Grammitis billardieri Willd.

HYMENOPHYLLACEAE
Hymenophyllum cupressiforme Labill.
Hymenophyllum flabellatum Labill.
Hymenophyllum peltatum (Poir.) Desv.
Hymenophyllum rarum R.Br.

LINDSAEACEAE
Lindsaea linearis Swartz

LYCOPODIACEAE
Lycopodium varium R.Br.

POLYPODIACEAE
Microsorum diversifolium (Willd.) Copel.

SELAGINELLACEAE
Selaginella uliginosa (Labill.) Spring

POACEAE   (GRAMINEAE)
Agrostis capillaris L.
Agrostis parviflora R.Br.
Agrostis stolonifera L.
Aira caryophyllea L.
Briza maxima L.
Bromus diandrus Roth
Bromus sterilis L.
Cynosurus echinatus L.
Danthonia caespitosa Gaudich
Danthonia dimidiata Vick.
Danthonia pilosa R.Br.
Danthonia racemosa R.Br.
Danthonia semiannularis (Labill.)R.Br.
Danthonia setacea R.Br.
Deyeuxia accedens Vick.
Deyeuxia monticola (Roemer & Schultes) Vick.
Deyeuxia quadriseta (Labill.) Benth.
Dichelachne rara (R.Br.) Vick.
Ehrharta distichophylla Labill.
Holcus lanatus L.
Ehrharta stipoides Labill.
Phalaris aquatica L.
Phragmites australis (Cav.) Trin. ex Steudel
Poa sp.
Poa labillardieri Steudel
Poa poiformis (Labill.) Druce
Poa rodwayi Vick,
Poa sieberiana Sprengel
Stipa sp
Stipa aphylla (Rodway) J.E.S. Townrow
Stipa mollis R.Br.
Stipa pubinodis Trin. & Rupr.
Stipa rudis Sprengel
Themeda triandra Forsskal

RESTIONACEAE
Hypolaena fastigiata R.Br.
Leptocarpus brownii Hook.f.
Leptocarpus tenax (Labill.) R.Br.

XANTHORRHOEACEAE
Lomandra longifolia Labill.
Lomandra nana (A.Lee) A.Lee
Xanthorrhoea australis R.Br.

SINOPTERIDACEAE
Cheilanthes austrotenuifolia Quirk & Chambers
Pellaea falcata (R.Br.) Fee

Appendix 2

Plant communities containing *C. oblonga*. Structural descriptions follow the classification of Specht (1970) except for understorey descriptions which are in the style of Duncan and Brown (1985)

Eucalyptus **dominated woodlands**

E. amygdalina (E.viminalis) grassy low woodland

E. amygdalina shrubby low open woodland

E.amygdalina grassy low open woodland

E. viminalis shrubby woodland

E. viminalis shrubby low open woodland

E. viminalis grassy low woodland

E. viminalis - *E. pulchella* shrubby low woodland

E. viminalis - *E. ovata* woodland

E. ovata shrubby woodland

E. ovata sedgy low woodland

Eucalyptus **dominated scrub**

E. amygdalina - *Acacia dealbata* closed scrub

Eucalyptus **dominated shrubland**

E.ovata grassy tall shrubland

E.ovata tall shrubland

E.ovata tall open shrubland

Non *Eucalyptus* **dominated scrub**

Melaleuca pustulata - *Pomaderris apetala* - *C.oblonga* closed scrub

Leptospermum lanigerum - *E. viminalis* - *Leptospermum scoparium* open scrub

Melaleuca pustulata (C.oblonga) open scrub

Non *Eucalyptus* **dominated shrubland**

C.oblonga (grassy) tall open shrubland

C.oblonga - *Acacia mucronata* tall open shrubland

C.oblonga - *Hakea microcarpa* - *Leptospermum lanigerum* low open shrubland

Hakea microcarpa - *C.oblonga* tall open shrubland

Appendix 3

Plant communities containing *C.rhomboidea*. Structural descriptions follow the classification of Specht (1970) except for understorey descriptions which are in the style of Duncan and Brown (1985).

***Eucalyptus* dominated forests**

E.pulchella (E.viminalis) - C.rhomboidea low open forest

E.viminalis shrubby tall open forest

E.viminalis - E.globulus shrubby tall open forest

E.globulus - E.nitida shrubby open forest

E.globulus - Allocasuarina verticillata - C.rhomboidea low closed forest

***Eucalyptus* dominated woodlands**

E.globulus - E. tenuiramis shrubby woodland

E.globulus - E.viminalis - E.amygdalina shrubby woodland

E.globulus (shrubby) low open woodland

E.globulus shrubby open woodland

E.globulus shrubby woodland

E.globulus - E.pulchella open woodland

E.globulus - E.pulchella woodland

E.globulus - E.viminalis - E.obliqua grassy woodland

E.globulus - E.obliqua - E.pulchella open woodland

E.globulus (C.rhomboidea) heathy low open woodland

E.globulus (shrubby) low woodland

E.globulus - E.delegatensis (E.viminalis) shrubby woodland

E.viminalis - E.obliqua sedgy/grassy woodland

E.viminalis shrubby low woodland

E.viminalis shrubby woodland

E.viminalis - E.amygdalina shrubby woodland

E.viminalis - E.globulus (shrubby) woodland

E.viminalis - E.amygdalina low open woodland

E.viminalis - (E.pulchella) low open woodland

E.viminalis - E.globulus - E.amygdalina low open woodland

E.viminalis - E.amygdalina (heathy) low woodland

E.viminalis (C.rhomboidea) low woodland

E.viminalis - E.globulus shrubby open woodland

E.amygdalina - E.viminalis heathy woodland

E.amygdalina - E.viminalis sedgy woodland

E.amygdalina - E.viminalis shrubby grassy low woodland

E.amygdalina (C.rhomboidea) low open woodland

E.amygdalina - E.viminalis open woodland

E.obliqua sedgy low woodland

E.obliqua - E.viminalis shrubby woodland

E.obliqua - E.amygdalina heathy woodland

E.obliqua - E.globulus shrubby woodland

E.ovata - E.amygdalina shrubby low woodland

E.ovata shrubby woodland

E.tenuiramis heathy woodland

E.tenuiramis shrubby low woodland

E.tenuiramis - E.amygdalina heathy woodland

E.pulchella - E.amygdalina (shrubby) woodland

E.pulchella - E.viminalis woodland

E.pulchella - C.rhomboidea (grassy) low woodland

E.pulchella - E.globulus low woodland

E.pulchella - E.globulus woodland

E.regnans - E.obliqua shrubby open woodland

E.nitida low open woodland

E.nitida low woodland

Eucalyptus dominated shrubland

E.viminalis (E.ovata) Allocasuarina verticillata tall
shrubland

E.viminalis - C.rhomboidea tall shrubland

E.viminalis (Acacia dealbata) sedgy tall open shrubland

E.tenuiramis - C.rhomboidea sedgy tall open shrubland

E.nitida - Acacia mucronata heathy tall open shrubland

E.globulus - C.rhomboidea tall open shrubland

E.globulus tall open shrubland

Other *Eucalyptus* dominated communities

E.globulus low closed heath

E.nitida closed heath

Non *Eucalyptus* dominated forests

Allocasuarina verticillata - *E.globulus ssp bicostata* grassy low open forest

C.rhomboidea (E.globulus) shrubby low open forests

C.rhomboidea - *Acacia mucronata* - *Melaleuca ericifolia* low closed forest

C.rhomboidea - *Acacia mucronata* - *Melaleuca ericifolia* low closed forest

Melaleuca ericifolia - *L.laevigatum* - *C.rhomboidea* low closed forest

C.rhomboidea - *L.laevigatum* low open forest

C.rhomboidea low closed forest.

Non *Eucalyptus* dominated woodlands

Acacia dealbata sedgy low open woodland

C.rhomboidea - *E.pulchella* low woodland

Non *Eucalyptus* dominated scrub

Pomaderris - *Banksia marginata* closed scrub

Allocasuarina verticillata - *E.globulus* closed scrub

C.rhomboidea - *Leptospermum scoparium* closed scrub

Leptospermum laevigatum - *Leptospermum glaucescens* - *B.marginata* closed scrub

Melaleuca ericifolia - *L.laevigatum* - *C.rhomboidea* closed scrub

Allocasuarina verticillata closed scrub

L.laevigatum - *C.rhomboidea* closed scrub

L laevigatum - *C.rhomboidea* - *Leucopogon parviflorus* open scrub

C.rhomboidea - *Melaleuca ericifolia* closed scrub

C.rhomboidea - *L.laevigatum* closed scrub

C.rhomboidea - *Allocasuarina verticillata* - *L.laevigatum* open scrub

C.rhomboidea open scrub

Non *Eucalyptus* dominated shrubland

Allocasuarina verticillata - *C.rhomboidea* tall open shrubland

Other non *Eucalyptus* communities

L.laevigatum - *L.glaucescens* - *C.rhomboidea* closed heath

Kunzea ambigua - *C.rhomboidea* open heath

L.laevigatum - *C.rhomboidea* - *Kunzea ambigua* closed heath

Leucopogon parviflorus - *C.rhomboidea* - *Kunzea ambigua* closed heath.

Appendix 4

A note on the taxonomy of *Callitris* with special reference to *Callitris oblonga*

There has been such confusion in the taxonomy of *Callitris* species that a number of non-taxonomic papers have deliberately used common names to avoid confusion (e.g. Lacey, 1972 & 1973; Dale, 1979). The earliest systematic attempt at examining nomenclature of all *Callitris* species was carried out by Baker and Smith (1910) who recommended nomenclatural changes resulting from their phytochemical and systematic work. Chaos persisted because many of the names in use had not been validly published, leading Garden (1956) to undertake a complete revision of the genus. This led to delineation of 16 species, with one species being divided into 3 sub-species. This treatment showed *C. oblonga* as being endemic in Tasmania. A number of authors (e.g. Brown *et al* 1983) have treated *C.oblonga* as a Tasmanian endemic. There are *Callitris* forms from NSW however, which have been attributed to *C.oblonga* by a number of authors (Gray 1961, Beadle 1972, Jacobs and Pickard 1981).

The most recent evidence (Venning 1979) indicated 14 species of *Callitris* in Australia. Ten of the 16 described by Garden are still generally recognised without debate. The exceptions which have caused problems in the literature have been those species in the complex: *C. columellaris, C. hugelii - C. intratropica - C. preisii*. Venning (op.cit.) recommended that this complex be reduced to 3 species: *C. preissii, C. verrucosa* and *C. columellaris*. The 'inland form' of *C.columellaris,* also called *C.hugelii* has since been named as *C. glaucophylla* (Thompson and Johnson, 1986).

The problem that has arisen in relation to *C. oblonga* has also been examined by Venning (op. cit.) who points out that Garden (op. cit.) maintained that the nominal type locality was incorrect. She goes on to say:

"The synonymy in early descriptions reflects some confusion regarding the concept of this species. Endlicher (1847) and Carriere (1855) regarded *Frenela fruticosa* (R. Br.) Endl. and *Callitris oblonga* L.C.Rich. as synonymous, both occurring in eastern Australia. However, Parlatore (1868) and Bentham (1873) listed the former as a synonym of *Frenela endlicheri* Parl.

As no type material has been located, it is difficult to understand the reason for this inconsistent synonymy. One of the two following suggestions may apply. Firstly, whether the locality was incorrectly given as maintained by Garden (1956), or secondly the material originally described by Richard (1826) was a form of *Callitris endlicheri* that resembled what is today known as *C. oblonga*. Acceptance of the second suggestion would involve nomenclature changes. The name *C. oblonga* would need to be substituted for *C. endlicheri* and *C. gunnii* for *C. oblonga*. However, as no type material has been found any nomenclature changes would be premature, but these inconsistencies in synonymy should not be overlooked. The original description alone was not adequate to allow clarification."

Venning was unable to make as thorough a study on *C. oblonga* as on other *Callitris* species because of a lack of material.

Specimens of foliage bearing male and female cones of *C.sp. aff.oblonga* were examined for comparison with *C.oblonga*. The specimens were collected from Sandy Creek via Bull Creek NSW by Dr.J.Jarman and Dr.G.Kantvilas in August 1988.

The specimens of what is called here *C.sp.aff. oblonga* shows a marked difference to *C.oblonga* in the size of the female cones. The mature cones on the NSW specimens are half the size of mature Tasmanian specimens. The distinctive recurved spur on each of the 6 valves of *C.sp.aff. oblonga* are repeated to a much lesser extent on those of the Tasmanian *C.oblonga*. The NSW specimens were collected in August and bore maturing

male cones. The foliage of the NSW specimens were yellow green and not glaucous.

To avoid continuing confusion the material requires further examination and the publication of revised nomenclature. It is noted that Briggs and Leigh (1988) list the Tasmanian species as *Callitris* sp.1 (*aff.oblonga*) (Tasmania).

Appendix 5

Percentage frequency of taxa in classificatory groups. 1 = 1=10%; 2 = 11-20%; 3 = 21-30%; 4 = 31-40%; 5 = 41-50%; 6 = 51-60%; 7 = 61-70%; 8 = 71-80%; 9 = 81-100%.

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                        11
              12345678901

Ac   ax    -3---------        Anag arv   4---1-2----
Ac   bot   ---12--1---
Ac   deal  742522-----        Anop glan  ----------2
Ac   ech   ----1------        Anth tasm  -----1-----
Ac   gen   --232------        Aot  eric  ---2---2---
Ac   mear  -12-2------        Arct cal   -------4----
Ac   mel   --22-2-----        Arth min   ---1-------
Ac   muc   --3-42287-4        Aspl flab  ---124----8
Ac   myr   ---22--1---        Ast  disc  ---113-----
Ac   n-z   42-2268---2        Ast  hum   -1-682--1--
Ac   soph  ------2----        Ast  pin   ---2---1---
Ac   stri  --------1--        Ath  mos   ----------2
Ac   suav  ---1-------        Aust pus   ----------2
Ac   vern  --------1--        Aust ten   ----11-----
Ac   vert  --3227221--        Baec ram   ---21------
Acr  serr  -1211------        Bank marg  -2362445---
Ad   aeth  ----1------        Baue rub   -2--11-----
Agr  cap   -12--------        Baum junc  ---2-------
Agr  parv  -1---------        Bed  lin   -----1----2
Agr  stol  --2--------        Bedf sali  ---2-3----6
Air  car   -1-211--12-        Bey  visc  --3-252---8
Air  sp    -1---------        Bill long  ----1121---
Ajug aust  -3---1-----        Bill proc  -2---------
All  litt  -1-42122---        Bill scan  -------12--
Amp  xiph  ---2---1---        Blec nud   -----1-----
                              Blec wat   -----1-----
                              Bor  an    --------12-
                              Bor  cit   -------1---
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Dant	dim	----1------
Dant	pil	---1-------
Dant	rac	----1-2----
Dant	sem	-1---------
Dant	set	-1-21------
Dant	sp	---22-2----
Dauc	gloc	----1------
Dav	ul	---1-------
Dend	str	----1---1--
Dey	ac	----------4
Dey	mont	---1-------
Dey	quad	----1------
Dian	rev	4--12-2-2--
Dian	tasm	---314--3--
Dich	rar	----1------
Dich	rep	--22212--3-
Dick	ant	--------1-2
Dill	cin	---1---1---
Dill	glab	-------1---
Dill	ser	---1-------
Dill	sp	-------1---
Dip	mor	---22-4----
Dist	dist	4----------
Dod	visc	--2122-1162
Dros	aur	-2-32------
Euca	amyg	-224412----
Euca	del	----------2
Euca	glob	---337462-6
Euca	nit	-------33--
Euca	ov	4831-1-----
Euca	pul	----642---2
Euca	reg	------1----
Euca	ten	---21--1---
Euca	vim	7424756-1--
El	ac	4----------
El	ret	------1--1--
Ep	gunn	-1------1---
Ep	imp	-5-74223---
Ep	lan	---1-1-----
Ep	marg	----------2
Ep	pal	-------1---
Ep	sp	-1---1-----
Ep	tasm	-2-2-------
Er	verr	----1------
Erh	dist	-1242-2----
Euca	obli	---2-4----2
Ex	cupr	-13324-21--
Ex	syrt	---------1--
Exoc	sp	-------1---
Gahn	gram	---12------
Gahn	gran	--22-2-----
Gahn	rad	---21------
Gahn	sp	----1------
Gahn	trif	---1-------
Gal	alb	-----2-----
Gal	aust	---122---22
Gal	cil	----------2
Gal	gaud	---111-----
Bor	het	-------1---
Bor	pil	-------1---
Boss	cin	---2-------
Boss	pros	-32251-----
Boss	sp	---11-2----
Brac	ac	----2------
Brac	dep	-------1---
Brac	parv	--------1--
Brac	rig	----1------
Briz	max	---------2-
Brom	dian	------2--6-
Brom	ster	------2----
Bul	bul	----1------
Bul	sem	------2----
Burs	spin	4253758--3-
Cal	cat	-----1-----
Cal	sp	----1------
Cal	tet	--------1--
Call	obl	-9921141---
Call	pall	-15121--1--
Call	rhom	1--99989999
Car	brev	-1--42-----
Car	iynx	-22--------
Card	sp	-----1-----
Care	sp	42---------
Carp	ross	4--1-------
Cass	acul	9---112----
Cass	glab	---2---1---
Cass	mel	--2----11--
Cass	pub	-1-311-----
All	mon	---2---4---
All	vert	--223122732
Cent	er	-12-1---1--
Cent	stri	--------1--
Cer	font	---11------
Chei	aust	---131-----
Cir	vul	4----12----
Clem	aris	--3-242-4-2
Clem	gent	---21------
Come	vol	---342--12-
Gomp	hueg	-------1---
Cop	hirt	----12-----
Cop	quad	--2-16----4
Corr	lawr	-----1-----
Corr	refl	---341-31--
Corr	sp	---1-----1-2
Cot	sp	----1-4----
Cras	sieb	---11--1-52
Crat	sp	-1----2----
Cten	het	-----2----8
Cup	mac	------2----
Cyat	div	----12-----
Cyat	glau	----11-1--2
Cyat	jun	---122--122
Cyat	sp	----21--1-2
Cyn	ech	------2----
Dam	stri	---1-------
Dant	caes	---1---1---

Isol	nod	---2-1-----
Isol	subt	-----1-----
Isop	cer	-------1---
Jun	pall	4--------2-
Jun	pauc	-1---------
Kunz	amb	-----1-342-
Lag	sp	----------2-
Lag	stip	4---12-----
Las	mic	--2--------
Lasi	baue	-------21--
Leon	tar	-4--1-2----
Lep	conc	---31-224--
Lep	lat	----1-----2
Lep	lin	---25--1---
Lep	long	--2----1---
Lepi	elat	-324692-4-2
Lepi	sp	312-1-242--
Lept	brow	-2---------
Lept	drup	---1-------
Lept	glau	-------5---
Lept	gran	----2--1---
Lept	laev	-------569-
Lept	lan	45222221---
Lept	scop	--2522-54--
Lept	squa	-1-11------
Lept	ten	4--1---1---
Leuc	coll	--341--1---
Leuc	er	---1---1---
Leuc	parv	---2---216-
Leuc	sp	4--2-1-11--
Lind	lin	---21------
Liss	stri	42----2----
Lom	long	-796826----
Lom	nan	---1-------
Lom	tinc	-1-421-----
Loma	sp	-----1-----
Luz	n-c	---1-------
Luzu	sp	----11---2-
Lyco	var	----------4
Mel	eric	--32122253-
Mel	gib	-63----1---
Mel	pust	-1213------
Mel	squa	-----1-1---
Men	diem	----1------
Mic	div	-----2-11-6
Mic	hex	--6-212----
Mic	stip	--------1--
Mon	ell	---2---1---
Mono	glau	-------2---
Mono	sp	---1-1-2--2
Mueh	adpr	--------1--
Myop	ins	-------4----
Not	lig	--3-43--1-6
Od	ang	-1-1-2-----
Odix	sp	-----1-----
Ol	arg	---111----2
Ol	eric	----1------
Ol	lep	-------1---
Gal	sp	----132--52
Ger	pot	4----22---4
Ger	sol	-----1-----
Ger	sp	-----2-----
Glyc	clan	---2-------
Gnap	coll	41-122-----
Gnap	sp	---121-----
Gon	micr	--6-1-21---
Gon	tet	-3-351-----
Gon	teuc	---143--1-2
Good	elon	----1------
Good	lan	---24------
Good	lot	------1-----
Good	ovat	----14--1-4
Good	sp	---111-----
Gram	bill	----------2
Grev	aust	-12--------
Hak	liss	-----2-----
Hak	ser	-------1---
Hak	sp	-------1---
Hak	ter	---1---1---
Hov	lin	----1------
Heb	form	----11-----
Hel	ant	----------4
Hel	ap	----1------
Hel	cost	---11------
Hel	dend	4----------
Hel	lyco	----2------
Hel	obc	-------1---
Hel	pap	---1-------
Hel	scut	-----1------
Hel	scor	---22------
Hel	sp	--------1--
Hibb	asp	---1-------
Hibb	emp	-------2---
Hibb	fasc	---1-------
Hibb	hir	----1------
Hibb	rip	-1245--1---
Hibb	serp	---12------
Hibb	sp	--2-2------
Hyp	rug	----------2
Hist	inci	-----1--1--
Holc	lan	7--2--2----
Hov	long	----1------
Hyd	jav	---2-------
Hyd	sib	----12----2
Hyd	sp	----13----4
Hym	cup	----------2
Hym	flab	----------2
Hym	pelt	-----2----4
Hym	rar	-----1-----
Hyp	fast	---2---2---
Hyp	glab	--21-------
Hyp	gram	---13----2-
Hyp	rad	-2221-6--2-
Hyp	sp	----1------
Ind	aust	---11------
Iris	foet	------2----

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Ol   lir    ---1122-1--        Ros   sp     45----2----
Ol   myrs   ---------2         Rub   frut   --3---21---
Ol   pers   ---------2         Rub   parv   ----1------
Ol   phl    -----1--1-2        Rum   ac     ------2----
Ol   stel   ---1----2--        Rum   brow   ---------2-
Ol   visc   -----4-----        Rumo  ad     -----1----6
Ox   corn   -123479-12-        Scho  ap     -5-22------
Ox   sp     ------2----        Sel   ul     ---2---1---
Pat  frag   ---1-------        Sen   hisp   4--1-------
Pel  inod   ----1------        Sen   laut   ---------3-
Pel  sp     4---1------        Sen   lin    -----12----
Pell falc   -----1----2        Sen   min    ---1-------
Pers jun    ---11------        Sen   quad   ---11-2----
Phal aqua   -------2----       Sen   sp     -1-1-14-1--
Pheb bil    -----1-----        Sile  sp     ---------2-
Pheb squa   -----1-----        Sol   nigr   ---1-------
Phra aust   ------2----        Sol   sp     -----2----
Phyl asp    ----------2        Son   asp    ---------1--
Phyl gunn   --------1--        Son   sp     ------2--2-
Phyl aust   -1--1------        Sonc  ol     ---1--2-1--
Pim  drup   ----------4        Spha  vim    ---2-------
Pim  flav   -------1---        Spyr  ob     --2-212----
Pim  hum    ----1------        Spyr  sp     ---1-------
Pim  niv    ----21----2        Spyr  vex    --2--------
Pim  sp     ---2-2-----        Stac  mon    ----1---12-
Pitt bic    -----1-1--2        Sten  pim    -1---------
Plan lanc   4-2-116----        Stip  aph    ---11------
Plan sp     ----1------        Stip  mol    -1--1-2----
Plan var    ---11------        Stip  pub    ----1------
Plat form   ---1-------        Stip  rud    ---1-------
Plat tria   -1-31------        Stip  sp     --2-1------
Poa  lab    97---1--1--        Styl  gram   ---242-1--2
Poa  poif   ---1----15-        Tasm  lanc   --2--1----2
Poa  rod    ---171-----        Tet   cap    ---1-------
Poa  sieb   --2-12-----        Tet   impl   ------2--2-
Poa  sp     -2222361-24        Tet   pil    ---11------
Pol  prol   -----2----2        Thel  sp     ---------3-
Pol  tet    ---------5-        Them  tria   -3233------
Pom  apet   -26-288---6        Trif  dub    ----1----2-
Spyr micr   --2-1------        Trif  rep    ---------2-
Pom  ell    ---12--1---        Trif  sp     -----1-----
Pom  pil    ---1-------        Ul    eur    42911-4----
Pom  sp     ----1------        Urti  sp     ----1----2-
Por  mic    --2232----2        Ver   cal    ---11------
Pros las    ----12----2        Vic   glom   ---------2-
Prun vulg   -2----2----        Vici  sp     ---------2-
Pter esc    ---526224-2        Vinc  maj    ------2----
Pter long   -----2-----        Viol  hed    ---355-1---
Pult daph   ---1-2-15--        Viol  sp     ----1------
Pult gunn   ---31------        Wahl  grac   ---1-------
Pult jun    ---3222----        Wahl  gym    ----11-----
Pult ped    -1---------        Wahl  sp     ---221-----
Pult stri   -1---------        Xan   aust   ----1--1---
Ranu sp     ----1------        Xant  pil    -------1---
Rhag cand   -------115-        Xant  sp     ----1------
Ric  pin    ---1-------        Xant  trid   ----1--1---
Ror  sp     ------2----        Xyr   grac   ---1-------
Ros  rub    ------4----        Zier  arb    -----4-21-4

                               Zyg   bill   ---------2-
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Appendix 6 Species key

Ac	ax	ACACIA AXILLARIS
Ac	bot	ACACIA BOTRYCEPHALA
Ac	deal	ACACIA DEALBATA
Ac	ech	ACAENA ECHINATA
Ac	gen	ACACIA GENISTIFOLIA
Ac	mear	ACACIA MEARNSII
Ac	mel	ACACIA MELANOXYLON
Ac	muc	ACACIA MUCRONATA
Ac	myr	ACACIA MYRTIFOLIA
Ac	n-z	ACAENA NOVAE-ZELANDIAE
Ac	soph	ACACIA SOPHORAE
Ac	stri	ACACIA STRICTA
Ac	suav	ACACIA SUAVEOLENS
Ac	vern	ACACIA VERNICIFLUA
Ac	vert	ACACIA VERTICILLATA
Acr	serr	ACROTRICHE SERRULATA
Ad	aeth	ADIANTUM AETHOPOICIUM
Agr	cap	AGROSTIS CAPILLARIS
Agr	parv	AGROSTIS PARVIFLORA
Agr	stol	AGROSTIS STOLONIFERA
Air	car	AIRA CARYOPHYLLEA
Air	sp	AIRA SP
Ajug	aust	AJUGA AUSTRALIS
All	litt	ALLOCASUARINA LITTORALIS
All	mon	ALLOCASUARINA MONILIFERA
All	vert	ALLOCASUARINA VERTICILLATA
Amp	xiph	AMPEREA XIPHOCLADA
Anag	arv	ANAGALLIS ARVENSIS
Anis	av	ANISOPOGON AVENACEUS
Anop	glan	ANOPTERUS GLANDULOSUS
Aot	eric	AOTUS ERICOIDES
Arct	cal	ARCTOTHECA CALENDULA
Arth	min	ARTHROPODIUM MILLEFLORUM
Aspl	flab	ASPLENIUM FLABELLIFOLIUM
Ast	disc	ASTEROTRICHION DISCOLOR
Ast	hum	ASTROLOMA HUMIFUSUM
Ast	pin	ASTROLOMA PINIFOLIUM
Ath	mos	ATHEROSPERMA MOSCHATUM
Aust	pus	AUSTRALINA PUSILLA
Aust	ten	BEDFORDIA LINEARIS
Baec	ram	BAECKEA RAMOSISSIMA
Bank	marg	BANKSIA MARGINATA
Baue	rub	BAUERA RUBIOIDES
Baum	junc	BAUMEA JUNCEA
Bed	lin	HYMENOPHYLLUM SP
Bedf	sali	BEDFORDIA SALICINA
Bey	visc	BEYERIA VISCOSA
Bill	long	BILLARDIERA LONGIFLORA
Bill	proc	BILLARDIERA PROCUMBENS
Bill	scan	BILLARDIERA SCANDENS
Blec	nud	BLECHNUM NUDUM
Blec	wat	BLECHNUM WATTSII

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Bor    an      BORONIA ANEMONIFOLIA
Bor    cit     BORONIA CITRIODORA
Bor    het     BORONIA HETERONEMA
Bor    pil     BORONIA PILOSA
Boss   cin     BOSSIAEA CINEREA
Boss   pros    BOSSIDAEA PROSTRATA
Boss   sp      BOSSIAEA SP
Brac   ac      BRACHYSCOME ACULEATA
Brac   dep     BRACHYSCOME DECIPIENS
Brac   parv    BRACHYSCOME PARVULA
Brac   rig     BRACHYSCOME RIGIDULA
Briz   max     BRIZA MAXIMA
Brom   dian    BROMUS DIANDRUS
Brom   ster    BROMUS STERILIS
Bul    bul     BULBINE BULBOSA
Bul    sem     BULBINE SEMIBARBATA
Burs   spin    BURSARIA SPINOSA
Cal    cat     CALADENIA CARNEA
Cal    sp      CALADENIA SP
Cal    tet     CALYTRIX TETRAGONA
Call   obl     CALLITRIS OBLONGA
Call   pall    CALLISTEMON PALLIDUS
Call   rhom    CALLITRIS RHOMBOIDEA
Car    brev    CAREX BREVICULMIS
Car    iynx    CAREX IYNX
Card   sp      CARDAMINE SP
Care   sp      CAREX SP
Carp   ross    CARPOBROTUS ROSSIL
Cass   acul    CASSINEA ACULEATA
Cass   glab    CASSYTHA GLABELLA
Cass   mel     CASSYTHA MELANTHA
Cass   pub     CASSYTHA PUBESCENS
Cent   er      CENTAURIUM ERYTHRAEA
Cent   stri    CENTROLEPIS STRIGOSA
Cer    font    CERASTIUM FONTANUM
Chei   aust    CHEILANTHES AUSTROTENUIFOLIA
Cir    vul     CIRSIUM VULGARE
Clem   aris    CLEMATIS ARISTATA
Clem   gent    CLEMATIS GENTIANOIDES
Come   vol     COMESPERMA VOLUBILE
Cop    hirt    COPROSMA HIRTELLA
Cop    quad    COPROSMA QUADRIFIDA
Corr   lawr    CORREA LAWRENCIANA
Corr   refl    CORREA REFLEXA
Corr   sp      CORREA SP
Cot    sp      COTULA SP
Cras   sieb    CRASSULA SIEBERANA
Crat   sp      CRATAEGUS MONOGYNA
Cten   het     CTENOPTERIS HETEROPHYLLA
Cup    mac     CUPRESSUS MACROCARPA
Cyat   div     CYATHODES DIVARICATA
Cyat   glau    CYATHODES GLAUCA
Cyat   jun     CYATHODES JUNIPERINA
Cyat   sp      CYATHODES SP
Cyn    ech     CYNOSURUS ECHINATUS
Cyph   tasm    CYPHANTHERA TASMANICA
Dam    stri    DAMPIERA STRICTA
Dant   caes    DANTHONIA CAESPITOSA
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Dant   dim     DANTHONIA DIEMENICA
Dant   pil     DANTHONIA PILOSA
Dant   rac     DANTHONIA RACEMOSA
Dant   sem     DANTHONIA SEMIANNULARIS
Dant   set     DANTHONIA SETACEA
Dant   sp      DANTHONIA SP
Dauc   gloc    DAUCUS GLOCHIDIATUS
Dav    ul      DAVIESIA ULICIFOLIA
Dend   str     DENDROBIUM STRIOLATUM
Dey    ac      DEYEUXIA ACCEDENS
Dey    mont    DEYEUXIA MONTICOLA
Dey    quad    DEYEUXIA QUADRISETA
Dian   rev     DIANELLA REVOLUTA
Dian   tasm    DIANELLA TASMANICA
Dich   rar     DICHELACNE RARA
Dich   rep     DICHONDRA REPENS
Dick   ant     DICKSONIA ANTARCTICA
Dill   cin     DILLWYNIA CINEREA
Dill   glab    DILLWYNIA GLABERRIMA
Dill   ser     DILLWYNIA SERICEA
Dill   sp      DILLWYNNIA SP
Dip    mor     DIPLARRENA MORAEA
Dist   dist    EHRHARTA DISTICOPHYLLA
Dod    visc    DODONAEA VISCOSA
Dros   aur     DROSERA PELTATA
El     ac      ELEOCHARIS ACUTA
El     ret     ELAEOCARPUS RETICULATUS
Ep     gunn    EPACRIS GUNNII
Ep     imp     EPACRIS IMPRESSA
Ep     lan     EPACRIS LANUGINOSA
Ep     marg    EPACRIS MARGINATA
Ep     pal     EPACRIS PALUDOSA
Ep     sp      EPILOBIUM SP
Ep     tasm    EPACRIS TASMANICA
Er     verr    ERIOSTEMON VERRUCOSUS
Erh    dist    EHRHARTA DISTICOPHYLLA
Euca   amyg    EUCALYPTUS AMYGDALINA
Euca   del     EUCALYPTUS DELEGATENSIS
Euca   glob    EUCALYPTUS GLOBULUS
Euca   nit     EUCALYPTUS NITIDA
Euca   obli    EUCALYPTUS OBLIQUA
Euca   ov      EUCALYPTUS OVATA
Euca   pul     EUCALYPTUS PULCHELLA
Euca   reg     EUCALYPTUS REGNANS
Euca   ten     EUCALYPTUS TENUIRAMIS
Euca   vim     EUCALYPTUS VIMINALIS
Ex     cupr    EXOCARPOS CUPRESSIFORMIS
Ex     syrt    EXOCARPOS SYRTICOLA
Exoc   sp      EXOCARPOS SP
Gahn   gram    GAHNIA GRAMINIFOLIA
Gahn   gran    GAHNIA GRANDIS
Gahn   rad     GAHNIA RADULA
Gahn   sp      GAHNIA SP
Gahn   trif    GAHNIA TRIFIDA
Gal    alb     GALIUM ALBESCENS
Gal    aust    GALIUM AUSTRALE
Gal    cil     GALIUM CILIARE
Gal    gaud    GALIUM GAUDICHAUDII
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Gal    sp      GALIUM SP
Ger    pot     GERANIUM POTENTILLOIDES
Ger    sol     GERANIUM SOLANDERI
Ger    sp      GERANIUM SP
Glyc   clan    GLYCINE CLANDESTINA
Gnap   coll    GNAPHALIUM COLLINUM
Gnap   sp      GNAPHALIUM SP
Gomp   hueg    GOMPHOLOBIUM HUEGELII
Gon    micr    GONOCARPUS MICRANTHUS
Gon    tet     GONOCARPUS TETRAGYNUS
Gon    teuc    GONOCARPUS TEUCRIOIDES
Good   elon    GOODENIA ELONGATA
Good   lan     GOODENIA LANATA
Good   lot     GOODIA LOTIFOLIA
Good   ovat    GOODENIA OVATA
Good   sp      GOODENIA SP
Gram   bill    GRAMMITIS BILLARDIERI
Grev   aust    GREVILLEA AUSTRALIS
Hak    liss    HAKEA LISSOSPERMA
Hak    ser     HAKEA SERICEA
Hak    sp      HAKEA SP
Hak    ter     HAKEA TERETEFOLIA
Heb    form    VERONICA FORMOSA
Hel    ant     HELICHRYSUM ANTENNARIUM
Hel    ap      HELICHRYSUM APICULATUM
Hel    cost    HELICHRYSUM COSTATIFRUCTUM
Hel    dend    HELICHRYSUM DENDROIDIUM
Hel    lyco    HELICHRYSUM LYCOPODIOIDES
Hel    obc     HELICHRYSUM OBCORDATUM
Hel    pap     HELICHRYSUM PAPILLOSUM
Hel    scat    HELICHRYSUM SCUTELLIFOLIUM .
Hel    scor    HELICHRYSUM SCORPIODES
Hel    sp      HELICHRYSUM SP
Hibb   asp     HIBBERTIA ASPERA
Hibb   emp     HIBBERTIA EMPETRIFOLIA
Hibb   fasc    HIBBERTIA PROSTRATA
Hibb   hir     HIBBERTIA HIRSUTA
Hibb   rip     HIBBERTIA RIPARIA
Hibb   serp    HIBBERTIA SERPYLLIFOLIA
Hibb   sp      HIBBERTIA SP
Hist   inci    HISTIOPTERIS INCISA
Holc   lan     HOLCUS LANATUS
Hov    lin     HOVEA LINEARIS
Hov    long    HOVEA LANCEOLATA
Hyd    jav     HYDROCOTYLE JAVANICA
Hyd    sib     HYDROCOTYLE SIBTHORPIOIDES
Hyd    sp      HYDROCOTYLE SP
Hym    cup     HYMENOPHYLLUM CUPRESSIFORME
Hym    flab    HYMENOPHYLLUM FLABELLIFOLIUM
Hym    pelt    HYMENOPHYLLUM PELTATUM
Hym    rar     HYMENOPHYLLUM RARUM
Hyp    fast    HYPOLAENA FASTIGIATA
Hyp    glab    HYPOCHOERIS GLABRA
Hyp    gram    HYPERICUM GRAMINEUM
Hyp    rad     HYPOCHOERIS RADICATA
Hyp    rug     HYPOLEPIS RUGOSULA
Hyp    sp      HYPERICUM SP
Ind    aust    INDIGOFERA AUSTRALIS
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Iris    foet      IRIS FOETIDISSIMA
Isol    nod       ISOLEPIS NODOSUS
Isol    subt      ISOLEPIS SUBTILISSIMA
Isop    cer       ISOPOGON CERATOPHYLLUS
Jun     pall      JUNCUS PALLIDUS
Jun     pauc      JUNCUS PAUCIFLORUS
Kunz    amb       KUNZEA AMBIGUA
Lag     sp        LAGURUS SP
Lag     stip      LAGENIFERA STIPITATA
Las     mic       LASIOPETALUM MICRANTHUM
Lasi    baue      LASIOPETALUM BAUERI
Leon    tar       LEONTODON TARAXACOIDES
Lep     conc      LEPIDOSPERMA CONCAVUM
Lep     lat       LEPIDOSPERMA LATERALE
Lep     lin       LEPIDOSPERMA LINEARE
Lep     long      LEPIDOSPERMA LONGITUDINALE
Lepi    elat      LEPIDOSPERMA ELATIUS
Lepi    sp        LEPIDOSPERMA SP
Lept    brow      LEPTOCARPUS BROWNII
Lept    drup      LEPTOMERIA DRUPACEA
Lept    glau      LEPTOSPERMUM GLAUCESCENS
Lept    gran      LEPTOSPERMUM GRANDIFLORUM
Lept    laev      LEPTOSPERMUM LAEVIGATUM
Lept    lan       LEPTOSPERMUM LANIGERUM
Lept    scop      LEPTOSPERMUM SCOPARIUM
Lept    squa      LEPTORHYNCHOS SQUAMATUS
Lept    ten       LEPTOCARPUS TENAX
Leuc    coll      LEUCOPOGON COLLINUS
Leuc    er        LEUCOPOGON ERICOIDES
Leuc    parv      LEUCOPOGON PARVIFLORUS
Leuc    sp        LEUCOPOGON SP
Lind    lin       LINDSAEA LINEARIS
Liss    stri      LISSANTHE STRIGOSA
Lom     long      LOMANDRA LONGIFOLIA
Lom     nan       LOMANDRA NANA
Lom     tinc      LOMATIA TINCTORIA
Loma    sp        LOMATIA SP
Luz     n-c       LUZULA NOVAE-CAMBRIAE
Luzu    sp        LUZULA SP
Lyco    var       LYCOPODIUM VARIUM
Mel     eric      MELALEUCA ERICIFOLIA
Mel     gib       MELALEUCA GIBBOSA
Mel     pust      MELALEUCA PUSTULATA
Mel     squa      MELALEUCA SQUARROSA
Men     diem      MENTHA DIEMENICA
Mic     div       MICROSORUM DIVERSIFOLIUM
Mic     hex       MICRANTHEUM HEXANDRUM
Mon     ell       MONOTOCA ELLIPTICA
Mono    glau      MONTOCA GLAUCA
Mono    sp        MONOTOCA SP
Mueh    adpr      MUEHLENBECKIA ADPRESSA
Myop    ins       MYOPORUM INSULARE
Not     lig       NOTELAEA LIGUSTRINA
Od      ang       ODIXIA ANGUSTA
Odix    sp        ODIXIA SP
Ol      arg       OLEARIA ARGOPHYLLA
Ol      eric      OLEARIA ERICOIDES
Ol      lep       OLEARIA LEPIDOPHYLLA
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Ol    lir     OLEARIA LIRATA
Ol    myrs    OLEARIA MYRSINOIDES
Ol    pers    OLEARIA PERSOONIOIDES
Ol    phl     OLEARIA PHLOGOPAPPA
Ol    stel    OLEARIA STELLULATA
Ol    visc    OLEARIA VISCOSA
Ox    corn    OXALIS CORNICULATA
Ox    sp      OXALIS SP
Pat   frag    PATERSONIA FRAGILIS
Pel   inod    PELARGONIUM INODORUM
Pel   sp      PELARGONIUM SP
Pell  falc    PELLAEA FALCATA
Pers  jun     PERSOONIA JUNIPERINA
Phal  aqua    PHALARIS AQUATICA
Pheb  bil     PHEBALIUM BILOBUM
Pheb  squa    PHEBALIUM SQUAMEUM
Phra  aust    PHRAGMITES AUSTRALIS
Phyl  asp     PHYLLOCLADUS ASPLENIFOLIUS
Phyl  aust    PHYLLANTHUS AUSTRALIS
Pim   drup    PIMELEA DRUPACEAE
Pim   flav    PIMELEA FLAVA
Pim   hum     PIMELEA HUMILIS
Pim   niv     PIMELEA NIVEA
Pim   sp      PIMELEA SP
Pitt  bic     PITTOSPORUM BICOLOR
Plan  lanc    PLANTAGO LANCEOLATA
Plan  sp      PLANTAGO SP
Plan  var     PLANTAGU VARIA
Plat  form    PLATYLOBIUM FORMOSUM
Plat  tria    PLATYLOBIUM TRIANGULARE
Poa   lab     POA LABILLARDIERI
Poa   poif    POA POIFORMIS
Poa   rod     POA RODWAYI
Poa   sieb    POA SIEBERIANA
Poa   sp      POA SP
Pol   prol    POLYSTICHUM PROLIFERUM
Pol   tet     POLYCARPON TETRAPHYLLUM
Pom   apet    POMADERRIS APETALA
Pom   ell     POMADERRIS ELLIPTICA
Pom   pil     POMADERRIS PILIFERA
Pom   sp      POMADERRIS SP
Por   mic     PORANTHERA MICROPHYLLA
Pros  las     PROSTANTHERA LASIANTHOS
Prun  vulg    PRUNELLA VULGARIS
Pter  esc     PTERIDIUM ESCULENTUM
Pter  long    PTEROSTYLIS LONGIFOLIA
Pult  daph    PULTANAEA DAPHNOIDES
Pult  gunn    PULTENAEA GUNNII
Pult  jun     PULTENAEA JUNIPERINA
Pult  ped     PULTENAEA PEDUNCULATA
Pult  stri    PULTENAEA STRICTA
Ranu  sp      RANUNCULUS SP
Rhag  cand    RHAGODIA CANDOLLEANA
Ric   pin     RICINOCARPUS PINIFOLIUS
Ror   sp      RORIPPA SP
Ros   rub     ROSA RUBIGINOSA
Ros   sp      ROSA SP
Rub   frut    RUBUS FRUITICOSUS
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Rub    parv    RUBUS PARVIFOLIUS
Rum    ac      RUMEX ACETOSELLA
Rum    brow    RUMEX BROWNII
Rumo   ad      RUMOHRA ADIANTIFORMIS
Scho   ap      SCHOENUS APOGON
Sel    ul      SELAGINELLA ULIGINOSA
Sen    hisp    SENECIO HISPIDULUS
Sen    laut    SENECIO LAUTUS
Sen    lin     SENECIO LINEARIFOLIUS
Sen    min     SENECIO MINIMUM
Sen    quad    SENECIO QUADRIDENTATUS
Sen    sp      SENECIO SP
Sile   sp      SILENE SP
Sol    nigr    SOLANUM NIGRUM
Sol    sp      SOLANUM SP
Son    asp     SONCHUS ASPER
Son    sp      SONCHUS SP
Sonc   ol      SONCHUS OLERACEUS
Spha   vim     SPHAEROLOBIUM VIMINEUM
Spy    micr    SPYRIDIUM MICRANTHUM
Spyr   ob      SPYRIDIUM OBOVATUM
Spyr   sp      SPYRIDIUM SP
Stac   mon     STACKHOUSIA MONOGYNA
Sten   pim     STENANTHEMUM PIMELEOIDES
Stip   aph     STIPA APHYLLA
Stip   mol     STIPA MOLLIS
Stip   pub     STIPA PUBINODIS
Stip   rud     STIPA RUDIS
Stip   sp      STIPA SP
Styl   gram    STYLIDIUM GRAMINIFOLIUM
Tasm   lanc    TASMANNIA LANCEOLATA
Tet    cap     TETRARIA CAPILLARIS
Tet    impl    TETRAGONIA IMPLEXICOMA
Tet    pil     TETRATHECA PILOSA
Thel   sp      THELYMITRA SP
Them   tria    THEMEDA TRIANDRA
Trif   dub     TRIFOLIUM DUBIUM
Trif   rep     TRIFOLIUM REPENS
Trif   sp      TRIFOLIUM SP
Ul     eur     ULEX EUROPAEUS
Urti   sp      URTICA SP
Ver    cal     VERONICA CALYCINA
Ver    form    VERONICA FORMOSA
Vic    glom    VICIA GLOMERATA
Vici   sp      VICIA SP
Vinc   maj     VINCA MAJOR
Viol   hed     VIOLA HEDERACEA
Viol   sp      VIOLA SP
Wahl   grac    WAHLENBERGIA GRACILENTA
Wahl   gym     WAHLENBERGIA GYMNOCLADA
Wahl   sp      WAHLENBERGIA SP
Xan    aust    XANTHORRHOEA AUSTRALIS
Xant   pil     XANTHOSIA PILOSA
Xant   sp      XANTHORRHOEA SP
Xant   trid    XANTHOSIA TRIDENTATA
Xyr    grac    XYRIS GRACILIS
Zier   arb     ZIERIA ARBORESCENS
Zyg    bill    ZYGOPHYLLUM BILLARDIERI
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