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Conservation Biology and Management of 16 Rare or Threatened FABACEAE Species in Tasmania

by

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Submitted in fulfilment of the requirements for the degree of Master of Science

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November 1994

Declaration

This thesis contains no material which has been accepted for the award of any other higher degree or graduate diploma in any tertiary institution, and to the best of my knowledge and belief, contains no copy or paraphrase of material previously published or written by another person, except where due reference is made in the text.

A.J.J. Lynch

ABSTRACT

The 16 rare or threatened plants of the family Fabaceae of this study are all understorey components of dry sclerophyll communities in Tasmania. Most of the species occur in drought-stressed and nutrient-poor environments with limited competition and a history of disturbance. However, some of the 16 species occupy relatively fertile or mesic habitats. Several species display wide environmental tolerances. They have morphological features consistent with adaptations to nutrient-deficient soils and aridity, while some have evolved defences against grazing.

Some of the species were found to have biological characteristics atypical of legumes. Most of the species produce large quantities of physically dormant seed, however, dormancy in *Acacia axillaris* is both physiological and physical. Reproduction varies between species, with one species able to self-fertilise flowers and two others reproducing primarily vegetatively. The continuous regeneration of two species also differs from the typical pulse regeneration. Reproductive success varies spatially and temporally.

Many of the rare Tasmanian Fabaceae have distributions disjunct between Victoria and Tasmania, reflecting their past expansions and contractions of range during the Quaternary. A trans-Bassian disjunction is displayed by species classified as Type II or Group 1a/1b(+/-2) rarity. These species have a wide geographic range and are abundant within seasonally droughted sites in harsh environments. They are on the edge of their ecological range in Tasmania. Species of Type IV or Group 5 rarity may be limited by predation or intraspecific competition and have isolated or fragmented populations. The restricted Tasmanian endemics have a much narrower distribution but exist in large populations (Type VI or Group 1 or 2/1+2 rarity). Their narrow range predisposes them to endangerment. Morphological differentiation of Tasmanian and Victorian populations of some species implies that they are relatively old species isolated by Bass Strait. These species may have dispersed in earlier Pleistocene glacials rather than only the Last Glacial. Some species may be palaeoendemics persisting in refugia and adapted to the cold conditions of glacial environments. These species are confined to sites prone to frost or cold air drainage. The restriction of other species to riparian, poorly insolated or coastal montane and ridgeline sites suggests a preference for a humid environment.

Current threats to the rare Fabaceae include grazing, clearing, agricultural practices, coastal development, inappropriate firing, mining and the pathogen *Phytophthora cinnamomi.* Legislative protection and further reservation of some of the rare Fabaceae is required. Communication between land managers is also needed. Conservation of species' populations which are rare through local endemism, disjunction or marginal to the main population may be essential for preservation of genetic biodiversity.

As a result of this study, five species were considered to be more threatened than previously, and were upgraded to a higher degree of rarity or threat. Four of the species were considered to be less threatened than previously and were downgraded to a lower degree of threat.

ACKNOWLEDGEMENTS

Many people have been involved with aspects of this thesis, whether the fieldwork, data analysis, writeup or production, and I would like to sincerely thank all of them for their help. I would firstly like to thank my supervisor Jamie Kirkpatrick for the benefit of his knowledge and experience during this thesis. I would also like to thank the staff and other post-graduate students of the department for assistance and advice. Special encouragement was given by Annie Duncan, Jenny Dyring and Cassie, as well as my parents, Noela and Gary, who helped get me this far.

Co operation and assistance was given by Phil Barker, Helen Tyler and Mark Neyland. Useful topical discussions were had with Tony Auld (N.S.W. National Parks and Wildlife Service), Phil Barker (University of Tasmania), Dick Bashford (Forestry Commission, Tasmania), Robyn Coy (Parks and Wildlife Service), Mike Crisp (Australian National University) and Peter McQuillan (Department of Agriculture). Several volunteers also donated time to usually tedious work: Christine Corbett, Eric Ferguson, Bradley Howlett and Nigel Lockett. Alex Buchanan, Michael Askey-Doran, Mirranie Barker, Michael Battaglia, Bill Brown, Wayne Cole, Wil Fletcher, Diane Masters, Dennis Morris, Alasdair Wells and Penny Wells all contributed in some way.

Personnel of the Fingal district, Forestry Commission, Tasmania, are to be thanked for their co operation, as are the owners and managers of "Benham" (the O'Connor and Wigan families) and "Truelands" (the Nicholson family). Various white knights of the bush assisted resurrection of an immovable vehicle.

Assistance with accommodation of myself on Flinders Island was enabled by Derek Smith, and in Orbost by Mirranie Barker and Vaughan Monamy. Jim Reid and Peter Bobbi enabled the housing of seeds in the Botany Department growth cabinet, University of Tasmania.

Thanks are due to all those who personally and promptly gave me distribution records during the project, or allowed me to use their facilities. They included other researchers and botanists in Tasmania: Alex Buchanan and Dennis Morris (Tasmanian Herbarium), Mary Cameron (Queen Victoria Museum), P. Barker, F. Coates, R. Fensham, L. Gilfedder and J. Kirkpatrick (University of Tasmania, Department of Geography and Environmental Studies), F. Duncan and K. Williams (Tasmanian Forestry Commission), M. Askey-Doran, S. Harris and M. Neyland (Parks and Wildlife Service) and J. Davies; and from the mainland: T. Brown and J. Grace (CSIRO Division of Plant Industry, Canberra), I. Telford and E. Canning (Australian National Botanic Gardens), S. McCune (Royal Botanic Gardens, Sydney), N. Smith (Botanic Gardens of Adelaide and State Herbarium), B. Thompson (Department of Conservation and Environment, Orbost), J. Ross and M. Corrick (National Herbarium of Victoria), D. Tonkinson ("Go Green Victoria" and La Trobe University Wildlife Reserve Nursery) and F. Young (Department of Conservation and Environment, Flora and Fauna Survey and Management Group).

Mike Crisp, Mary Tindale and Peter Weston assisted with identification of *Almaleea, Glycine* and *Pultenaea* specimens. Mary Tindale, Tony Brown and Jim Grace commented on the *Glycine* key.

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Maps of species' distributions were promptly produced by F. Young (Department of Conservation and Environment, Flora and Fauna Survey and Management Group, Victoria), and C. Reed (Parks and Wildlife Service, Tasmania).

The research was partially funded by a grant from the Endangered Species Program, Australian National Parks and Wildlife Service (ANPWS ESP Project No. 4), administered through the Parks and Wildlife Service, Tasmania, and co supervised by Stephen Harris.

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1. INTRODUCTION

1.1 What Is Rarity?

Rarity is a relative term. In essence, a rare species is one which is of limited abundance. However, there is a tendency in any environment for most species to be infrequent, and only a relative few to be common (Drury 1974). Conversely, even though locally most species are rare, most species are common somewhere (Rabinowitz *et al.* 1986). Rarity may be at a local, regional, national or global scale. Therefore, both total abundance and extent of distribution need to be considered in evaluating species rarity. The corollary is that rare species may or may not necessarily be at risk of extinction. So, the threats to a species and its consequent level of endangerment need also to be considered in conservation planning.

1.2 Why Are Rare Species Important?

Australia is a signatory of the 1993 Convention on Biological Diversity; a convention aiming to conserve global biological diversity, to manage and use its components sustainably, and to share fairly and equitably benefits arising from the use of genetic resources (ANZECC 1994). Measures to conserve biological diversity in Australia have included the development of a nation-wide endangered species and habitats strategy. The Commonwealth Government established an Endangered Species Advisory Committee in 1988 to provide expert scientific advice and which published "An Australian National Strategy for the Conservation of Australian Species and Communities Threatened with Extinction" (ESAC 1992). Using this document and taking into account the resource and financial implications of a national approach, the Australian and New Zealand Environment and Conservation Council produced the draft "National Strategy for the Conservation of Australia's Biological Diversity" (ANZECC 1994). This document aims to co ordinate current conservation activities with the effective identification, conservation and management of Australia's biological diversity. Other measures include the development of national legislation, the Endangered Species Protection Act (1992), and the initiation of the Endangered Species Program to research and reduce the threats to endangered species.

The benefits of maintaining maximum biodiversity are numerous. Economically, species conservation can be justified as protection of a multitude of resources, including foods, medicines and industrial products. Examples within the Fabaceae include the potential use of the Queensland black bean *Castanospermum* *australe* in medical research, and the use of wild *Glycine* species in developing a hardier strain of the soybean, *Glycine max.* Preservation of biodiversity maintains the broadest potential for further utilisation of such resources. More indirectly, conservation of ecosystems benefits humanity through the maintenance of climatic stability and hydrological cycles, through prevention of soil erosion and the consequent loss of fertility and nutrient cycling, and in absorption and breakdown of pollutants. The role of rare species in ecosystems is poorly understood and should not be discounted. There are also aesthetic and cultural arguments in favour of species conservation. Many people identify with the natural environment aesthetically or for emotional, spiritual or recreational pursuits. The environment is now known to have a significant role in the culture of the Australian Aborigines. On an ethical basis, species have an intrinsic right of existence, and should be conserved out of respect for their evolutionary lineages, as well as for future generations of all species.

One of the most productive means of conserving biodiversity is through the conservation of rare and threatened species. It is these species which are the most vulnerable to extinction (Kruckeberg & Rabinowitz 1985) and therefore to reducing biodiversity. In determining the conservation biology of rare species, we also increase our knowledge of the factors limiting species distribution and abundance, that is, of biogeographic and evolutionary processes. Rare species may be viewed as the key to studying environmental changes and how species diversity and complexity make for robustness of the ecosystem within the range of perturbations experienced in nature and imposed by humans (Main 1982). These studies can be applied to the development of management plans and reserve design. They enhance our knowledge of management regimes beneficial for maximising biodiversity.

1.3 Classifications and Causes of Rarity

Rarity itself can be categorised, and such a process provides priorities for the interest and finances available for work to maintain species diversity. The first classifications of rarity considered only animals and birds, and were also mostly concerned with species considered endangered or recently extinct. The IUCN Red Data Books of 1966 (Vol. 1 Mammalia and Vol. 2 Aves) only included the categories rare and endangered. By 1972, however, the IUCN categories were Endangered, Vulnerable, Rare, Out of Danger, and Indeterminate. Other categories later included were Commercially Threatened, Threatened Community, and Threatened Phenomenon. Munton (1987) reviewed 151 lists of threatened species (some for animals, some plants, a few both) and their categories of threat and definitions. He found that categories varied considerably, and grouped 57 of the categories into 8 classes:

Species has disappeared
Species is under threat (Endangered, Threatened)
Species is declining
The species is only found in small numbers
The species is only found in a small area
There is lack of data on species status
Miscellaneous (Out of danger, migratory, care demanding)
Monitoring needed.

These categories were generally based on absolute numbers of individuals, although some included categories for endemics, species on the edge of their range, and unusual populations. Later classifications tended to also include statements on threat to the species. The ideas behind each category generally agree, however, the time scales and distances involved may differ. Some of the classifications include likely types of habitat and also factors such as "changes caused by man".

The Department of Conservation and Land Management, Western Australia, published in 1990 a schedule of endangered flora. The criterion for listing was that the species was rare (less than a few thousand adult plants in the wild, the numbers may vary according to the biology of the species), in danger of extinction (within one or two decades), or deemed to be threatened and in need of special protection. A flora list of species for consideration for future declaration was also included. These species were listed in one of five categories: Priority one, taxa with few poorly known populations on threatened lands; Priority two, taxa with few poorly known populations on conservation lands; Priority three, taxa with several poorly known populations, some on conservation lands; Priority four, taxa presumed extinct; Priority five, taxa in need of monitoring (Hopper *et al.* 1990).

The classification currently accepted in South-eastern Australia is that of Briggs and Leigh (1988), updated from earlier versions (Hartley & Leigh 1979, Leigh, Briggs & Hartley 1981). This system uses two codes, a numerical distribution code, and an alphabetical conservation status code which incorporates the IUCN categories (Table 1.1a). The same system has been a dapted for use at State level in Tasmania (Table 1.1b).

Table 1.1a: Classification system of degrees of rarity proposed by Briggs and Leigh (1988).

Distribution Category (Numerical Code)

1	Species known only from the type collection.
2	Species with a very restricted distribution in Australia, and with a maximum geographic range of less than 100 kilometres.
3	Species with a range over 100 kilometres in Australia, but occurring only in small populations which are mainly restricted to highly specific and localised habitats.

Conservation Status (Alphabetical Code)

X	Presumed Extinct - Species that have either not been found in recent years despite thorough searching, or have not been collected for at least 50 years and were known only from now intensively settled areas.
E	Endangered - Species in serious risk of disappearing from the wild state within one or two decades if present land use and other causal factors continue to operate.
V	Vulnerable - Species not presently Endangered but at risk of disappearing from the wild over a longer period (20-50 years) through continued depletion, or which largely occur on sites likely to experience changes in land-use that would threaten the survival of the species in the wild.
R	Rare - Species which are rare in Australia but which overall are not currently considered Endangered or Vulnerable. Such species may be represented by a relatively large population in a very restricted area or by smaller populations spread over a wider range, or some intermediate combination of distribution pattern.
K	Poorly known - Species that are suspected, but not definitely known, to belong to any of the above categories. At present field distribution information is inadequate.

Table 1.1b Supplementary codes introduced to consider degree of rarity and reservation status at State level in Tasmania (from Kirkpatrick *et al.* 1991b).

x	taxa that have not been located anywhere in Tasmania recently despite searching or have not been collected for more than half a century.
e	taxa that are likely to become extinct in Tasmania if present land-use changes and patterns and other causal factors of decline continue.
v	taxa that are likely to become extinct in Tasmania over a longer period than those classified e.
r1	taxa that have a distribution in Tasmania that does not exceed an area of 100 by 100 km.
r2	taxa that are distributed in 20 or less of the 10 by 10 kilometres National Mapping grid squares in Tasmania.
r3	taxa that do not fit r1 or r2, but which exist only in very small, localised populations wherever they occur in Tasmania.
k	taxa that probably fall in one or more of the above categories on a national basis, but for which there are insufficient data to place in any one category with any certainty.
u	taxa not known from any secure reserve in Tasmania (i.e. World Heritage Area and reserves requiring the approval of both houses of parliament for revocation).

These classifications, while creating priorities for conservation measures, encapsulate little information on the different types of rarity or of their causes. By not indicating the causes of rarity, they cannot prescribe action for preservation of the rare species (Main 1982). Rarity alone does not imply endangerment or impending extinction (Reveal 1981). A plant may (in human terms) always have been rare, and be restricted by natural biological or physical barriers (or time) from being more common; often such plants are edaphically restricted or habitat-specific. Humans may, however, have so altered the environment or the numbers of individuals as to impose rarity upon a species (Reveal 1981), and this type of rarity will become increasingly more common with further artificial alteration to the environment.

There is within discussion of rare species, a mingling of consideration of the extent and abundance of the species with biogeographic explanations for the origins and resultant distribution of the species. Griggs (1940) listed the different types of rare plants as including relict species, the currently closely restricted vestiges of races once widespread; local endemics, relict species modified after geographical separation from their relatives; and recently arisen mutants still within their parents' range.

Stebbins (1942) recognised several types of rarity based on distribution of the species: 1. individuals or small groups scattered across a large part of their range, and separated by miles, but usually abundant in some regions; 2. the extreme localisation of a species occurring in only a few widely separated localities, although abundant enough where found; 3. the extreme endemism in which a species occurs in only one or two spots on the entire globe, but is represented at these sites by hundreds of individuals; 4. innumerable intermediate cases connecting the three types. Stebbins listed three possible causes: 1. new species which have had insufficient time to disperse; 2. senescent species unable to disperse; 3. species with high genetic homogeneity that occupy only a few ecotypes and whose distribution is currently more restricted than in the past (depleted species) or whose range was never more extensive (insular species).

Simpson (1944) classified rare species as: 1. numerical relicts, species in decline; 2. geographical relicts with smaller ranges than their ancestors; 3. phylogenetic relicts, slowly-evolving groups that have changed little since remote times; 4. taxonomic relicts, groups much less varied than previously.

In considering the types of geographic distribution that rare species may display, Drury (1974) remarked upon three types: few individuals or small groups widely scattered over a large area (species adapted to stressed sites); few individuals widely dispersed in communities, but in many suitable areas across their range (widespread but locally infrequent); and, large numbers restricted to very few locations. Main (1982) refined these categories into five common types: 1. aggregated, areas of locally high density; 2. disjunct, with local high density areas separated by areas of low density; 3. patchy, with discrete occurrences of higher density; 4. fragmented, where the species does not occur where it might be expected; 5. dispersed, low frequency, widespread distribution. Again, this classification does not indicate causation. However, Main goes on to reaffirm that any local biological assemblage exists in a dynamic state. He listed the environmental factors likely to contribute to variations in the rate of increase (fecundity, speed of development, duration of life) as including: 1. fluctuations -

climatic oscillations or variations in seasonal intensity; 2. predation during establishment; 3. intra-specific competition; 4. environmental conditions for regeneration; 5. disturbance; and 6. physiological tolerance or competitive exclusion. Rarity can therefore be viewed as a dynamic reaction between selection, ecophysiological capacities of species, and environmental stresses that induce patchiness of the environment (Main 1982).

The area the species occupies (by numbers of individuals) is the operative term in establishing the degree of rarity (Reveal 1981), although this is also dependent on the dynamics of populations and their natural fluctuations. The density of the species within a population must be great enough to permit reproductive interactions and competitive requirements, and the vigour of the populations must also be sufficient. Therefore, the degree of biological vulnerability and the degree of threat also determine the degree of rarity (Rabinowitz 1981). As stated earlier, rarity does not necessarily imply impending extinction. However, the greater the degree of rarity, the higher the extinction potential for a species. The species which are the most rare are also the closest to extinction.

Rabinowitz (1981) refined characteristics of range, habitat specificity and local abundance, as seen to influence rarity, into an eight-celled typology (Table 1.2). It is a table of results of these influences, rather than a typology of mechanisms or causes. The classification considers rarity via the current geographic distribution of the species, disregarding the fundamental reasoning for the species' origins, dispersal mechanisms, and environmental tolerances and stresses.

Table 1.2. Typology of geographic rarity based on characteristics of range, habitat specificity and local population size (Rabinowitz 1981).

GEOGRAPHIC RANGE	Large		Small	
HABITAT SPECIFICITY	Wide	Narrow	Wide	Narrow
LOCAL POPULATION SIZE				
Large, dominant somewhere	I Locally abundant over a large range in several habitats	II Locally abundant over a large range in specific habitat	V Locally abundant in several habitats but restricted geographically	VI Locally abundant in a specific habitat but restricted geographically
Small, non-dominant	III Constantly sparse over a large range and in several habitats	IV Constantly sparse in a specific habitat but over a large range	VII Constantly sparse and geographically restricted in several habitats	VIII Constantly sparse and geographically restricted in a specific habitat

Soulé (1986) also recognised the same components of rarity: a within-habitat component, a between-habitat component, and a geographic component.

This system can be related to the concepts of alpha-, beta-, and gamma-diversity respectively (Cody 1986). Unlike Rabinowitz, however, whose typology considers the species' rarity as static, Soulé notes the sampling components of rarity, as well as natural temporal variation in turnover of species in a particular habitat. Scale-induced problems decrease as the size of the sampling area increases, until at a global scale, rarity is detectable only through absolute numbers of individuals (Soulé 1986).

Recently, Prober (1989) has developed a model which brings together distributional elements with six main hypotheses of the causes of rarity. The model comprises a flow chart based on knowledge of the distribution, habitat, phylogenetic relationships and ecology of the rare species (Figure 1.1). The Prober model incorporates the simple typologies of Griggs (1940), Stebbins (1942) and Drury (1974), as well as the causes of rarity considered by Main (1982). However, when there is little information on a rare species apart from its distribution, the typologies of Main (1982) or Rabinowitz (1981) are best suited.

1.4 Rarity in Australia

Rarity is a natural phenomenon. However, the rate of extinction in Australia has increased dramatically since European settlement. The average world-wide extinction rate over the last 600 million years has been estimated at 0.2 - 2 species per year (including known periods of mass extinctions), whereas in the last 200 years, 83 species of vascular plants have become extinct in Australia alone (ESAC 1992). Approximately 179 species of vascular plants are currently considered endangered nationally, 661 species are considered vulnerable, while 1 173 species are listed as rare nationally (Leigh & Briggs 1992). There are clearly a large number of rare or threatened species in Australia today: 18% of the total flora, or 3 580 species (Leigh & Briggs 1992). In Tasmania, 7% of the flora, or 144 species, are classified as rare or threatened nationally (Leigh & Briggs 1992).

Much of the loss of species can be attributed to clearing of native ecosystems for subsequent grazing and agriculture. The area of Australia covered with rainforest has been reduced by 50%, while the proportion of forest and woodland has declined by one-third (Walker 1992 in ANZECC 1994). In temperate eastern Australia, approximately 90% of native vegetation has been lost through clearing or agriculture (Walker 1992 in ANZECC 1994). 72% of the extinct flora (55 species) and 85% (172 species) of the endangered species are believed to have been adversely affected by agriculture or grazing (Leigh *et al.* 1984).

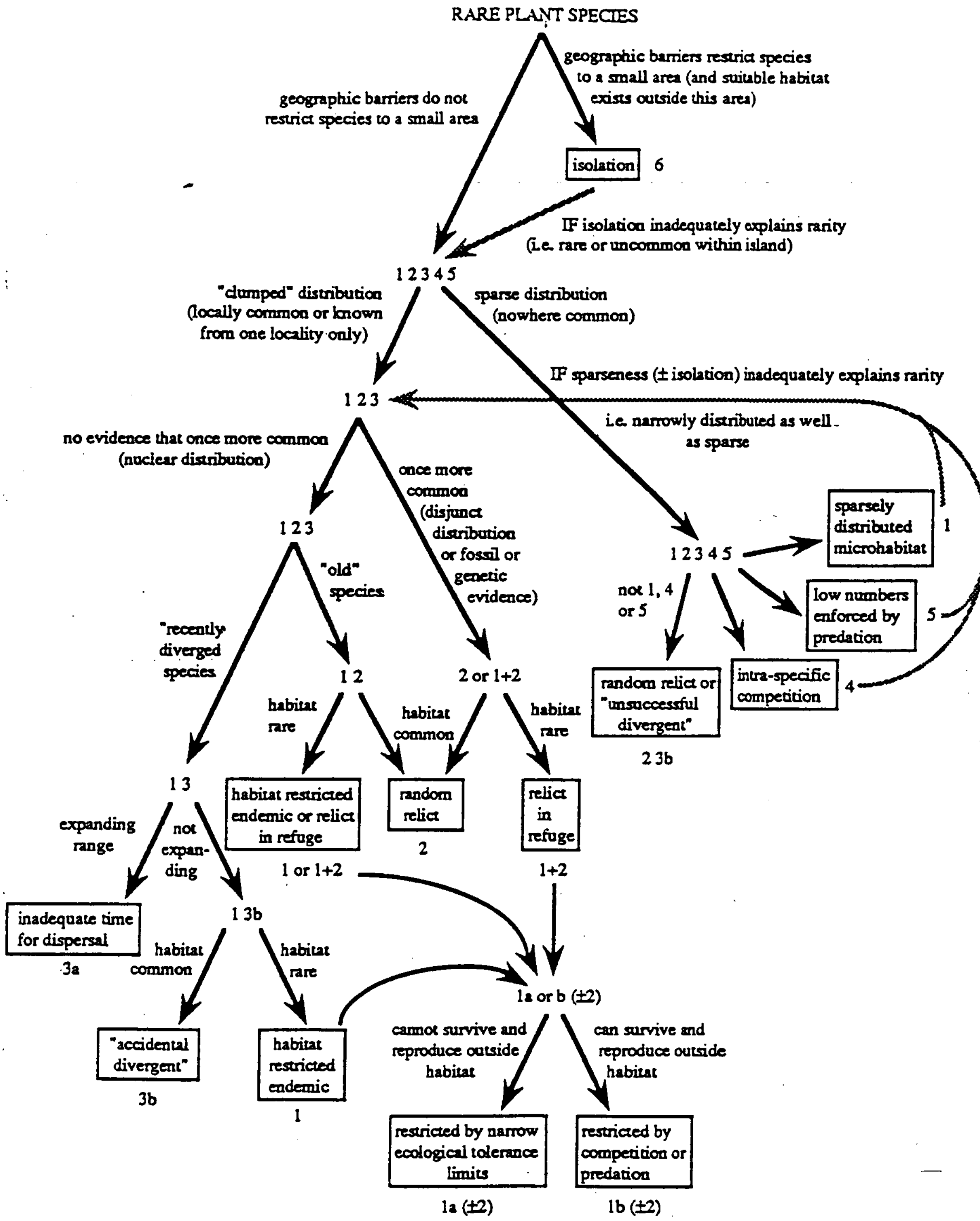


Figure 1.1: A flow chart indicating an approach to investigating causes of rarity in plant species (Prober 1989). (A species is considered disjunct if one or more populations occur outside the long-term dispersal range of the nearest conspecific populations. A recently diverged species is one which diverged so recently that it is unlikely to have had sufficient time to expand beyond its present boundaries. Grey lines indicate paths which need only be taken if the preceding hypothesis only partly explains rarity in the species of interest (Prober 1989)).

1.5 Rarity in the Fabaceae

The Fabaceae is an important and conspicuous element of the Australian flora. It comprises the largest number of species of dicotyledonous plants of any family in Australia. Following the modified Takhtajan (1969) classification, used in the Census of Vascular Plants of Tasmania (Buchanan *et al.* 1989), this family includes the three sub-families Mimosoideae (wattles), Papilionoideae or Faboideae (pea-flowers, beans) and Caesalpinoideae (cassias, bauhinias). The latter group has a predominantly tropical to subtropical distribution and is not represented by native species in Tasmania. Species of the Fabaceae, although differing in floral characteristics, share the leguminous fruit character and may be referred to as "legumes".

In Tasmania, the Fabaceae is one of the three largest dicotyledonous families, exceeded in numbers of species by the Asteraceae and the Epacridaceae (Table 1.3). All three of these families have high proportions of endangered, vulnerable or rare species (approximately 33%), either on a State-wide or, in the case of the Asteraceae and Epacridaceae, on a National basis. The Fabaceae and Asteraceae have high numbers of species unreserved in Tasmania.

Table 1.3: Numbers of species of the Asteraceae, Epacridaceae and Fabaceae in Tasmania, the number of each of extinct, endangered, vulnerable, rare or unreserved status, and the total proportion of restricted species of each family in Tasmania (codes listed in Table 1.1; modified from Kirkpatrick *et al.* 1991b).

FAMILY	NO. OF SPP. IN TAS.	CONSERVATION STATUS									% RARE
		X	E	V	R	x	e	v	r	u	(E/e/V/v / R/r)
Asteraceae	167	2	0	1	13	7	5	5	45	15	33
Epacridaceae	87	0	0	3	10	0	0	3	26	6	33
Fabaceae	71	0	0	1	3	0	4	6	14	11	34

1.6 Research on Rare Species

Research on Fabaceae outside Australia has concentrated on habitat characteristics, phytosociology and demography (Boyd *et al.* 1988, Griese 1989, Gustafsson 1991, 1992), growth, phenology and seed production (Hegazy & Eesa 1991), pollination ecology (Karron 1987), germination and firing response (Borchert 1989, Keeley 1991) and genetic variation (Hickey *et al.* 1991). Smith (1987) incorporated a study of demographics with monitoring regeneration after a controlled burn. Indeed, Main (1982) listed the most important factors for maintaining populations of rare species as population structure, especially the significance of cyclic changes in structure and abundance; breeding system; population genetics; gene flow; and likely causes of rarity, e.g. predators, parasites, diseases, genetic uniformity and physiological specialisation.

Research on rare species in Australia has accelerated in the last decade as a result of increasing public concern for threatened species and biodiversity and also because of the availability of research grants through organisations such as the Australian Nature Conservation Agency and the World Wildlife Fund. The research has entailed *ex situ* and *in situ* studies. *Ex situ* studies primarily have been used to propagate and maintain rare or threatened species in cultivation; for example, the Endangered Species Collection at the Australian National Botanic Gardens. These plants may be used for research, education or reintroduction into the wild (Richardson 1992).

Much of the research on threatened species has been *in situ* studies involving surveys of species' distributions, their degree of rarity, phytosociology, demography and environmental influences (e.g. Chuk 1982, Parsons & Browne 1982, Pickard 1983, Kirkpatrick & Brown 1984ab, Duncan 1988, Regan *et al.* 1988, Prober & Austin 1991, Davies 1992, Prober 1992). Intensive work on conservation biology has tended to involve studies of reproductive systems, pollination ecology, germination and establishment (e.g. Lamont & van Leeuwen 1988, Stock *et al.* 1989, Zammit & Zedler 1990, Coates 1991, Gilfedder & Kirkpatrick 1993, Pyrke 1993). A large number of studies have investigated genetic diversity and mating systems of rare species, particularly for species of *Eucalyptus* (e.g. Fripp 1983, Moran & Hopper 1983, 1987, Sampson *et al.* 1989, Peters *et al.* 1990, Prober *et al.* 1990), *Banksia* (Coates & Sokolowski 1992) and *Stylidium* (Coates 1992).

Despite including so many rare species, little biological research has so far been done on rare Fabaceae within Australia. Case studies of extinct and endangered species of Fabaceae and Mimosaceae by Leigh *et al.* (1984) detailed the known information on the species' descriptions, habitats, threats, reservation status, cultivation, and also some recommendations on conservation needs. However, this publication highlighted the lack of specific biological and ecological information. Later studies have begun to address issues of distribution and population structure (Crisp & Lange 1976), regeneration (Auld 1990), grazing effects (Anon. 1993, Auld 1993), post-fire germination (Bradstock & Auld 1987, Auld & O'Connell 1991), propagation and breeding systems (Leigh & Briggs 1989), genetic diversity (Coates 1988) and management recovery plans (Kelly & Coates 1991, Jusaitis 1992, Muir 1992, Zich 1993).

A high proportion of Tasmania's rare species is found within the Fabaceae family. Yet there has been little detailed investigation of their biology or of factors determining their rarity. The species researched in this study are from twelve genera which vary widely in abundance and habitat preference; from sea-level to the subalpine, and throughout eastern Tasmania, the north coastal area and Flinders Island, as well as on the west coast. Some of the species occur in grassy woodland communities, one of the State's most drastically altered habitats (Kirkpatrick *et al.* 1988), while others occupy sclerophyll forest. Only three of the studied species occur in more than one reserve. Consequently, management plans are needed which prescribe measures that can be taken by land managers and land owners to ensure the long-term survival of the species.

1.7 Features of the Fabaceae

The adaptations of Australian woodland and heath species to sclerophylly (leaf hardness) and xeromorphy (morphological characters associated with drought resistance; Beadle 1966) is exemplified by the Fabaceae (Bowen 1981). Xeromorphic characters, including sclerophylly, were engendered by gradual adaptation to nutrient deficient soils, determined ecologically by phosphate level, rather than to increasing aridity (Beadle 1966). However, the associated evolutionary characters, such as smaller leaf and plant size, predispose such species to tolerance of water deficit. Other features enabling Fabaceae to inhabit low nutrient and dry environments include specialised adaptation of some species to phosphate retrieval (Lamont 1984), and mycorrhizal associations and root nodulation facilitating uptake of phosphate, sulphate, zinc, and trace metals which stimulate growth and nitrogen fixation (Bowen 1981).

Perhaps the most important characteristic of legumes which has enabled their success in the Quaternary Australian environment is their nitrogen fixing capacity. In symbiosis with *Rhizobium*, a soil inhabiting bacterium, most legumes are known to exchange a continuing source of carbohydrate and other growth factors for nitrogen and nitrogenous compounds fixed by the microorganism from the atmosphere (Bowen 1986). Such symbioses are the major source of nitrogen fixation in ecosystems (Bowen 1986).

The ability to fix nitrogen makes legumes economically important to the agricultural industry, and the major diazotrophic (dinitrogen fixing) plants exploited in world agriculture (Postgate 1982). This facility enables legumes to be pioneer plants, colonizing nitrogen-deficient areas (Postgate 1982) or disturbed environments. Soil organic matter tends to be low in woodland communities due to their low biomass levels and high fire frequencies. This organic matter is important as a reservoir of nutrients, in improving the soil structure and its water-holding capacity, and in loosely absorbing ammonium ions and preventing them from leaching (Bowen 1986). Since much of the soil organic matter and some 20-40% of nitrogen in the surface soil and litter may be lost in a fire, the dominant regrowth will be by species with the selective advantage of being nitrogen fixers and which can start to replenish soil nitrogen (Raison 1979, Bowen 1986). Other ground disturbance, such as by clear-felling, also causes nitrogen losses by allowing increased activity of the bacteria which convert ammonium salts to nitrate (Bowen 1986).

Legumes are generally assumed to have adapted to fire (Gill 1981, Attiwill & Leeper 1987) or disturbance (Cavanagh 1987), since they have long-lived seeds characteristic of plants in habitats subject to such stochastic disturbance events (Harper 1977). The seeds may need some stochastic event such as a hot temperature fire or high-level flood event to create suitable regeneration conditions, or they may regenerate successfully without such disturbance.

Species which regenerate vigorously after fire usually do so by one of two methods: either the species has a hardy root-stock from which it can re-shoot, or it creates a seed bank in the soil by producing hard-coated seeds which, upon ripening, fall to the ground and are incorporated into the soil. When a fire burns the community, the dormancy of the seeds is broken and a large quantity of germinating seed is locally available. Both methods are used by legumes, however, the latter is the more common.

Legume seeds generally have a physical dormancy in which germination is impeded by the "hardness" of the testa (seed coat) preventing the passage and exchange of water and gases into and out of the embryo (Cavanagh 1987). A structural difference in the lenses of seeds of mimosoid-caesalpinioid species compared to papilionoid species is of significance. The lens, in mimosoid-caesalpinioid species, is a discrete mound of short Malpighian cells loosely attached to the mesophyll tissue by thin-walled weak cells, which rupture when stressed, such as by heating. The lens tissue then separates, imbibition follows and subsequently, germination. In papilionoid species, the Malpighian cells are longer at the lens, and are bowed and stressed. The seeds of papilionoid species may become increasingly more permeable during storage as the lens cells separate, and may respond to a wider range of treatments than mimosoid species. In experimental germination trials, heating, percussion treatments, or temperature fluctuations may rupture the unstable cells and create a fissure for water penetration (Cavanagh 1987).

The natural analogue of experimental germination trials to break physical dormancy is that germination occurs *in situ* after wildfires or mechanical soil disturbance, such as in flooding or animal digging. Legumes are generally assumed to have adapted to fire (Gill 1981, Attiwell & Leeper 1987) or disturbance (Cavanagh 1987). Fire acts to stimulate seed germination of species in the seed bank, however, it also reduces competition from fire-sensitive species and creates a short-term, high nutrient micro-environment. The germination cues from environmental changes related to fires include heat, chemicals leached from charred wood, release from toxic compounds, increased light, stratification (Parker & Kelly 1989) and smoke (Anon. 1994, Baxter *et al.* 1994).

Much of the fruit falls from legume pods directly to the ground. The elaiosomes, small, white appendages which are specialised food bodies, act as ant attractants and aid in dispersal of the seed. The seed is usually carried to the nest, the elaiosome removed and eaten, and the seed discarded either within the nest or nearby (Hughes & Westoby 1990). These authors found that virtually all elaiosome-bearing seeds in Australian dry sclerophyll vegetation are removed by ants within a few days of seed release. At least 23 species of Fabaceae from heathy dry sclerophyll forest near Sydney, N.S.W., were found to be myrmecochorous (ant-dispersed; Rice & Westoby 1981) including species of *Acacia, Glycine, Hovea, Pultenaea* (Rice & Westoby 1981), *Bossiaea obcordata* (Hughes & Westoby 1990) and *Hardenbergia violacea* (Berg 1979). For these myrmecochorous species, the seeds may become concentrated within nutrient-rich ant nests. They may germinate if a sufficient heat pulse penetrates to their depth of burial. Seeds may also become more dispersed, although the dispersal distance may still not be very great. Seeds of *Hovea rosmarinifolia* were usually carried less than one metre (Berg 1975 in Buckley 1982), *Acacia pulchella* seeds were carried 1.94 m in one hour (Shea *et al.* 1979 in Buckley 1982), while *A. bivenosa* seeds were carried up to 77 m (Buckley 1982). The seeds of some myrmecochores are effectively scarified during seed handling and elaisome removal, which may enhance germination (Buckley 1982).

1.8 Aims of Thesis

This project concentrates on the reproductive requirements and ecology of 16 rare or threatened Fabaceae species in Tasmania. In order to manage rare plants, we need knowledge of their habitat requirements and the reasons for their rarity. To maintain the current numbers of populations, it is necessary to know whether active or passive management is required, whether the species regenerate successfully in the presence or absence of particular disturbance regimes. It is such specific information which may indicate reasons for the difference in abundance of these species in comparison to their more common or widespread relatives. The aims of the study are, specifically, to:

1. examine the distribution, habitat and regeneration ecology of the 16 species;
2. outline the biological and environmental factors influencing rarity of the species;
3. summarise the conservation status of each species, listing the main threats, and detailing management recommendations; and to
4. discuss the nature and extent of rarity amongst the species.

By considering the distribution, habitat and regeneration ecology of so many species, biological and regional trends can be observed, and the conservation status of species can be assessed more accurately than from perusal of literature and records. Past collections indicate where a species once occurred, but not whether it is still there, its abundance, status in the community, nor its total distribution (Reveal 1981). The number of Herbarium specimens is also unlikely to be proportional to the relative abundances of all species.

In order to investigate the ecological requirements of these species, the aims of the thesis can be rephrased as the following points:

1. what is the known distribution of the species and the abundance and vigour of individuals at the sites?;
2. is the species limited by habitat availability?;
3. is the species rarity a function of a weakness in its reproduction?; and
4. how does the species fit current typologies of rarity?

To answer these questions, aspects of the species' distributions, habitat characteristics, phenology, population structure, germination and soil-stored seed bank are investigated. The thesis addresses these questions to varying degrees for the 16 species (see Section 2.1, Table 2.3). The methodology and experimental techniques are described in detail in Chapter 2. All background, observations and trial results for each species are discussed in separate sections (Chapters 3-18). A general discussion follows in Chapter 19. This chapter includes a discussion of the nature and extent of rarity in the subject species in the context of current typologies of rarity. Management implications and recommendations are discussed in Chapter 20.

2. METHODOLOGY

2.1 Species Selected for Study

The species originally considered for the study were taken from a draft list of dicotyledons considered to be inadequately reserved in Tasmania (Kirkpatrick *et al.* 1991a). However, some of these species were found either to be more common than previously noted or had been mistakenly recorded as indigenous to Tasmania. The list was, therefore, refined to those species in Table 2.1.

Table 2.1: The level of priority, conservation status and endemism of the selected endangered, vulnerable or rare species of the family Fabaceae.

Priority	Species	Conservation Status: Briggs & Leigh 1988	Conservation Status: Kirkpatrick *et al.* 1991b	Endemism
1.	*Acacia axillaris*	3V	Rr2	Endemic Tasmania
	Acacia pataczekii	2R	Rur2	Endemic Tasmania
	Glycine latrobeana	3RCa	Rr3	
	Hovea corrickiae		r1	
	Pultenaea selaginoides *	2V	Vv	Endemic Tasmania
2.	*Acacia retinodes*		ur1	
	Bossiaea obcordata		uv	
	Desmodium gunnii *		uv	
	Eutaxia microphylla		r2	
	Hardenbergia violacea		uv	
	Psoralea adscendens		r1	
	Pultenaea hibbertioides *		uv	
	Pultenaea humilis		e	
	Pultenaea paleacea var. *sericea* *		uv	
	Pultenaea prostrata		e	
	Viminaria juncea		ue	

*	this species under taxonomic revision
X, x	Taxa that have not been located recently despite thorough searching or have not been collected for more than 50 years
E, e	Extinction likely (endangered; 10-20 years) if present land-use or causal factors of decline continue (E = nationally, e = in Tasmania)
V, v	Vulnerable - at risk of extinction (20-50 years) if there is continued depletion or the current land-use changes (V = nationally, v = in Tasmania)
R, r	Rare - not currently Vulnerable or Endangered nationally; one or more populations occur within a habitat that is secure into the forseeable future (R = nationally, r = in Tasmania)
u	unknown from any secure reserve (i.e. reserves requiring the approval of both Houses of Parliament for revocation)
1/2/3	Briggs & Leigh 1988: 2 - geographic range < 100 km; 3 - geographic range > 100 km Kirkpatrick *et al.* 1991b: 1 - occurs over an area of less than 100 by 100 kilometres; 2 - occurs in 20 or less of the 10 by 10 kilometres National Mapping grid squares of Tasmania; 3 - exist only in very small, localised populations in Tasmania
Ca	Population adequately reserved

The species were classified into two groups according to their conservation priority and accessibility. The group with the highest priority (Group 1) are either endemic to Tasmania or of very limited distribution both in Tasmania and on the mainland. The species in Group 2 generally are rare in Tasmania but are widespread in Victoria, and do not qualify for the Victorian list of Rare or Threatened Plants (Gullan *et al.* 1990).

Some species were the subjects of other research projects and this, as well as prioritization, affected the intensity of research undertaken for each species. *Acacia axillaris* and *Glycine latrobeana,* for example, were both the subjects of studies by researchers at the Department of Geography and Environmental Studies, University of Tasmania. *Glycine latrobeana* is also being researched at La Trobe University, Victoria, so work on this species in the present study was restricted to survey and identification.

The vascular plant species nomenclature follows Buchanan *et al.* (1989), except for *Almaleea subumbellata* (syn: *Pultenaea subumbellata)* which follows Crisp and Weston (1991), and *Desmodium gunnii (Desmodium varians* var. *gunnii)* which follows Hacker (1990). The conservation status of vascular plant species was determined from the recently produced list of the reservation and conservation status of Tasmanian native higher plants (Kirkpatrick *et al.* 1991b).

2.2 Conservation Biology

The aspects of conservation biology considered in the experimental trials are given in Table 2.2. Previously recorded populations were relocated and their habitat surveyed. Other populations were also searched for to gauge the extent and abundance of the species. Along with survey of the species' habitats, information on the characteristics of the sites was gained. The second part of the study examined the biological characteristics of the species.

Table 2.2: Aspects of conservation biology considered in the current study.

	ASPECT	—> INDICATIVE OF...
1.	Distribution	Extent and abundance
	Habitat	Site characteristics and limitations
2.	Phenology (and pollinators)	Fecundity and timing Seed availability
	Population structure	Regeneration timing
	Germination	Seed dormancy Seed viability Regeneration mode
	Soil-stored seed bank (and disturbance)	Regeneration mode Persistence at site

Solbrig (1980) divides life cycle strategies into five phases:

1. pre-dispersal (from fertilization to seed release) when the new plant is still dependent on the parent plant;
2. dispersal phase;
3. germination and establishment phase, from germination to the reproduction of the first pair of true leaves;
4. adult stage, including both the pre-productive and reproductive adult;
5. flowering, gametogenesis and fertilization.

Phases 1 and 5 were considered in a phenology study, which monitored the plants from bud development, through flowering, to seed production and release. Phase 3 was treated in a study of the germination requirements of some species, and also in estimation of the soil-stored seed bank. These studies indicated aspects of seed dormancy and viability, regeneration mode and persistence at the site. Disturbance trials also contributed to these aspects. Phase 4 was considered for several species using size-class analysis of the populations, and by observation of the apparent regeneration modes of the species. The size-class distributions were compared to age (size)-class distribution types considered indicative of specific regeneration modes. The size-classes were not related to age so it was only possible to determine between continuous or pulse regeneration. In-depth biological consideration was restricted to five of the rarest species: *Acacia axillaris, A. pataczekii, Bossiaea obcordata, Hovea corrickiae* and *Pultenaea selaginoides.*

2.2.1 Distribution

Collection records from the Tasmanian Herbarium were used for the original distribution data. Subsequent information was gained from literature, specifically Kirkpatrick *et al.* (1980), Curtis and Morris (1975), Duncan (1983, 1988) and from the field notes of T. Moscal. Supplementary records and new records came from field researchers, as listed in the Acknowledgements. Information on the species' wider distribution on the Australian mainland was gathered from Beauglehole (1980), Costermans (1983), Galbraith (1977) and Jessop and Toelken (1986), as well as from the Department of Conservation and Environment (Victoria), the Australian National Botanic Gardens Herbarium (A.C.T.), the National Herbarium of N.S.W. and the State Herbarium (S.A.). As many sites as possible were visited to reaffirm the species' identification, their continuing existence at the site, and information on habitat, species abundance and extent.

2.2.2 Habitat Survey

Herbarium and literature records were noted and later relocated, if possible, for all species. A pro-forma survey sheet was completed in 10 by 10 m quadrats subjectively considered representative of the communities. Information recorded included location: grid reference (Tasmap 1:100 000 mapsheets), landform, position upon landform, altitude, aspect, gradient, rock type, clast size, general soil type; disturbance to site and extent; community floristics and structure: the predominant height and cover abundance of species present and cover abundance of lifeforms present (e.g. herbs, grasses, sedges); and the abundance and extent of the rare species present, and the density, mode and proximity of its regeneration. The following modified Braun-Blanquet cover-classes were recorded for all species to assist with description of the vegetation structure:

x	local (outside quadrat)	4	25-50% cover
1	<1% cover	5	50-75% cover
2	1-5% cover	6	>75% cover.
3	5-25% cover		

Total abundance of the rare species in Tasmania was estimated according to the following scale:

1 - 10	individuals present
10 - 100	individuals present
100 - 1 000	individuals present
more than 1 000	individuals present.

The structure of the vegetation was described according to Specht *et al.* (1974). Site attributes were subjectively compared to indicate similarities or trends in the recorded characteristics for each species.

2.2.3 Population Structure

Size-class data were collected for *Acacia axillaris* at Dukes Marsh and Mt. Barrow, *Acacia pataczekii* at Ben Lomond, and *Hovea corrickiae* at Mt. Elephant. In a belt transect of two by ten metres, the diameters of the main stem of all specimens were measured at ground level. The *A. pataczekii* populations were quite sparse and the transects were extended to include approximately 20 individuals. All data are presented as percentage frequencies of size-classes.

2.2.4 Phenology

Most species of Group 1 were considered in a study of their phenological timing and activity. *Glycine latrobeana* was not included in the phenology study because of the overlap of other research at the University of Tasmania. Instead, a phenology study was also conducted on *Bossiaea obcordata*, which at the time was only known, in Tasmania, from one population of less than fifty plants which were apparently not reproducing. A population of each of *Acacia axillaris, A. pataczekii, B. obcordata, Hovea corrickiae, Pultenaea selaginoides* was monitored fortnightly over the spring and summer of 1990. The populations were chosen to be representative of the species' habitat and range, to limit travel time, and be easily accessible. Qualitative differences in phenology were noted when other populations were visited.

Ten widely dispersed individuals of each species were selected randomly. Four branches of each individual were selected randomly and tagged. In the case of *Acacia pataczekii*, however, scattered individuals of a similar diameter and which appeared to be the oldest reproductively active plants were chosen. This species was known to sprout vigorously from rhizomes, and so plants close together may have represented the same genet. The timing and position of each phenological stage was marked on diagrams of the branches. The phenological stages noted were:

No buds present;	Flowering (peak);
Bud development and swelling;	Flowering (late stage);
Budburst;	Pod development and ripening;
Flowering (early stage);	Pod dehiscence.

Seed production of other individuals of this species throughout the community was observed. Vegetative growth and the success of each stage was noted qualitatively, as well as the development of galls on the *Acacia* species.

Observations of the five species continued in the spring and summer of 1991. *Glycine latrobeana, Pultenaea hibbertioides, P. humilis* and *P. prostrata* were also monitored in the second season. Observations were made at four- to six-week intervals. The latter species were chosen because of their proximity to the original species.

2.2.5 Pollination

Insects observed to be visiting the flowers of the research plants were collected using a muslin butterfly net and a plastic aspirator. The insects collected were placed in a vial of alcohol, the vials labelled and sent care of Robyn Coy (Parks and Wildlife Service) to CSIRO Division of Entomology (Canberra) for identification. Insects were collected from *Acacia axillaris, A. pataczekii, Hovea corrickiae* and *Pultenaea selaginoides*.

Visitation of flowers by a particular insect does not prove actual pollination by that insect. Transfer of pollen from anther to a vector and from vector to stigma, along with resultant fertilisation must be demonstrated for a conclusive link between the interactions of each entity (Cox & Knox 1986).

2.2.6 Propagation

Trials were initiated in autumn 1991 to examine the germination requirements of selected species. The species tested were primarily those studied phenologically and from which large quantities of seed were collected. *Glycine latrobeana* was excluded because of inadequate quantities of seed, while *Bossiaea obcordata* and *Viminaria juncea* had recently been tested in N.S.W. (Auld & O'Connell 1991). The species tested were *Acacia axillaris, A. pataczekii, Hovea corrickiae, Pultenaea humilis, P. prostrata* and *P. selaginoides.* Insufficient quantities of *P. humilis* seed were available for the full range of trials. Samples of this species were limited to 25 seeds, and trials were not replicated. Seed was also limited for *P. prostrata,* for which most trials could not be replicated. The dimensions of 20 randomly selected seeds of each of these species were measured, and their shape and colour described.

Two germination techniques were applied to each species: a dry heat (oven) treatment and a scarification treatment. The heat treatment involved packaging a seed sample of 30 seeds in foil with the probe of a thermocouple, and placing the sample in a small baffle oven for two minutes at the prescribed temperature. This duration of exposure was considered adequate following the conclusions of Auld and O'Connell (1991). After heating, the packages were opened and left to cool. The scarification treatment involved nicking a small part of the seeds' testa, using a scalpel for the larger seeds and sandpaper for the smaller seeds.

All seeds were then washed in diluted Bleach solution, rinsed, and washed in Benlate fungicide. The seeds were placed in plastic Petri dishes with moistened filter paper, and the dishes placed inside plastic bags to retain moisture. The bags were kept in controlled temperature cabinets at 20^{o}C with a 12 hour photoperiod for three months. The seeds were checked daily for germinants for the first two months, and every two days during the third month. A control dish of fungicided, untreated seeds was included.

At the end of three months, the remaining seeds were scarified and left a further month. Seeds which had not germinated at the end of this period were tested for viability using the tetrazolium test (Freeland 1976). Seeds which had not imbibed were scarified and left overnight to imbibe. All seeds were then incised along the longitudinal median opposite the radicle, and transferred to an aqueous solution of 1.0% tetrazolium chloride for at least four hours. The cut surface was examined for red-pink granular areas; indications of active mitochondria having reduced the colourless tetrazolium salt to a non-diffusible, red-coloured formozan (Freeland 1976). Seed viability was classified according to the International Seed Testing Association (1976, 1981) guidelines.

Additional trials were undertaken for *Acacia axillaris* because of its lack of response to pretreatment. These trials were wet heat (100^{o}C and 80^{o}C), effective embryo excision and cold stratification (5^{o}C) treatments. The wet heat treatments involved immersion of seeds in water at the required temperature (100^{o}/80^{o}C), which was maintained at that temperature and monitored constantly using a thermometer for the two minute period. The seeds were removed from the water once the water had cooled, and placed in fungicided Petri dishes. Effective embryo excision involved removing enough of the seed coat so that there could be no physical barrier to the embryo to prevent imbibition or germination. Cold stratification treatments involved placing scarified seeds into a refrigerator held at a constant 5^{o}C for either one or two months. The seed trays were then placed in growth cabinets. All seed trays were left to germinate, the dishes inside plastic bags to retain moisture. All germination data (final results after three months) were converted to percentages, arcsin transformed, tested for normality, and analysed in a one-way ANOVA by species using the treatments and control as factors to detect significant treatment response. If the F-ratio was significant, a Scheffe (Statgraphics 1991) multiple range test was done to determine which treatment means were significantly different. The means and standard errors ($^{+}/_{-}$ 1 s.e.) were plotted graphically on diagrams of mean results.

Most references on propagation of legumes recommend seed germination rather than vegetative propagation. Experimental trials of propagation by cuttings were conducted for several species, in conjunction with W. Fletcher (Plants of Tasmania Nursery) and W. Cole (Royal Tasmanian Botanic Gardens), to see whether this is an option for plants which produce low quantities of seed or non-viable seed. Suitable plant material was collected in February and May, 1991, and the cuttings taken. The cuttings were pretreated with a growth hormone, generally with a two second dip in 2 000 ppm I.B.A. (Indole butyric acid), placed in the growth medium, and maintained in glasshouse trays with bottom heating and misting. The species tested were *Acacia axillaris, A. pataczekii, Bossiaea obcordata, Pultenaea hibbertioides* and *P. selaginoides.*

2.2.7 Soil-Stored Seed Bank

A seed bank trial was conducted on *Pultenaea selaginoides* at Hardings Falls on the Swan River. The other species of Group 1 were either on very rocky or loose soil, or did not produce enough seed to make the trial valid. Steel piping with a diameter of 6.9 cm was used to extract 30 cylindrical columns of soil at 0.4 m intervals along transects through the population. The cores reached depths of approximately 12-15 cm, and were subsequently transferred to PVC pipe for transport to the laboratory. They were stored in a cool room at 5^{o}C until analysis. The cores were sectioned at two centimetres, four centimetres, and six centimetres from the surface to make four layers. Each sample was individually washed through 1.70 mm and 0.355 mm sieves, and then dried. The material was later inspected under a dissecting microscope for intact seeds of the subject species, which were collected and counted.

2.2.8 Disturbance

The disturbance trial was limited by rocky soil conditions. It was conducted on two of the species from Group 1 and two species from Group 2 which appeared, from general observations, to respond to disturbance. Experimental plots were set up in late summer, 1991, at Devils Elbow on the Elizabeth River for *A. axillaris;* near the Golden Gate Road, Tower Hill, for *B. obcordata;* at the Den Ranges, south of Lefroy, for *P. hibbertioides;* and at Hardings Falls, on the Swan River, for *P. selaginoides.* Four plots each were constructed for *A. axillaris* and *P. selaginoides.* The plots were two metres by one metre in dimension, and consisted of bird-wire fences (one metre in height) supported by star-pickets.

One-half of the internal area was heavily mechanically disturbed using a mattock. The sites chosen were placed close to extant shrubs, known to be producing fruit, to ensure that seed would be present within the plot. The fences were designed to exclude vertebrate animals.

The plots set up for *B. obcordata* and *P. hibbertioides* were unfenced. At the sites for both species, large quantities of immature plants were present and it was subjectively decided that grazing was not likely to be a factor limiting seedling establishment. The four plots for *B. obcordata* were two metres by one metre, marked in the corners by star-pickets. One-half of the area was disturbed. The plots at the *P. hibbertioides* site, however, consisted of two unfenced transects of ten metres by one metre with each alternate metre mechanically disturbed. Transects were used to benefit from the existence of a local and recent fire boundary within the community. The second transect crossed over this fire boundary.

A summary of the trials or observations conducted on each species is shown overleaf in Table 2.3.

Table 2.3: Research trials/ observations conducted for each of the subject species.

SPECIES	PRIORITY	RESEARCH TRIALS					
		Phenology	Germination	Propagation	Population structure	Seed Bank	Disturbance
Acacia axillaris	1	X	X	X	X	-	X
Acacia pataczekii	1	X	X	X	X	-	-
Bossiaea obcordata	2	X	-	X	-	-	X
Hovea corrickiae	1	X	X	-	X	-	-
Pultenaea hibbertioides	2	x	-	X	-	-	X
Pultenaea humilis	2	x	X	-	-	-	-
Pultenaea prostrata	2	x	X	-	-	-	-
Pultenaea selaginoides	1	X	X	-	-	X	X

X Major trial conducted on this species
x Less intensive trial conducted on this species
- Trial not conducted on this species

3. *ACACIA AXILLARIS* Benth. (Midlands Mimosa, Small Spike Wattle)

3.1 Morphology (from Curtis & Morris 1975, Stones & Curtis 1978a, pers. obs.)

Acacia axillaris is a medium to tall shrub, reaching up to about four metres in height. It is dense and prickly, branching from near ground level. Bipinnate compound leaves are found only in the seedling stage, and usually consist of two pairs of pinnae. Adult foliage consists of narrow linear, smooth phyllodes, 1.5-3 cm by 1.5 mm, which taper to a pungent point. The flowers are borne on short peduncles, with two to four present in the axil of a phyllode. Each flower bursts from three to four very small sepals and petals, displaying the characteristic ball-shaped *Acacia* flower of abundant stamens. The pods are brown and thin-textured, of about 3-4 cm by 2-3 mm. They may hold up to six shiny, black seeds (3.5 mm by 1.5 mm), which lie longitudinally in the pod. The seeds are capped by a pale yellow elaiosome, folded several times.

A. axillaris has been confused in the past with *A. riceana*, *A. siculiformis* and *A. genistifolia*. Although the foliage of all four may be relatively similar, the buds of each are distinctive, firstly in the nature of the inflorescence (that is, the latter two species have an inflorescence shaped in a spherical head, the former two in an extremely compacted spike arrangement), and secondly in the length of the peduncle (that is, very short for *A. axillaris* and *A. siculiformis*, and usually longer for the other two species; Figure 3.1). A good reference for separating these species is the key of Gray (1990).

Figure 3.1: Differentiation of four Tasmanian phyllodinous *Acacia* species based on bud characteristics: *A. axillaris*, *A. riceana*, *A. siculiformis*, *A. genistifolia* (left to right; adapted from Simmons 1981).

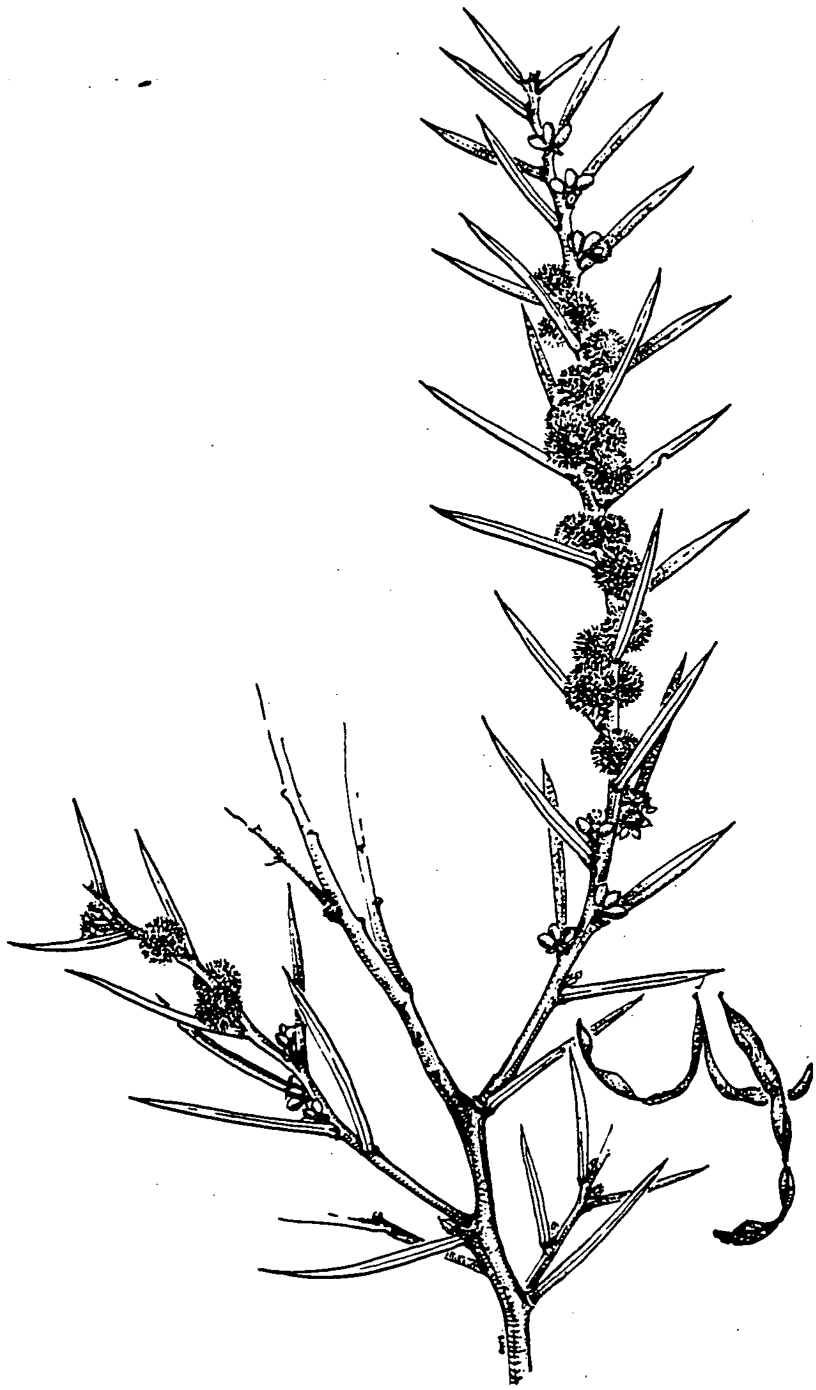


Figure 3.2: Leaf morphology and flowers of *Acacia axillaris* (from Simmons 1981).

3.2 Distribution and Rarity

Acacia axillaris is endemic to Tasmania, and restricted to north-eastern Tasmania and the Midlands. It is rare nationally (**Rr2**; Kirkpatrick *et al.* 1991b), and has also been considered vulnerable (**3V**; Briggs & Leigh 1988). Most of its locations comprise reasonably large populations and Kirkpatrick *et al.* (1991b) state that it is reserved in the Mt. Barrow State Reserve. This site, however, consists of approximately 100 plants near the boundary of the reserve while downstream populations are completely outside the reserve. The species can not be considered adequately reserved.

A. axillaris is concentrated primarily in central eastern Tasmania; in the riparian communities along the Elizabeth River, the St. Pauls River and its tributary, Dukes River (Figure 3.3). The species is quite abundant in this area, with large populations occurring along the Elizabeth River from Devils Elbow, five kilometres east of Campbell Town, to Chimney Hill, 13 km farther east. Scattered individuals occur right into Campbell Town itself. On the St. Pauls River, scattered populations can be found from Avoca east to Smiths Tier. The species possibly extends into Rosemount Flat and Nowhere Else, but access to this area was denied by the landholder. A large population does occur farther to the north-east on one of the tributaries of the St. Pauls River, the Dukes River, in the Dukes Marshes.

A. axillaris is not confined to riversides, however, since it also occurs on lower valley sides and in soaks within the catchment of the Elizabeth River. Most interestingly, healthy and regenerating populations were discovered in 1990 in a subalpine community at over 1 000 m on Mt. Barrow, northern Tasmania, and at 500 m on the Lake River, Great Western Tiers. Simmons (1981) states that the species also occurs on the Clyde River, however, there are no other records to support this location. The other record of note is one by Dr. W. Curtis in 1971 from the Prosser River in south-eastern Tasmania. No subsequent collections or further location of this population have, however, been made, and another collection made at the same time but in a different location was re-determined as *A. genistifolia*. The record is an unlikely reference (Dr. W. Curtis, pers. comm.) and should be discounted.

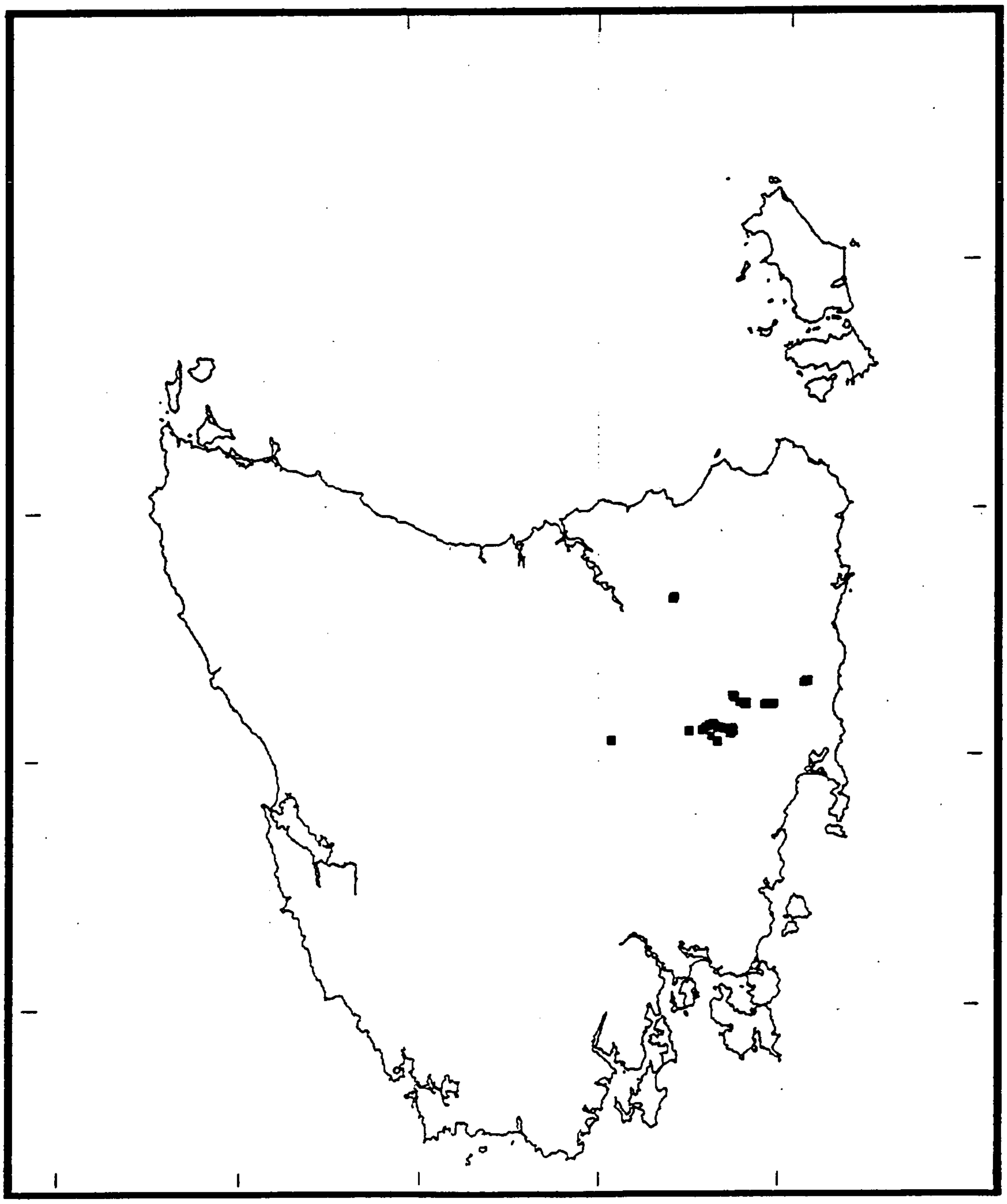


Figure 3.3: Distribution map of recently confirmed locations of *Acacia axillaris*.

3.3 Habitat

The habitat of this species has not previously been considered in detail. Galbraith (1977) listed it as coastal, however, none of the sites could be described as such. Simmons (1981) considered *A. axillaris* to be a plant horticulturally suited to cooler climate gardens with adequate moisture. This statement was made probably in connection with its previously presumed riparian nature, but prior to knowledge of the Mt. Barrow and Lake River populations. These populations suggest a hardy, frost-tolerant nature for this species.

There was a strong relationship amongst the locations which this species inhabited and proximity to permanent water or to waterlogged conditions. Most of the populations occurred on either the Elizabeth or St. Pauls Rivers, or their tributaries. The populations on the Elizabeth River were spread primarily between Devils Elbow, six kilometres east of Campbell Town (Figure 3.4), and the Harrimount Bridge, 14 km farther east, but almost 26 km by river. Occasional plants occurred downstream as far as Campbell Town itself, and plants may also be scattered farther up the catchment, to the north-east and south-east of Harrimount, as well as in other tributaries or drainage lines into the St. Pauls River system.

Figure 3.4: Typical riparian habitat of *Acacia axillaris*; Devils Elbow, Elizabeth River.

Most of the sites occurred on basic igneous substrates, either dolerite or basalt, at elevations between 200 and 550 m, the exception being the Mt. Barrow sites at elevations of 1 000 and 1 140 m. The sites on the Elizabeth and St. Pauls Rivers receive between 500 - 750 mm rainfall per annum, with the Dukes Marsh and Lake River sites receiving 750 - 1000 mm p.a. The Mt. Barrow site again is anomalous, with 1 500 - 2 000 mm p.a.

Along most of this section of the Elizabeth River, *A. axillaris* occurred on the lower slopes and riverside of the narrow river valley. Sites were present on a variety of aspects and slopes, and populations, varying in density, were abundant. At Devils Elbow, *A. axillaris* dominated the understorey of a low *A. melanoxylon* woodland. *A. axillaris* formed a four metre shrub layer, along with *Melaleuca ericifolia* and *Leptospermum lanigerum.* It also dominated a sparse two metre shrub layer, along with *M. ericifolia.* The ground cover was open, however, there were moderately dense clusters of *Lomandra longifolia.* Other local species included *Beyeria viscosa, Notelaea ligustrina, Pomaderris apetala, Poa sieberiana, Carex appressa, Eleocharis gracilis, Hypericum japonicum* and *Hydrocotyle hirta.* Flood debris was evident, and during the year that the disturbance plots were set up for this species, the one metre high cages accummulated debris on their top. This site had not burnt for about 12-14 years.

Farther east, at Ginger Marsh, *A. axillaris* formed a four metre tall open scrub community with *Leptospermum lanigerum.* The *Leptospermum* dominated two metre and one metre tall shrub layers, the lower one also commonly containing *Callistemon viridiflorus.* The ground was moist, being clothed in a mid-dense cover of moss. Other species present included *Eleocharis gracilis, Gahnia grandis, Hakea epiglottis, Westringia rubiaefolia, Polystichum proliferum, Blechnum nudum, Hydrocotyle muscosa, Myriophyllum pedunculatum, Utricularia dichotoma, Poa rodwayi, P. sieberiana* and *Carex breviculmis.* Seedlings of *A. axillaris* were occasionally observed. The site was a marshy, river flat on a silty organic soil, with the *Acacia* continuing up onto the steep lower valley sides. Recent burning at these sites was not evident, and they all are lightly grazed by sheep, cattle, wallabies and deer. Logging occurred farther east more than thirty years ago.

South-west of the Harrimount Bridge, firing has been more recent; sporadic fires have patch burnt the area, so that the vegetation ranges in age between 2-3 and more than 20 years old. This area of gentle slopes and river flats, was underlain by stony brown doleritic loam. *Eucalyptus pauciflora* and *E. rodwayi* dominated the open woodland with the understorey varying from *Leptospermum scoparium* dominated to *Poa gunnii - Danthonia* sp. dominated. Other heath species were present: *Banksia marginata, Cyathodes parvifolia, Epacris impressa, L. lanigerum, Grevillea australis, Leptomeria drupacea, Acrotriche serrulata, Lissanthe montana* and *Lissanthe strigosa;* as well as graminoids and herbs: *Juncus* sp., *Schoenus apogon, Poa labillardieri, Gahnia grandis, Carex gaudichaudiana, Acaena novae-zelandiae, A. echinata, Gnaphalium collinum* and *Hypochoeris radicata.*

Some sites were not riparian. At Black Snake Marsh, on a tributary one kilometre north of the river, *E. amygdalina* and *E. pauciflora* dominated a herb-rich woodland with scattered *Acacia axillaris* in the rockier, heathier gentle slopes above the marsh. *Lomandra longifolia* dominated the ground cover, along with *Epacris impressa, Acrotriche serrulata, Lissanthe strigosa* and *Cyathodes parvifolia,* with *Glycine clandestina, Poa labillardieri, Viola hederacea, Ranunculus* sp., *Hypericum gramineum, Leontodon taraxacoides, Gonocarpus tetragynus, Acaena novae-zelandiae, Hydrocotyle sibthorpioides* and *Oxalis corniculata* within the herbfield.

Two other non-riparian sites occurred at Keach Hill, ten kilometres east of Campbell Town, and farther along the Lake Leake Road, 15 km east of Campbell Town. These two sites were in cleared paddocks. At Keach Hill, approximately 80 *Acacia axillaris* shrubs occurred in a sedgy grassland. They were of varying sizes, and had been heavily grazed into dense, round shrubs. The more eastern site was also a grassy sedgeland with remnant woodland and heath species, mostly cleared for grazing. An isolated group of six *A. axillaris* shrubs occurred near the fenceline. Both sites were on gentle slopes of north-eastern aspect at the head of soaks of tributaries draining into the Elizabeth River.

On the St. Pauls River, *A. axillaris* was scattered between Avoca and the Hop Pole Creek confluence, a distance of almost 30 km. The sites varied little in altitude (200 - 230 m), except for the site at Dukes Marsh (500 m). Plants were scattered along the riverside for 1.5 km east of Avoca, amongst low shrubland of emergent *Eucalyptus ovata, Melaleuca gibbosa, Hakea microcarpa, Leptospermum lanigerum, Lissanthe strigosa, Lomandra longifolia, Poa labillardieri, Bromus mollis, Schoenus apogon* and the mainly introduced herbs, *Plantago lanceolata, P. coronopus, Leontodon taraxacoides, Cotula coronopifolia, Acaena novae-zelandiae, Oxalis perennans, Gonocarpus tetragynus, Hypochoeris radicata, Dichondra repens, Trifolium repens, Centella cordifolia* and *Hydrocotyle sibthorpioides.* The weeds *Ulex europaeus* and *Rosa rubiginosa* were present in moderate cover. *Acacia axillaris* was usually near the water's edge on slopes of less than 5^{o} with north-east to south westerly aspects, and amongst basalt rocks or bare ground. Flood debris farther upslope was evident.

About seven kilometres south-east of Avoca, *A. axillaris* occurred on the silty loam of an alluvial basaltic flood-plain amidst *Eucalyptus ovata* open woodland. The understorey was also open, and dominated by *A. axillaris, Gahnia grandis, Leptospermum lanigerum* and *Poa labillardieri.* Other less common species included *Callitris oblonga, Melaleuca gibbosa, Hakea microcarpa, Acacia dealbata, Lepidosperma lineare, Diplarrena moraea, Leontodon taraxacoides, Hypericum japonicum, Empodisma minus, Wahlenbergia* sp., *Carex iynx* and *Schoenus apogon.* There was no evidence of recent firing in this area. Flood litter was observed in the upper branches of a shrub almost two metres above the normal river level. The area is private property, and grazed by sheep and cattle.

Near Royal George, *A. axillaris* occurred in a similar community, the outskirts of which were also encroached by fire, clearing and grazing. *A. axillaris* appeared to be even-aged, with a few root shoots evident. The site was again a river flat, under *E. ovata* woodland with a dense two metre tall shrub understorey of *Callitris oblonga, A. genistifolia, Leptospermum lanigerum, Hakea microcarpa, Callistemon viridiflorus, Grevillea australis, Epacris tasmanica* and *E. gunnii.* The ground cover was predominantly *Lomandra longifolia* and *Poa labillardieri,* with *Diplarrhena moraea, Carex* sp., *Ajuga australis, Oxalis corniculata, Leontodon taraxacoides* and *Schoenus apogon.* Recent firing was not evident. Gorse was prevalent, and intruding into the community. Small patches of the *Acacia* were scattered along the river to the east in remnant riverine woodland.

Another site occurred upstream farther to the north-east, and at higher altitude in the Eastern Tiers, at Dukes Marsh. Plants were scattered in clusters at the base of a rocky slope on the marsh edge, in the ecotone between the closed marsh scrub and the heathy *E. pauciflora - E. rodwayi* woodland, over a distance of at least 500 m. The understorey comprised a two metre tall heath layer dominated by *Hakea epiglottis, Leptomeria drupacea* and *Bedfordia linearis,* with a one metre layer dominated by *A. axillaris* and *Pultenaea gunnii.* The ground cover was primarily *Hibbertia serpyllifolia* and *Diplarrhena moraea,* with other species including *Lomatia tinctoria, Micrantheum hexandrum, Leptospermum lanigerum, Westringia rubiaefolia, Leucopogon collinus, Bedfordia linearis, Poa labillardieri, Gonocarpus serpyllifolius* and *Schoenus apogon.* Other locally occurring species were *E. dalrympleana, Hovea lanceolata, Bauera rubioides, Callistemon viridiflorus, Dianella revoluta, Epacris gunnii, Veronica formosa, Restio australis* and *Grevillea australis.* One juvenile *Acacia* was present, while most of the mature plants were very branched and gnarled, with very thick main stems (six centimetres diameter) at only one metre height. The slopes above the open heath appeared to have a higher firing frequency. The population structure of a site farther upstream which contained an obvious fire boundary was recorded (Figure 3.5a). Analysis indicated that the populations either side of the fire boundary were even-aged, and had regenerated after separate fire events. The populations displayed a similar pattern of plant diameters and therefore ages of plants and regeneration response.

Two sites were recently "discovered" in 1991: on Mt. Barrow, in the north-east of Tasmania, and on the Lake River in the Great Western Tiers. The Mt. Barrow population was situated on at least two sites on Coquet Creek, at altitudes of 1 000 m and 1 140 m. These sites were both in subalpine communities, on dolerite, and receive more than 1 500 mm p.a. rainfall. The lower altitude site consisted of a *Leptospermum lanigerum* tall shrubland (Figure 3.6). The understorey was dominated by a 2.5 m layer of *Acacia axillaris,* with a lower layer of *Cyathodes parvifolia, Richea scoparia, Persoonia gunnii* and *Bellendena montana.* The population was almost confined to the small creekline, with vegetation farther away usually consisting of heathy sedgeland. Small seedlings of *A. axillaris* were relatively common. There was a high degree of fallen timber, and some of the *Acacia* were prostrate, due to having been pinned by fallen timber. They were frequently multi-stemmed, with a shallow root system. The community had not burnt for many years, and *A. axillaris* was regenerating continuously and without fire (Figure 3.5b).

Farther northeast (1.4 km) and upslope (1 135 m), part of the other population occurred in *Leptospermum lanigerum* and *Nothofagus cunninghamii* scrub just below the *Eucalyptus archeri* treeline (J. Davies, pers. comm.). This population, in a dolerite blockstream, was very localised, and comprised only twelve plants. Both of these populations occurred outside the Mount Barrow State Reserve, in State forest. Several hundred metres downstream, more than one hundred plants were present in the same scrub community on a blockstream, and probably just inside the reserve. Areas varied in density from open to closed scrub with emergent *E. archeri.* The dominant species were *L. lanigerum, N. cunninghamii, Acacia axillaris, Richea scoparia* and *Telopea truncata,* with sparse cover of *Poa gunnii* and *Carex breviculmis,* and moderate to high exposures of dolerite boulders. Other species present included *Tasmannia lanceolata, Bellendena montana, Coprosma nitida, Cyathodes parvifolia, Orites revoluta, Baeckea gunniana, Lycopodium fastigiatum, Rubus gunnii, Craspedia alpina, Oxalis magellanica, Hydrocotyle sibthorpioides* and *Geranium potentilloides. Acacia axillaris* stems reached 0.12 m diameter, and occasional seedlings were present (Figure 3.5c). Flood damage was evident on some shrubs.

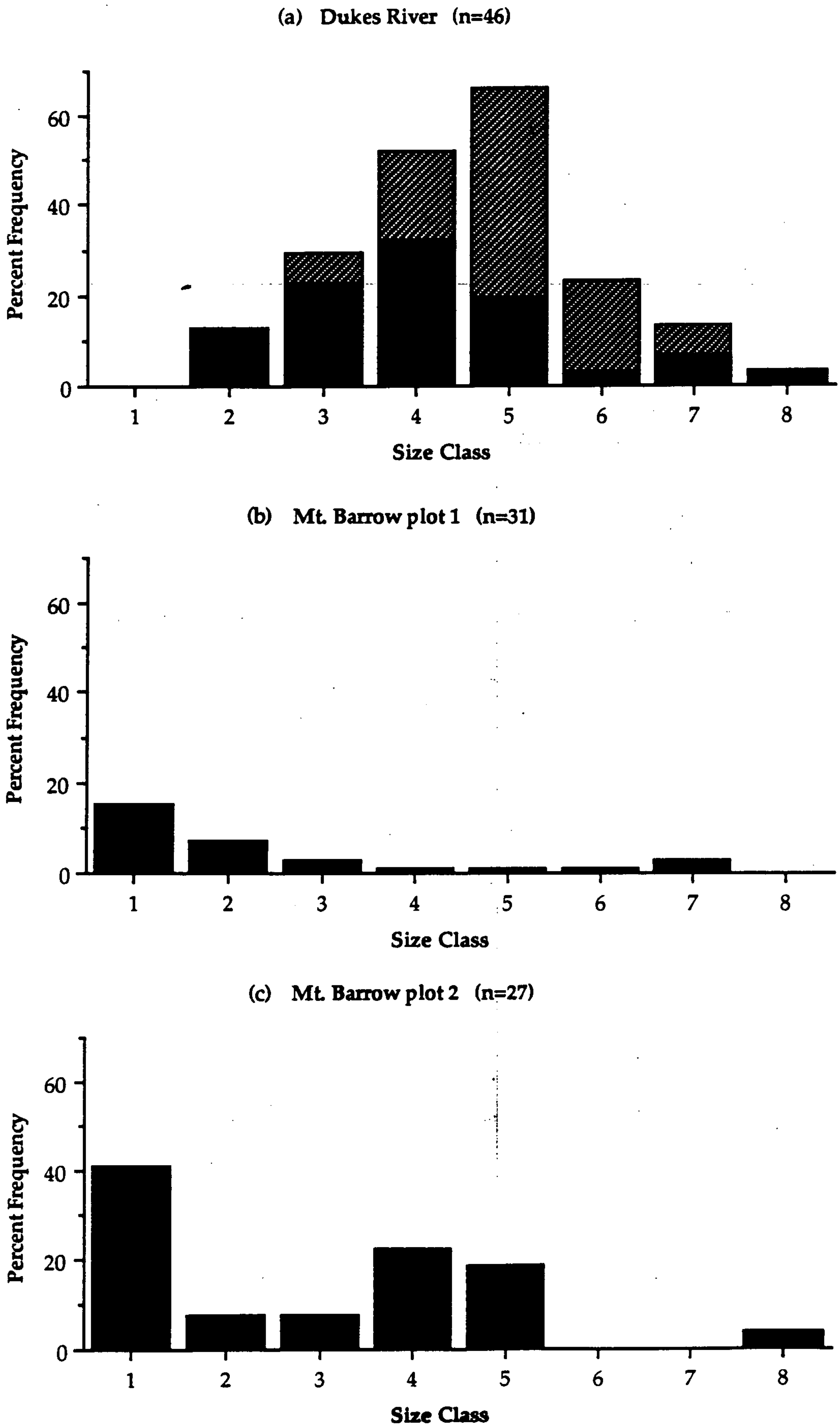


Figure 3.5: Population structure using centimetre size classes of *A. axillaris* communities: (a) across a fire scar, Dukes Marsh, Eastern Tiers (different shading indicates plants from each side of the fire scar; (b) Mt. Barrow (1 140 m); (c) Mt. Barrow (1 000 m).

Figure 3.6: ***Acacia axillaris* in *Leptospermum lanigerum* tall shrubland, Mt. Barrow.**

The Lake River population comprised an isolated stand of *A. axillaris* in marshy *E. dalrympleana* woodland at an altitude of almost 500 m. This site occurred on river flats, although older plants of less variable floristic structure were scattered on the adjacent lower hillslopes. The plants occur on dolerite, but are just downstream from a boundary with alluvial sediments and mudstone. The understorey on the marsh was dominated by dense low heaths, such as *Cyathodes juniperina*, and the graminoids and grasses: *Lomandra longifolia, Poa labillardieri, P. labillardieri* var. *acris, P. sieberiana, P. annua, Agrostis capillaris, Ehrharta stipoides* and *Juncus* sp. The herbs *Oxalis perennans, Holcus lanatus, Acaena novae-zelandiae, Taraxacum officinale, Geranium solanderi, Veronica gracilis, Hypericum gramineum* and *Cirsium arvense* were also present. On the south-westerly, 5^{o} lower slopes, individuals of *A. axillaris* reached about 0.15 m diameter and were multi-stemmed. There were more bare areas of ground here. Most of the *Acacia* were 2 - 2.5 m height, although there was one juvenile of 0.8 m. *Eucalyptus rodwayi* was present as well as *E. dalrympleana,* and the herb cover was more diverse. Other species to those previously mentioned included *Bossiaea cordigera, Gonocarpus tetragynus, Carex* sp., *Hypochoeris radicata, Lagenifera* sp., *Viola hederacea, Lotus corniculatus, Prunella vulgaris, Hydrocotyle sibthorpioides* and *Plantago lanceolata.* The site was grazed by sheep, deer, wombats, hares and wallabies. Disturbance from intensive grazing at this site has allowed the establishment of introduced herb and grass species.

Table 3.1: Summary of habitat records and conservation information for *A. axillaris*.

Recent Records:	> 9 sites recorded, 9 extant	
Habit:	Medium to tall usually multi-stemmed shrub, up to 4 m height, with dense, prickly, branches, narrow-linear phyllodes (1.5-3 by 0.15 cm) with a pungent point, and 2-4 flowers on a short raceme in the phyllode axils	
Population Size:	> 1 000	
Regeneration:	Type:	Germination of seed; root shoots
	Observed?:	Both rare, slightly more common with altitude
Habitat:	Landform:	Usually restricted to river flats or lower valley sides, or seasonally waterlogged sites, drainage lines or creeks Basic igneous substrates, either dolerite or basalt
	Altitude:	Between 200 and 550 m, the exception being the Mt. Barrow sites at 1 000 and 1 140 m
	Aspect:	Variable
	Slope:	Variable: up to 10°
	Community:	Variable: woodlands of *Acacia melanoxylon* or *Eucalyptus* spp.,or *Leptospermum lanigerum* scrub with *Melaleuca* spp., *Poa* spp., *Carex* spp., *Lomandra longifolia*
Fire response:	Presumed to resprout after cool to moderate fires, not known whether populations will regenerate by seed after hot fires	
Conservation Status:	Proposed:	**Vv**
	Current:	**Rr2** (Kirkpatrick *et al.* 1991b); **3V** (Briggs & Leigh 1988)
Reserve:	Mt. Barrow State Reserve	
Comment:	Approximately 100 plants reserved	

3.4 Phenology

References to the flowering period of *A. axillaris* are reasonably sparse (Table 3.2). The specimens collected for sketching in the Endemic Flora of Tasmania publication were collected on the Elizabeth River near Campbell Town, 20th of September, 1967, and the fruit also from the Elizabeth River, 14th of January, 1968 (Stones & Curtis 1978a). Specimens in bud held at the Tasmanian Herbarium have been collected 21st of May, 1981, 15th - 16th of June, 1981, 10th of July, 1981, July 1985, and 12th of June, 1988, while flowering material was collected in September 1893, 4th of September, 1967, 20th of November, 1981 and 2nd of October, 1982. Pods may persist on the shrubs if seeds are immature or have been subjected to predation; one herbarium collection of July 1981 held galled pods. The literature references and the fertile material from the herbarium were all probably from populations on the Elizabeth and St. Pauls Rivers, and should accordingly conform to a similar phenological pattern. The period given by Blombery includes the time in which the species is actually in bud, since buds begin to form after the fruit is mature but before dehiscence.

Flower buds for this species were observed to develop towards the end of fruit development in summer, sit dormant on the plant through the winter, and

Table 3.2: **Phenology of *A. axillaris*, as determined from literature and Herbarium records.**

Source	J	F	M	A	M	J	J	A	S	O	N	D
Blombery (1967)	FP	F	F	F	F	F	F	F	F	F	FP	P
Simmons (1981)									F	F		
Stones & Curtis (1978a)	P								F			
Cameron (1981)										F		
Herbarium records					b	b	b		F	F	F	

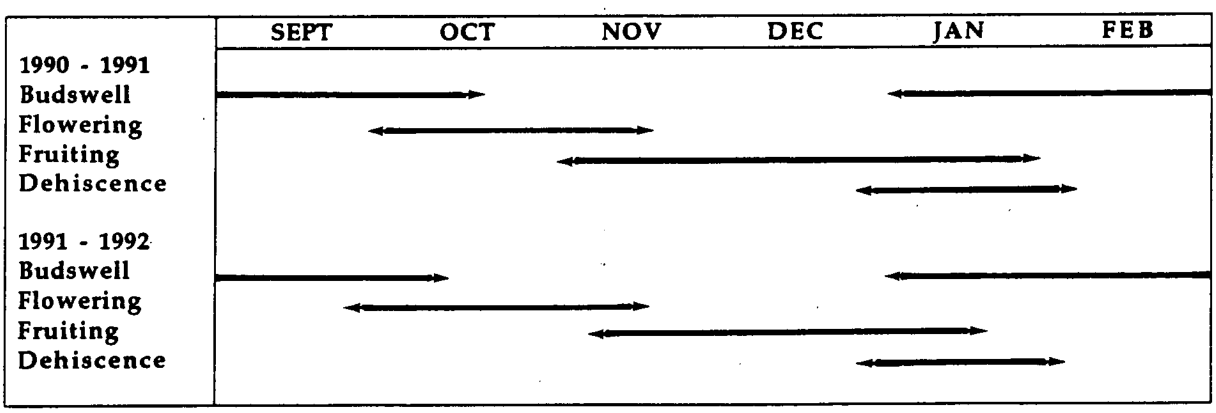
(Month of Year)

b Buds present
F Flowering
P Fruit present

then swell in preparation for flowering in early spring. Earliest flowering, in 1990, began at the start of October, with the peak period being in the middle fortnight of October (Table 3.3). Pods were not observed before the second week of November, although formation would have begun immediately following fertilisation. Pods and seeds developed through December and January, and began to ripen and dehisce in early January. Pods continued to ripen and dehisce through January. However, the subalpine population of *A. axillaris* on Mt. Barrow was in middle to late dehiscence (by percentage of the population at this stage) in early March, 1991.

A similar phenological pattern was evident during the following season, 1991 - 1992 (Table 3.3). Unlike other species monitored over these two seasons (*A. pataczekii, Bossiaea obcordata, Hovea corrickiae, Pultenaea selaginoides*), the drier summer of the latter season did not appear to have affected the timing of stages in development of *A. axillaris*. This may have been due to the proximity of the sites of this species to permanent water supplies.

Table 3.3: **Field observations of phenological activity, spring to summer, 1990 - 1991 and 1991 - 1992, at St. Pauls River site (Benham).**



A low percentage of seed from the Midlands populations survived to podburst undamaged by insect attack. Predation on *A. axillaris* seed was manifested as small, circular holes in the testa, just visible by eye, and sometimes surrounded by clear gum exudate from the interior of the seed. The insect involved was probably a larval stage of weevil (family Curculionidae; P. McQuillan, pers. comm.). It was considered that even if the embryo was still complete after damage to the testa, that pathogens would have mortally infected the embryo (D. Bashford, pers. comm.), and the seed would not be viable. The higher altitude populations, however, had a greater survival rate, and therefore seed from these populations was used for the germination trials.

3.5 Propagation

Germination trials conducted on *A. axillaris* included the scarification and dry heat (oven) treatments trialled on all species: the dry heat trials of two minutes exposure to 100°C, 80°C, and 60°C, as well as a scarification trial and control. No response was gained, however, from these trials, despite apparent imbibition of seeds at rates concordant with germination in other species. Other germination methods were, therefore, instigated: these were wet heat (100°C and 80°C), effective embryo excision, and cold stratification (5°C) treatments. The numbers of seeds in the later trials varied depending on how many replicates were trialled.

There was significant variation between the treatment groups ($p < 0.0001$, d.f. = 9, $F = 7.983$). However, the only trials to receive moderate germination response (Figure 3.7) were the treatments of cold stratification for two months (treatment 2) and embryo excision (treatment 10); from which 28.7% and 26.5% germination respectively was achieved. Insignificant numbers of seeds germinated in the treatments of cold stratification for one month (treatment 1; 8.3%), 100°C wet heat (treatment 5; 2.5%) and scarification (treatment 9; 1.7%). Resultant germination was not significantly different between the cold stratification for two months and embryo excision treatments which formed one group of homogeneous results, or between all other treatments which formed the other (Table 3.4).

The rates of germination (Figures 3.8 to 3.10) showed that most of the germination occurred within about the first forty days, with scattered germination continuing for the excised seeds (treatment 10).

Propagation using vegetative cuttings of this species was attempted using a two second pretreatment with I.B.A. and also one of six seconds. The longer treatment was more effective, with a resultant strike rate of 20%, compared to 5%. The cuttings were made in March, maintained through winter in a glasshouse, and flowered the following spring.

Table 3.4: **Scheffe multiple range analysis of variation between treatment means.**

Treatment	Trial	N	Homogeneous Groups	
3	Control	60	X	
4	100°C dry	60	X	
6	80°C dry	60	X	
7	80°C wet	40	X	
8	60°C	60	X	
9	Scarified	60	X	
5	100°C wet	40	X	
1	Cold 1mth	60	X	
10	Excised	74		X
2	Cold 2mth	135		X

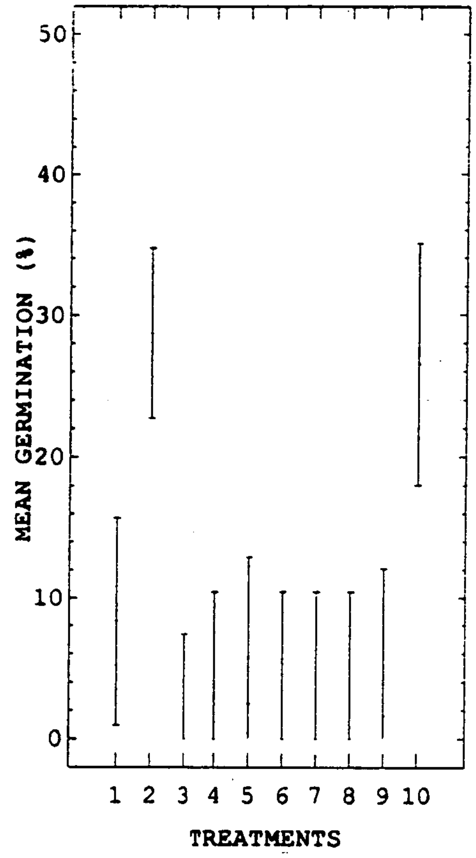


Figure 3.7: **Range of mean results for germination trials with standard errors.**

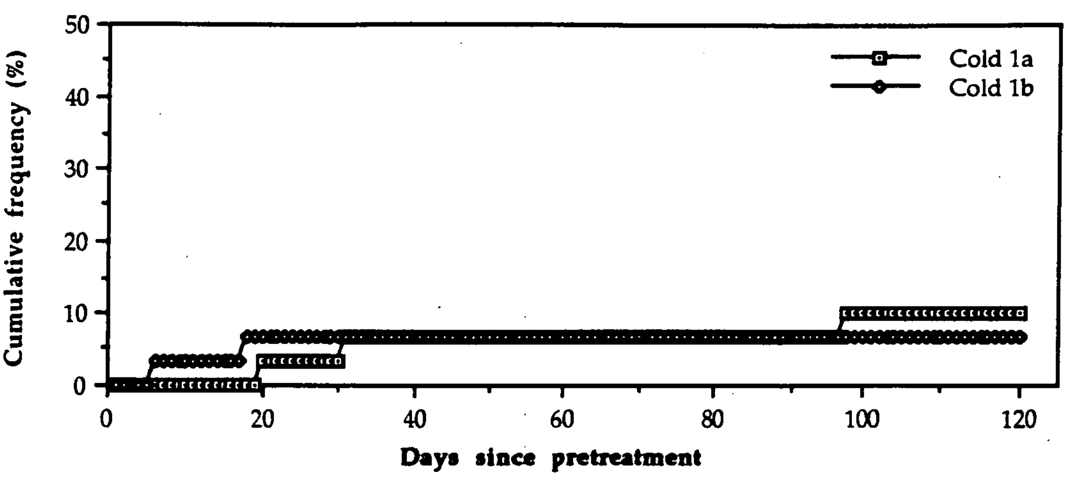


Figure 3.8: **Germination response of *A. axillaris* after pretreatment by cold stratification (one month; a, b and c groupings represent replicate treatments).**

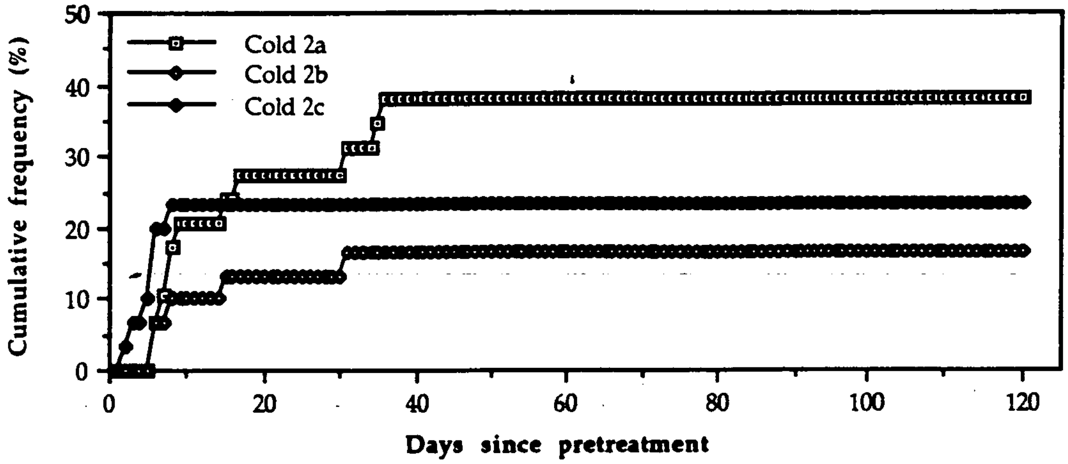


Figure 3.9: Germination response of *A. axillaris* after pretreatment by cold stratification (two months; a, b and c groupings represent replicate treatments).

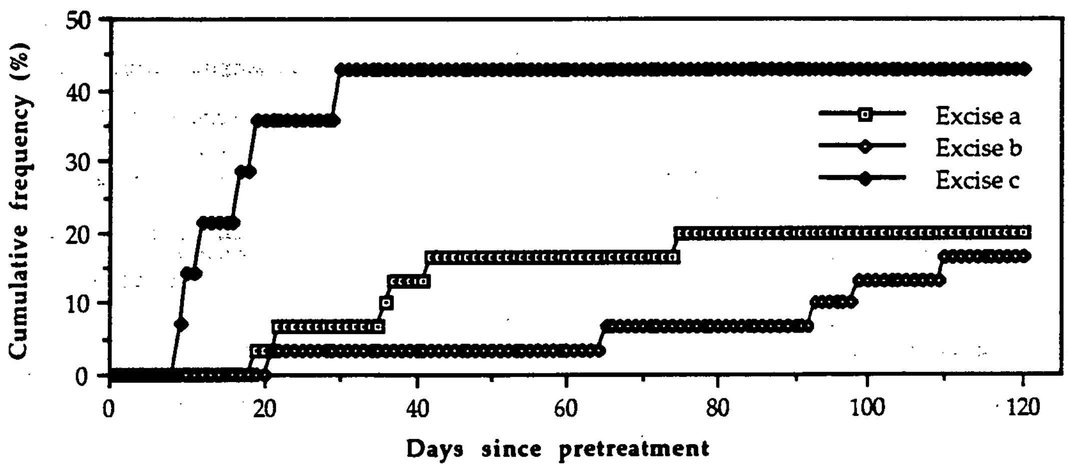


Figure 3.10: Germination response of *A. axillaris* after pretreatment by excision of embryo (a, b and c groupings represent replicate treatments).

3.6 Disturbance

No germinants were recorded in any of the four plots, either disturbed or undisturbed halves, by 22nd January, 1992; approximately one year after trial initiation. Very few germinants were seen at most populations, although a few sites did have many seedlings or juveniles. These sites were in the subalpine community at Mt. Barrow, at Keach Hill, and occasional sites on the Elizabeth River. Most sites are grazed by sheep, except for Mt. Barrow (ungrazed) and Keach Hill (grazed by cattle). The Mt. Barrow site showed no sign of recent burning.

3.7 Pollination

Two beetles and a midge were collected from this species when in flower in spring, 1990. The plants at the phenology site, St. Pauls River (Benham), were observed on three occasions for periods of approximately six hours. These insects were the most common. One of the beetles, a Chrysomelid, was collected from the leaves of the plant, whereas the other beetle was roving on both leaves and flowers. The midges were in the locality of the flowers. No identifications have yet been returned.

3.8 Discussion

Acacia axillaris is restricted to north-eastern Tasmania and the Midlands. It occurs in riparian communities, on the lower slopes of the valleys and along drainage lines primarily at altitudes between 200 - 230 m in the catchments of the Elizabeth and St. Pauls Rivers. At the upstream end of the Elizabeth River, however, sites reach 550 m altitude. The higher altitude populations (Mt. Barrow 1 000 - 1 140 m a.s.l., the Lake River 500 m, and Dukes Marshes 500 m) indicate an important aspect of the species' ecology. In general, legumes regenerate from seed after fire or disturbance breaks the physical barrier of the seed coat. However, the heat trials were unsuccessful in effecting germination of *A. axillaris.* The scarification trial was very successful for all other species but also failed for *A. axillaris.* Further trials found wet heat (100^{o}C and 80^{o}C) also not to be effective, although the standard wet heat (boiling water) treatment has previously been found to be successful (D.G. Geeves, pers. comm.). No details, however, of the collection site of the seed nor its age were available. The moderate success of the cold stratification (5^{o}C) treatment could be expected for a subalpine species or one restricted to areas subject to cold air drainage. Dormancy in seed of this species appears to be characterised by both a physiological mechanism inhibiting germination as well as by the physical barrier of the impermeable seed coat, that is, a combinational dormancy (Baskin & Baskin 1989).

The most obvious ecological analogue of this trial is that the corresponding environmental parameter required to break dormancy is low winter temperature. It is possible that fluctuating temperatures may also be found to be effective in breaking dormancy. Low levels of germination were also induced in the germination trials by effectively excising the embryo from the seed coat. Scarification did not initiate germination, so imbibition was not the only requirement of these seeds. The greater aeration of these seeds may have been required for germination. The greater exposure of the embryo to air temperature may mean that it is more susceptible and sensitive to fluctuations, and it may be this shock that also effected some germination in wet heat scalding which may be more intense to an embryo than a dry 100°C heating. The relationship between excision and cold stratification is obviously complex, and all the more interesting for being one of the more unusual germination strategies of a legume. It does accord with the distribution of the species in river valleys, drainage lines and subalpine creeklines, such that even in relatively moist sites the plants were usually very close to the water. The implication is that, in the Midlands, this restricted distribution has not been induced through clearing but because of sensitive physiological needs of the species. Cold stratification is a common requirement of many species from higher altitudes of southern Australia (Mott & Groves 1981). This requirement delays germination until late in winter or early in spring, ensuring a more favourable environment for seedling establishment (Mott & Groves 1981). The inhibitor may be in the seed coat or within both the embryo and the seed coat (Mott & Groves 1981). The success of excision of the embryo of *A. axillaris* from the testa in effecting germination suggests that the inhibitor in seed of this species is in the testa.

The higher altitude, subalpine - montane populations have plants with finer phyllodes that are narrower and slightly less robust than those of the lower altitude Midlands populations. This morphological variation appears to be consistent across the species' range and may indicate a varietal difference. The altitudinal disjunction of *A. axillaris* may imply that the populations have different physiological tolerances or that they are subject to different environmental pressures. However, the lack of populations between those at 200 - 500 m a.s.l. and those above 1 000 m a.s.l. means that the possibility that this morphological variation is clinal cannot be dismissed.

Seed for the germination trials on this species was collected from the Mt. Barrow population. Most of the seed collected from two sites on the St. Pauls River during the phenological study (altitude 220 m) had been subjected to predation by insects, whereas the higher altitude population suffered a much lower incidence of attack. It may be that the presumed later flowering and fruiting of the higher altitude populations results in the phenology of these populations not overlapping with that of the predatory insects. Alternatively, the environmental conditions may be outside the tolerance range of the insects. Investigation of other sites may determine if predation affects lowland populations only, and to any great degree, each season.

The sites where *A. axillaris* occurs do not tend to suffer moisture deficiency. Most sites were close to permanent water or to waterlogged conditions, varying from rivers to catchment soaks. The sites above 500 m altitude also receive relatively high annual rainfall. This species was the only one of the five whose phenology was monitored over two seasons that varied very little in timing of fruit production. The drier summer of the 1991 - 1992 season did not appear to have extended the development period of *A. axillaris* seed, possibly because of the proximity of the sites to water. Another consequence of this proximity is that many of the populations suffer some degree of flood disturbance. Litter was often found suspended in shrubs at least one metre high. Disturbance created during flood events may be a regeneration stimulus, however, there was insignificant response from the experimental scarification trial and the disturbance trial for this to be concluded.

Most of the sites do not have a high fire frequency, primarily because of their proximity to rivers. The Mt. Barrow site also has a paucity of fire-contributing factors, such as limited ignition sources, lower summer temperatures, slower rates of fuel load accumulation and high rainfall. Analysis of the population size structure of several communities indicated that populations may recover after fire, possibly by resprouting after cool or moderate intensity burns. It is not known how the plants recover after high intensity fires. The communities at Dukes Marsh contained plants of even size distribution, indicating single cohort regeneration after fire from dormant seed in the soil seed bank.

Fire is not required for the regeneration of *Acacia axillaris*. The combinational dormancy of its seed is most readily broken by cold stratification rather than disturbance or fire. Most of the sites occupied by the populations do not have a high fire frequency. Regeneration of seedlings in the field was not common at most of the Midlands sites, although occasional seedlings were observed. Seedlings were relatively common at Mt. Barrow and Ginger Marsh, while small plants of less than 30 cm height were commonly observed at Keach Hill and near Tea Tree Hill, both on the upper reaches of the Elizabeth River. These sites did not appear to have been fired recently, except for Tea Tree Hill, which had burnt 2-3 years previously. Regeneration at the unburnt sites appeared to be at low levels but apparently continuous. *A. axillaris* has been observed to have germinated in sites not burnt for at least 20 years. The species also has the capacity to send up root shoots.

Fire is not required for regeneration at high altitude sites. Two of the Mt. Barrow sites are located on blockstreams amid *Leptospermum lanigerum* and *Nothofagus cunninghamii* scrub with emergent *Eucalyptus archeri*. These sites are rocky with very low litter levels, and therefore are unlikely to carry fire. The Eucalypt also appears to regenerate on such sites without fire. Flood damage was evident on some shrubs. This disturbance may limit competition from other species and maintain an open environment suitable for regeneration by *A. axillaris*. Where the vegetation has not burnt for many years, the plants appear restricted to more open microsites, such as in disturbed areas and creeklines, and in the ecotones between communities. At another high altitude site, seedlings had germinated without firing and were surviving to replace older shrubs.

Lower levels of regeneration at the Midlands sites could be a result of several factors: firstly, insect predation of seed severely limits the amount of viable seed available; secondly, if the seed is dependent on a particular cold regime or fluctuating temperatures, these may be more readily achieved at higher altitude sites; and thirdly, the Midlands sites may have drier soil conditions, so that mortality of spring germinants is higher. Grazing did not appear to be a factor since seedlings did occur at Ginger Marsh which is grazed by both sheep and wallabies. Also, the fenced disturbance plots acted simultaneously as exclusion plots but regeneration within these plots did not occur. Further investigation into the effects of insect predation on both lowland and montane populations is required, considering to what degree predation is detrimental to regeneration of the species, and how variable this predation is spatially and temporally.

It is expected that the plants would be killed by high intensity fires. However, more investigation of the regeneration requirements of the species at lower altitude is needed. Investigation of the soil-stored seed bank may aid further understanding of the species' fire ecology. Flood disturbance may be sufficient to maintain open microsites, or in areas of high competition such as at Dukes Marsh, fires at frequencies of about ten to fifteen years may maintain a more open environment suitable for regeneration by this species. Longer term monitoring of populations is required.

4. *ACACIA PATACZEKII* D.Morris (Wally's or Pataczek's Wattle)

4.1 Morphology (from Curtis & Morris 1975, Stones & Curtis 1978b, pers. obs.)

Acacia pataczekii is a tall shrub or small tree up to about six metres in height. It has been mistaken in the past for *A. melanoxylon* and *A. mucronata,* and has been suggested to be a hybrid between *A. myrtifolia* and *A. melanoxylon* or *A. mucronata* (M. Brown, pers. comm.) because of its rarity and its limited sexual reproduction. *A. pataczekii* has obliquely elliptic, glaucous phyllodes with apiculate or mucronate apices, similar to the other three species. Its phyllodes are, however, more "bluish" or glaucous than these species, and lacks the distinctive parallel venation of *A. melanoxylon* and *A. mucronata. A. pataczekii, A. myrtifolia* and *A. melanoxlyon* have angular branchlets, while *A. pataczekii* and *A. myrtifolia* both have a small gland on the upper margin of the phyllode. *A. myrtifolia,* however, is a shrub of 0.03 - 0.1 m in height.

Figure 4.1: Morphology of *Acacia pataczekii* (from Simmons 1981).

The young branches of *A. pataczekii* are angular and may be a reddish-brown colour. The phyllodes are notable by a conspicuous oval gland on the upper margin about 2-4 mm from the base; some phyllodes may have another similar gland on this same margin up to half-way along the phyllode. The areas of the phyllode containing these glands are often preferentially eaten by insects. The inflorescences of *A. pataczekii* occur in small spherical heads of about 15 flowers on axillary racemes that may be ten centimetres in length. Galling of the flowers is common, but the development of the purplish-brown, oblong pods is infrequent. The pods are generally 2.5-4.5 cm in length and 0.7-1.0 cm in width. They may contain three to six dark brown, flattened oval seeds of 3-3.5 mm by 2.5-3 mm.

4.2 Distribution and Rarity

Acacia pataczekii is listed as rare in Tasmania (**Rur2;** Kirkpatrick *et al.* 1991b) and nationally (**2R**; Briggs & Leigh 1988). It is a Tasmanian endemic restricted to dry sclerophyll forest in the north-east of the State (Figure 4.2). Most of the populations occur within the Fingal forestry district while several occur in the Deloraine forestry district.

Several sites have been recorded from Fingal Tier. Two of these, at Mt. Foster, were extant and healthy. One population occurs at Tower Hill, to the north of Fingal. The other group of sites occurs farther to the north-west: on the eastern slope of Ben Nevis, to the north of Ben Lomond, and one large population was discovered in late 1991 on the north-eastern slope of Ben Lomond. The two areas of Mt. Foster and the plateau surface extending between Roses Tier and Ben Nevis appear to be the stronghold of the species, with many thousands of "individuals" present. An estimate of the actual number of genomes is very difficult because of the vigour with which this species propagates vegetatively; larger plants are generally surrounded by smaller individuals of varying sizes, which usually comprise rhizomatous offshoots of the central plant. The Mt. Foster populations are also very dense and abundant with "individuals", but tend to have less variation in population structure. They also did not appear to fruit as successfully as the Roses Tier populations (Section 4.4). Several new populations of *A. pataczekii* were located during this study, while two records from Gunns Road were not searched for. It is possible that other extant populations have been overlooked.

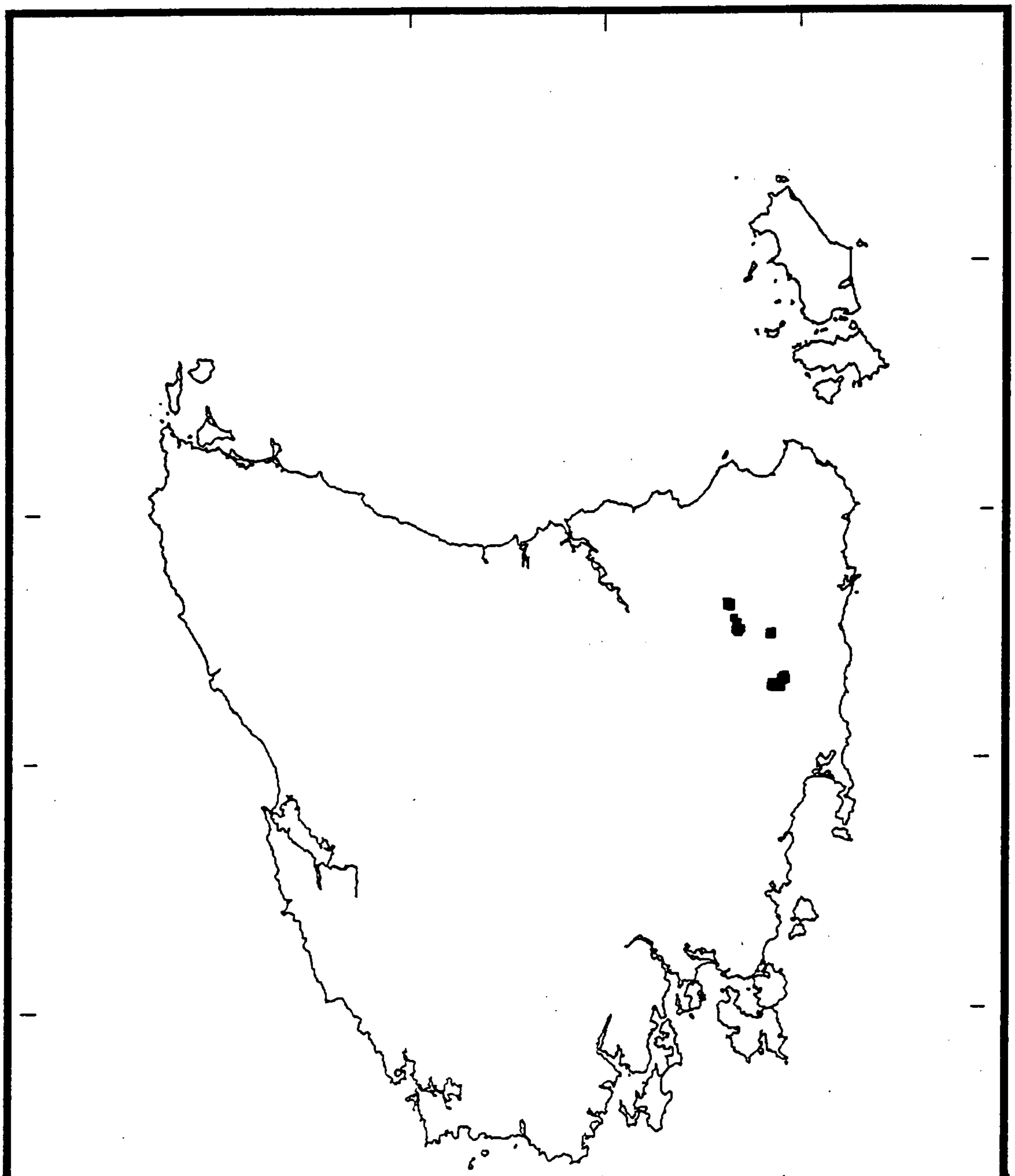


Figure 4.2: Distribution map of recently confirmed locations of *Acacia pataczekii*.

4.3 Habitat

A. pataczekii occurs at a variety of hilly sites all above 525 m in altitude. It occurs in areas with complex geologies, and often on the boundaries between two lithologies. They are also areas of moderate to high rainfall, varying from sites with more than 750 mm p.a. to sites with up to 1 500 mm p.a. The sites with the lower rainfall encircle the Fingal Valley, while higher rainfall is associated with proximity to north-eastern Ben Lomond.

All of the populations occur within dry or wet sclerophyll forest, although this varies from low woodland at high altitude and exposure to tall open forest and woodland on lower, more protected sites. The communities reflect this variation from *Eucalyptus delegatensis* and *E. archeri* grading to *E. delegatensis - E. dalrympleana - E. obliqua* with open heathy to shrubby understoreys, the composition of which also reflect the altitudinal variation. *A. pataczekii* usually dominates the understorey.

The Fingal district has a number of scattered populations; at Fingal Tier, Mt. Foster and Tower Hill. Several records from the Forestry Commission place the species at Fingal Tier south of Fingal: on the top of the Tier and top of the scarp, west and north-west of Fehres Marsh. These sites were not, however, relocated during this study. One small site was found in a small, regenerating clear-felled coupe to the south-west of these other records and east of Mt. Foster, and small populations of *A. pataczekii* are probably scattered across this part of Fingal Tier.

The coupe population was situated on both sides of a forestry track across gentle slopes and flats adjacent to a small creek gully. The area has a history of disturbance with previous selective logging for a bush sawmill and construction of narrow railways through the bush. The regenerating vegetation comprised a shrubby open woodland of *Eucalyptus delegatensis* and *E. dalrympleana* on a dolerite substrate with a clayey soil. The understorey was dominated by a moderate cover of shrubs such as *Banksia marginata, A. pataczekii, Leptospermum scoparium, Pultenaea juniperina* and *Cyathodes parvifolia.* There were reasonable quantities of fallen timber on the ground, which had patchy unvegetated areas of exposed soil. The ground vegetation was grassy, with low shrubs and herbs. Common species included *Poa labillardieri, Acacia dealbata, Hibbertia riparia, Lomatia tinctoria, Pteridium esculentum* and *Gahnia grandis,* along with *Craspedia alpina, Pentachondra* sp., *Helichrysum scorpioides, Brachyscome scapiformis, Wahlenbergia gracilis, Stackhousia monogyna, Gentianella diemenica, Dichelachne inaequiglumis, Danthonia penicillata, D. laevis, D.*

nitens, Deyeuxia quadriseta, Agrostis avenacea and *Stipa pubinodis. Acacia pataczekii* was regenerating vigorously from rhizomes.

A group of records also located this species near the summit and northern scarp of Mt. Foster, with a quite extensive patch on the north-eastern slope. One of the sites on the Mt. Foster plateau occurred on a north-easterly aspect, in a more open part of the canopy due to a high degree of exposed dolerite and skeletal soils. Several cohorts of *Eucalyptus delegatensis* were present, and *E.* aff. *archeri*, although the community had probably not burnt in the last twenty years. The open heathy woodland had an understorey primarily of *Lomatia tinctoria, Acacia pataczekii* and *Cyathodes parvifolia.* Other species were *Cyathodes glauca, Leucopogon hookeri, Brachyloma ciliatum, Epacris impressa, Poa labillardieri, P. rodwayi, Deyeuxia monticola, Pentapogon quadrifidus, Galium australe, Viola betonicifolia, Asperula* sp., *Crassula sieberiana, Elymus scabrus* and *Gnaphalium collinum. A. pataczekii* was regenerating, but was subject to attack from leaf miners.

On the eastern slope of Mt. Foster, a mid dense cover of *Acacia pataczekii* dominated the understorey of a *Eucalyptus delegatensis* heathy open forest. This community again had several cohorts, but had not burnt recently. The surveyed site was on a moderately steep, south-eastern aspect of the plateau slope, on shallow doleritic soils. On the flatter base of this slope, there was a *Leptospermum lanigerum* open forest with a moss - grass - sedge understorey. Leaf miners were active on the *Acacia* in this locality. *A. pataczekii* dominated at 2.5 m, while at less than one metre, *Cyathodes parvifolia, Lomatia tinctoria, C. glauca* and *Poa labillardieri* were common. Other species included *Coprosma nitida, Monotoca submutica* var. *autumnalis, Leucopogon hookeri, Drymophila cyanocarpa, Pimelea drupacea, Wahlenbergia gymnoclada, Billardiera longiflora, Poranthera microphylla, Agrostis parviflora* and *Dichelachne rara.* The eastern provenance of the montane/ subalpine heath species *Richea gunnii* has also been recorded from this area (O'Wheel 1984).

At Tower Hill was a mature stand which had regenerated in an area disturbed by mining (there being large shafts and trenches through the area; Figure 4.3), selective logging and tracks associated with these activities. The site had not burnt for about twenty-seven years (M. Miller, pers. comm.). This population was actively resprouting from rhizomes up to ten metres distance from the main stems of established plants. The community was an heathy open forest of *Eucalyptus sieberi, E. amygdalina* and *E. viminalis,* with an understorey dominated by *Acacia pataczekii, Pultenaea juniperina, Pteridium esculentum,* with occasional *Exocarpos cupressiformis, Bursaria spinosa, Lomatia tinctoria* and *Eucalyptus* juveniles. Other species were *Daviesia ulicifolia, Coprosma hirtella, Gonocarpus tetragynus, Lomandra*

Figure 4.3: ***A. pataczekii*** **in heathy open dry sclerophyll forest at Tower Hill.**

longifolia, Stylidium graminifolium, Drymophila cyanocarpa and *Dianella revoluta.* The substrate consisted of an orange, skeletal, clayey soil on argillaceous sediments. The site is in undulating country, sloping gently to a creekline in the south-east.

The populations in areas of higher rainfall, Ben Nevis, Roses Tier and the lower slopes of Ben Lomond, predominantly occurred on granodiorite, although the Ben Lomond sites were close to exposures of siliceous sediments. The plateau surface extending between Roses Tier and Ben Nevis appeared to be the stronghold of this species, with many thousands of "individuals" present.

At the northern end, on the eastern slope of Ben Nevis, several populations have been recorded on the moderate slopes and undulating plain at altitudes between 860 m and 940 m altitude. Sites were usually close to roads, partly an artefact of where people have easily travelled, but also because of the influence disturbance has on suckering by the species. One of these sites, on an east-facing slope of the mountain, consisted of *Eucalyptus delegatensis* with *E. dalrympleana* woodland over a *Leptospermum lanigerum* open scrub. *Acacia pataczekii* was common in the understorey, but may suffer from light competition by the overtopping *Leptospermum*. The density of *A. pataczekii* was greater in areas of canopy gaps, possibly in response to the increased light level. These gaps may be the result of topographic irregularities (e.g. break in slope, occurrence of rock outcrops) or of disturbance to the canopy species. Other species at this site included *Notelaea ligustrina, Telopea truncata, Bedfordia salicina, Tasmannia lanceolata, Lomatia tinctoria, Cyathodes parvifolia, Drymophila cyanocarpa* and *Pimelea drupacea*. The community had not burnt for many years, and occasional falls of the *Leptospermum* kill plants beneath, including *A. pataczekii*. Soil disturbance, probably associated with past selective logging, was evident.

On the north-eastern slope of Ben Lomond, *A. pataczekii* extended over an area of approximately 1.5 km by 2.5 km, varying between 800 m and 1 060 m altitude. A transect of plots was conducted over this altitudinal gradient surveying both the floristic and structural variation (Figure 4.4). The site of highest elevation (1 060 m) comprised a low woodland of *E. delegatensis* (dbh = 0.4 m) with *E. archeri* over a dense 2.5 m shrub layer, a mid dense 1.5 m shrub layer, and the ground almost completely covered in litter or sparse rocks and occasional *Poa* sp. The upper shrub layer was dominantly *Orites revoluta* and *A. pataczekii*, while the lower layer was dominantly *Cyathodes parvifolia*, with *C. glauca, Coprosma nitida* and *Pultenaea juniperina*. Other species included *Pittosporum bicolor, Drymophila cyanocarpa* and *Hydrocotyle hirta*. This site occurred at the top of a break in slope, and sloped gently to the north-north-east.

The next highest site (about 1 030 m) was situated on a narrow terrace with a slope of 4^{o} to the north-east. *E. delegatensis* (dbh = 0.7 m) dominated an open forest with a mid dense *A. pataczekii* shrub layer at 4-6 m, and a very sparse two metre tall shrub layer. Other shrubs included *Pimelea drupacea, Cyathodes parvifolia, C. glauca, Leucopogon collinus,* while other more sparse species included *Drymophila cyanocarpa, Chiloglottis* sp., *Schoenus* sp., *Viola hederacea, Blechnum penna-marina, Hydrocotyle hirta* and *Poa* sp. The ground litter cover was dense.

A site at about 980 m altitude consisted of *E. delegatensis* tall open forest with a mid dense four metre tall shrub layer dominated by *Bedfordia salicina* and *A. pataczekii*. Lower shrubs were very sparse, and much of the ground was covered with litter and occasional fallen timber. The site sloped at 12^{o} with an aspect of

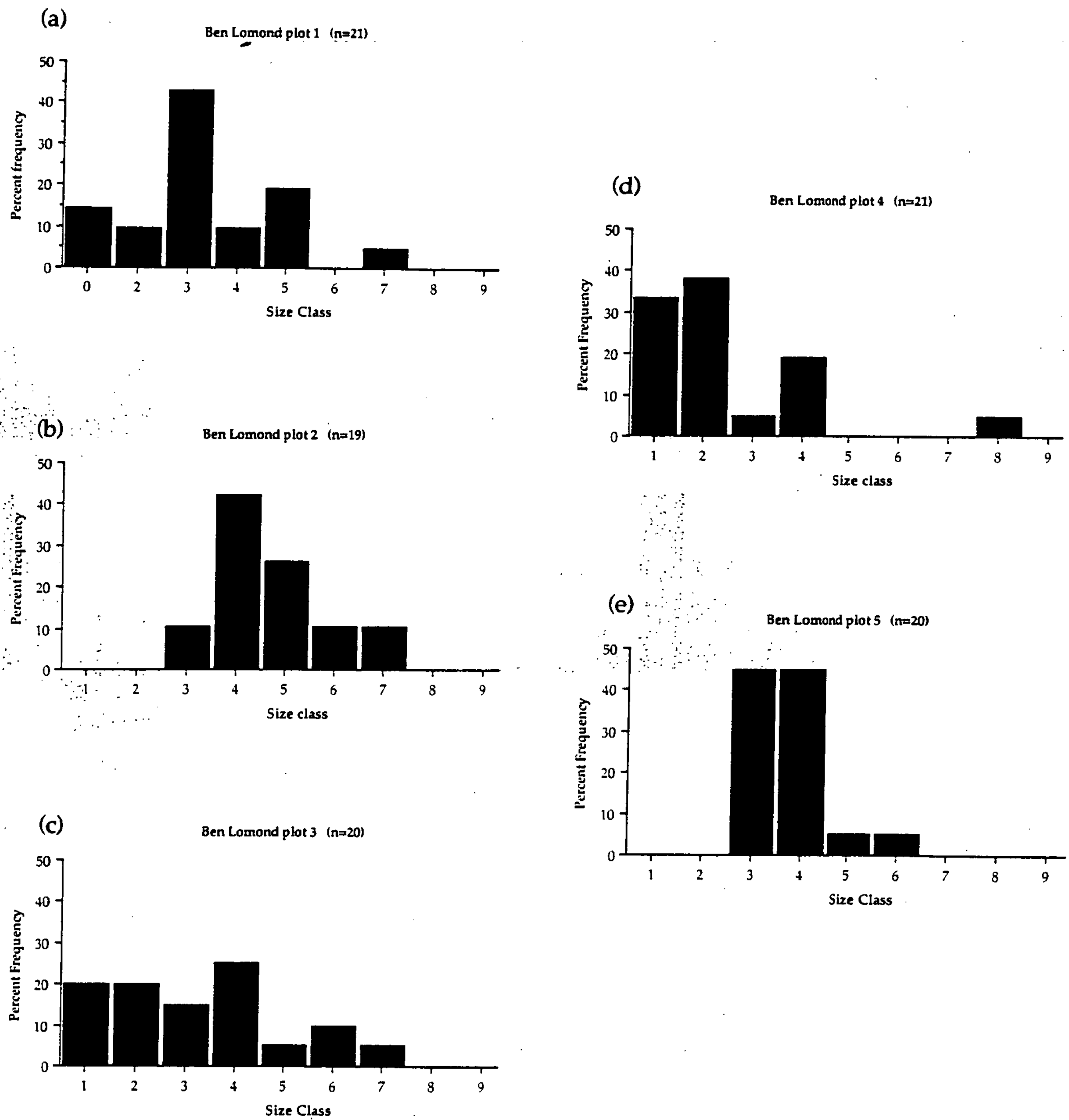


Figure 4.4: **Structural variation using centimetre size classes of *A. pataczekii* along an altitudinal gradient at Ben Lomond: (a) 1 060 m; (b) 1 030 m; (c) 980 m; (d) 920 m; and (e) 810 m.**

about 30^{o}. *Cyathodes parvifolia, Polystichum proliferum, C. glauca* and *Pteridium esculentum* were common, while other species present included *Pimelea ligustrina, Poranthera microphylla, Drymophila cyanocarpa, Hydrocotyle javenica, Geranium* sp. and *Ranunculus* sp.

At 920 m altitude, *Acacia pataczekii* was sparse in a 2-4 m shrub understorey, along with occasional *Bedfordia salicina*, in *Eucalyptus delegatensis* with *E. dalrympleana* tall open forest. A lower shrub layer, at 1.5 m, was moderately dense, and dominated by *Pultenaea juniperina* with sparse *Lomatia tinctoria*. Other species included *Pteridium esculentum, Coprosma quadrifida, D. cyanocarpa, Gonocarpus tetragynus, Poranthera microphylla, Acaena novae-zelandiae* and similar herbs to the previous site. *Leptospermum lanigerum, Telopea truncata, Notelaea ligustrina* and *Tasmannia lanceolata* were local to this site. The site sloped at 10^{o} to the north-east. A shale outcrop was exposed by a road-cutting at 900 m altitude, while the previous sites, above the road, were on dolerite.

The lowest site, at 810 m altitude, was in *E. obliqua - E. dalrympleana* tall open forest, with a moderate to dense four metre tall layer of *A. pataczekii*, and a sparse one metre layer of *Pteridium esculentum, Lomatia tinctoria*, and occasional herbs such as *Chiloglottis* sp., *Viola hederacea* and *D. cyanocarpa* on the densely littered ground. Because this site was on a flat ridgeline below the plateau scarp, it had been logged in the past. The survey site sloped at 2^{o} to the north-west.

The floristic structure of *A. pataczekii* at these transect sites is shown in Figure 4.4. The stem size-class distributions of this transect were characterised by stems between 3-8 cm diameter (Figures 4.4 b, e), or else by a similar distribution but with additional small stems (suckers) of 1-2 cm diameter (Figures 4.4 a, c, d). The first group may reflect even-aged post-fire regeneration. The presence of suckers in the second case indicates subsequent population growth, possibly in response to increased light due to canopy disturbance.

Two other sites have been recorded from Roses Tier in the last twenty years: one on a ridgeline near Gunns Road, the other on a creek gully slope south of Gunns Road. Few details were recorded: the latitudinal - longitudinal co ordinates. A note with the latter collection stated that the *Acacia* was five metres tall, and locally common. These two sites were not relocated during this study.

Table 4.1: Summary of habitat records and conservation information for *A. pataczekii.*

Recent Records:	10 sites recorded, (8-) 10 extant	
Habit:	Tall shrub or small tree to 6 m height, with obliquely elliptic, glabrous and glaucous phyllodes with apiculate or mucronate apices	
Population Size:	> 1 000 *	
Regeneration:	Type:	Vigorous suckering from rhizomes up to 10 m from main stem
	Observed?:	Observed at all sites
Habitat:	Landform:	Moist gullies and flats, mountain summits, slopes and plateau scarps
	Altitude:	(525 - 700 -) 810 - 1 060 m
	Aspect:	(North-west -) North to South-east
	Slope:	0 - 12°
	Community:	Low woodland to tall open forest of *Eucalyptus delegatensis, E. dalrympleana (E. sieberi, E. obliqua, E. archeri)* with open heath to shrubby understorey dominated by *Acacia pataczekii, Pultenaea juniperina, Cyathodes parvifolia, Leptospermum* spp.
Fire response:	Fire not required for germination, moderate germination after cool to hot fires (see Section 4.5) Recovers from root shoots after soil disturbance and basal shoots after fire (Kirkpatrick *et al.* 1980)	
Conservation Status:	Proposed:	**Rur1**
	Current:	**Rur2** (Kirkpatrick *et al.* 1991b); **2R** (Briggs & Leigh 1988)
Reserve:	-	
Comment:	*Vigorous rhizomatous resprouting makes distinguishing separate genetic individuals very difficult Often in areas with complex geologies, and on the boundaries between two lithologies. They are also areas of moderate to high rainfall, varying from sites with more than 750 mm p.a. to sites with up to 1 500 mm p.a.	

4.4 Phenology

Little is known about this species, it having only being recognised as distinct in 1970 (Stones & Curtis 1978b). Literature references to the phenology of *A. pataczekii* are summarised in Table 4.2. Blombery (1967), as previously with *A. axillaris* (Section 3.4), gives a long flowering period for *A. pataczekii.* Stones and Curtis (1978b) collected flowering specimens from Tower Hill on 10th of October, 1974, but maintain that flowers open early in spring. They collected fruit from Roses Tier, 3rd of March, 1975, and observed that developing fruits were frequently infested by small larvae. Fertile specimens held at the Tasmanian Herbarium were collected, for specimens in bud: January 1970, 11th of June, 1972, 5th of September, 1976, 31st of May, 1978, 9th of May, 1980, 24th of February, 1982; for flowering specimens: October 1972, 2nd of October, 1973, 31st of October, 1974, 20th of October, 1984; for fruiting specimens: 17th of November, 1972; while vegetative specimens were collected: November 1976. Few mature pods have been collected (Stones & Curtis 1978b). Kirkpatrick *et al.* (1980) state that *Acacia pataczekii* regenerates from basal resprouts after fire and from rhizomes after soil disturbance.

In spring, 1990, *Acacia pataczekii* began flowering in mid September (Table 4.3). Buds had largely formed during the end of the previous fruiting season. Flowering occurred until about mid November, with fruit observed in early

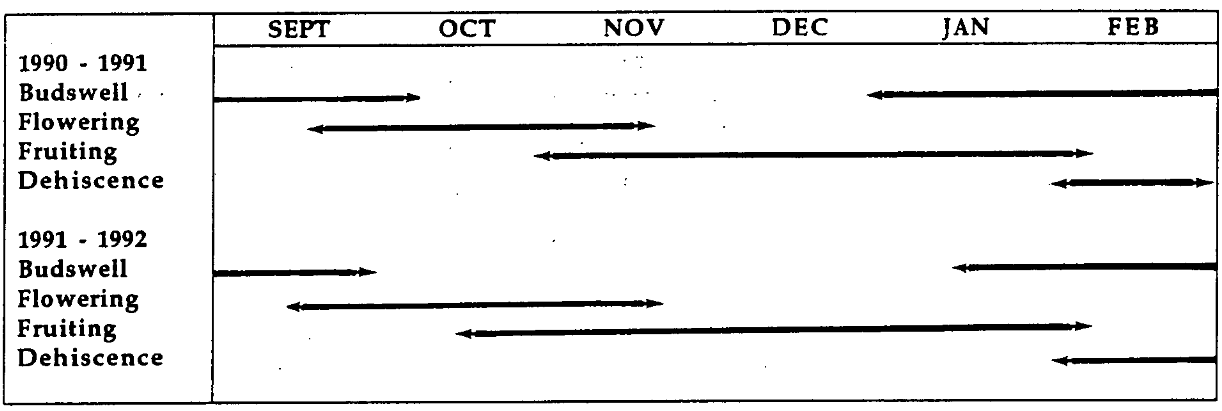
Table 4.2: **Phenology of *A. pataczekii*, as determined from literature and Herbarium records.**

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Blombery (1967)	FP	F	F	F	F	F	F	F	F	F	FP	P
Cameron (1981), Simmons (1981)										F		
Stones & Curtis (1978b)			P						F	F		
Herbarium records	b	b			b	b			b	F	P	

b Buds present
F Flowering
P Fruit present

development after successful fertilisation of flowers, in early November. The pods and seeds took until early February to develop and ripen, and pods began to dehisce in early February. In 1991 - 1992, the pattern was similar, except that fruiting began about two weeks earlier and the pods began to dehisce about one week into February. At the peak of flowering, 20th of October, 1981, the globular flower heads of *A. pataczekii* were found to contain an average of 13.5 flowers/ head (D. Bashford, pers. comm.).

Table 4.3: **Field observations of phenological activity, spring to summer, 1990 - 1991 and 1991 - 1992, at Tower Hill site.**



The phenological survey showed that the population monitored at Tower Hill had very low seed production. A trial to investigate the low level of fecundity by attempting to increase cross-pollination by manual transfer of pollen had no effect; no seeds were produced on the test shrubs. It is, therefore, implied that loss of a pollinator does not contribute to the low fecundity of this species; many insects, some suitable as pollinators, were observed to be attracted to the flowers. The very low sample, however, due to the very low incidence of fruiting across the population makes comparison difficult. One of the populations at Fingal Tier was also observed to not produce fruit. Only the populations at Ben Lomond and Ben Nevis successfully produced any quantity of fruit, and the most successful shrubs were on the roadside at the latter site. At Ben Lomond, fruit were largely confined to the upper branch tips of the shrubs.

Larvae of a minute gall midge, the cecidomyiid fly, *Asphondylia* sp. (K.M. Harris, pers. comm.), have been recorded as causing galling of flower heads of *Acacia pataczekii* (Elliott & deLittle 1985). Observations by D. Bashford (Forestry Commission, Tasmania) in 1980 indicated that one Cecidomyiidae larva, or rarely two, was present at the base of the gynoecium of an *Acacia* flower soon after flowering, that is, just after the stamens had withered or fallen. Small larval stages were observed and collected on 28th of October, 1980. All gynoecia had larvae at the base, which had either entered the gynoecia or were external. Observations in the 1981 - 1982 season revealed that the larvae enter through the base and cause deformation of the tissue, although the ovule may still develop (D. Bashford, pers. comm.). Several pods were observed which had continued to develop along with a gall at one end or in the centre of the pod. While galling was observed to be abundant, and to damage many pods, it by no means however excluded successful fertilisation of flowers. Galling was still prevalent at the Ben Nevis populations which did produce fruit.

Other damage may be caused to *A. pataczekii* by leaf miners of the Gracillariidae, *Acrocercops* sp. These insects tunnel beneath the outer layer of the leaf (or phyllode) to eat the leaf tissue beneath, causing discoloration of leaf tissue (a silver-white blister) and also reducing the phyllode's photosynthetic capability (Elliott & deLittle 1985). The species pupates in an oval flattened cocoon, either inside or outside the phyllode, and miners of *Acacia, Kennedia, Glycine, Eucalyptus, Typha* and Proteaceae species are known (C.S.I.R.O. 1970). Such leaf mining was observed in June, 1990, at one of the Mt. Foster populations. It was not observed to be common at the Tower Hill, Ben Lomond or Ben Nevis sites.

The extrafloral nectary is a small, multicellular, glandular structure which occurs on a wide range of dicotyledonous plants, including all Australian *Acacia,* which may be strongly scented but devoid of floral nectaries (Knox *et al.* 1986, Marginson *et al.* 1985). In *Acacia*, the extrafloral nectary occurs on the adaxial face of the petiole or rachis, or edge of the phyllode. Some species secrete nectar all year round, and the nectaries are considered to have three possible functions: as minimal ant-guards (to attract ants which defend their food source (and the new growth and reproductive organs) against competitive predators and destructive herbivores); as wasp-guards (as for ants); and for attracting insects, birds and other animals for pollination (Knox *et al.* 1986). In *A. pataczekii,* one, sometimes two and very rarely three such nectaries were observed on the edge of the phyllodes.

Observations of active nectary secretion were made of the sample phenological shrubs at Tower Hill during the flowering season 1990 - 1991, and at fruit ripening in 1992. Activity was noted at all stages of development, from budding - early budburst to pod ripening. Secretion seemed to occur primarily when the weather was clear, and the shrubs were directly exposed to sunlight. This type of weather also corresponds with periods of insect activity (Knox *et al.* 1985). Secretion was predominantly restricted to newly formed or young phyllodes, or those which had been subjected to predation, at or near the end of major branches or branchlets. The phyllodes did not necessarily have an axillary raceme of flowers during floral activity, but were usually near flowers. Six of the sampled shrubs secreted on at least one observed occasion, with particular branches secreting on up to three occasions. Quite often all sampled branches or all sampled branches that secreted on any occasion were observed to all be actively secreting at the same time. This happened to six of the shrubs spread over four occasions. Successful pod production (in 1991, since no fruit were observed at Tower Hill in 1992) did not appear to be correlated with observed incidence of nectary activity, although one branch with fruit had been observed to secrete on two occasions. Secretion may, however, have occurred on the other fruiting branches on other occasions. The two sampled shrubs that did produce fruit in 1991 were recorded to have active nectaries on other sampled branches.

4.5 Propagation

Germination trials for this species included the dry heat trials of two minutes exposure to 100^{o}C, 80^{o}C and 60^{o}C, as well as a scarification trial and control. This species was notable in being one of the few in which there was marked response from the control sample of seeds, indicating that no treatment was necessary for germination of some seeds.

An initial scarification test on fresh seed was conducted prior to the germination trials. All seeds germinated, indicating the high viability of the collected seeds. The germination trials conducted on *A. pataczekii* demonstrated significant variation between responses ($p < 0.0002$, d.f. = 4, F = 62.522). A significant treatment response (Figure 4.5) was gained from the scarification trial (treatment 1: mean 100%), which was greater than all other trials. All other trials did not vary significantly and from each other and formed another homogeneous group (Table 4.4).

Table 4.4: **Scheffe multiple range test of variation between treatment means.**

Treatment	Trial	N	Homogeneous Groups	
2	100°C	60	X	
5	Control	30	X	
3	80°C	60	X	
4	60°C	60	X	
1	Scarified	60		X

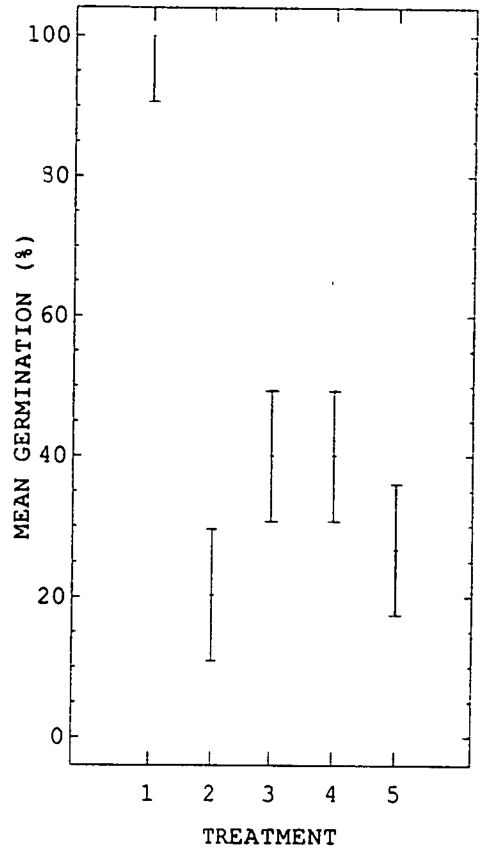


Figure 4.5: **Range of mean results for germination trials with standard errrors.**

Both the heat treatment of 80°C (treatment 3) and of 60°C (treatment 4) effected germination of 40% (mean value for each trial). However, this value was not significantly greater than the untreated control seeds (treatment 5), 26.7% of which germinated. The 100°C pretreatment had the lowest result (treatment 2: mean 20.3%). This low response reflects the high proportion of seed that were killed by this treatment (mean 22%), as indicated by their consequent rapid fungal infection and decomposition. A significantly greater number of seeds were killed by the 100°C trial than by any other trial. This indicates that high temperatures may be detrimental to the seed of *A. pataczekii*.

The rates of germination were also interesting (Figures 4.6 to 4.10). The scarification trial proved very effective, with all seeds germinating within 31 days. The response of seeds to the heat trials, however, was much slower, and occurred throughout the 120 days of the trial.

Propagation using vegetative cuttings of this species was attempted using pretreatment with 2 000 ppm I.B.A. The treatment was not effective, with none of the cuttings surviving. Several transplants of some of the numerous small rhizomes were, however, successful.

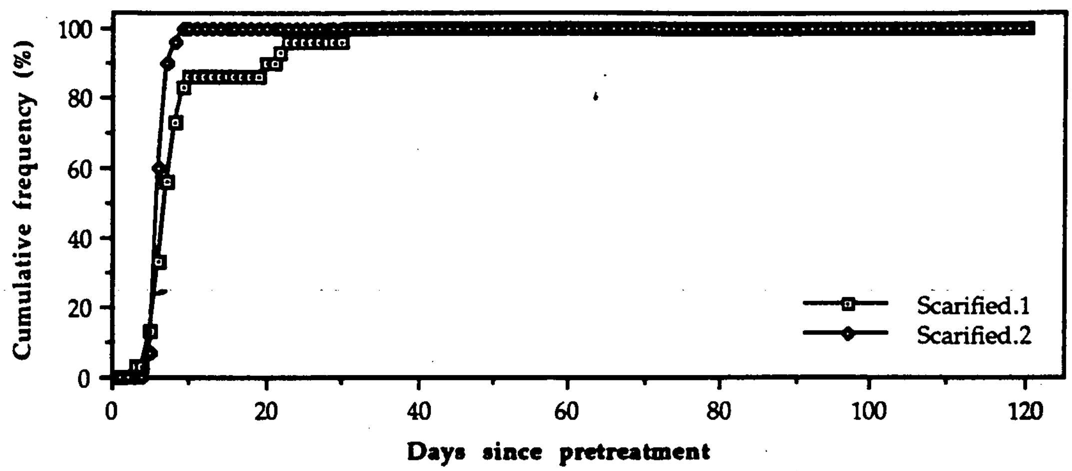


Figure 4.6: Germination response of *A. pataczekii* to scarification pretreatment (groups 1 and 2 represent replicate treatments).

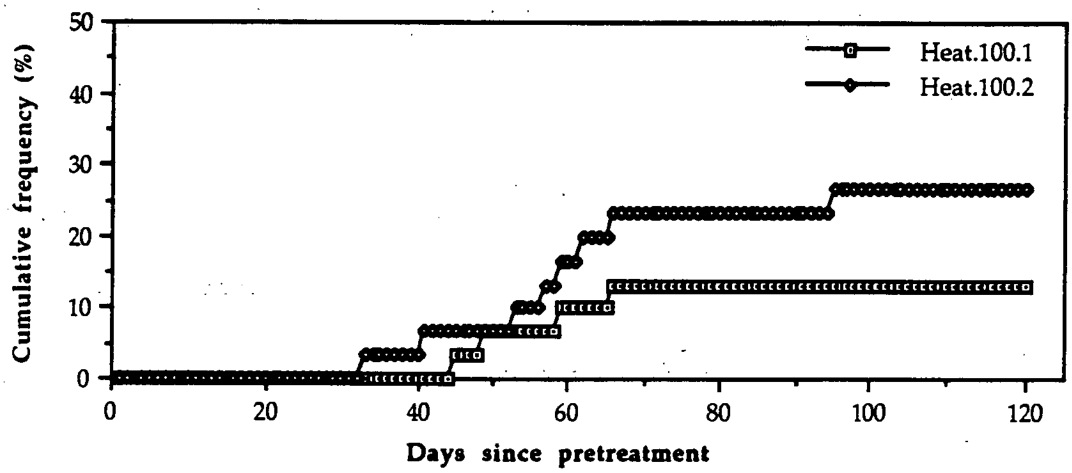


Figure 4.7: Germination response of *A. pataczekii* to pretreatment of 100°C (groups 1 and 2 represent replicate treatments).

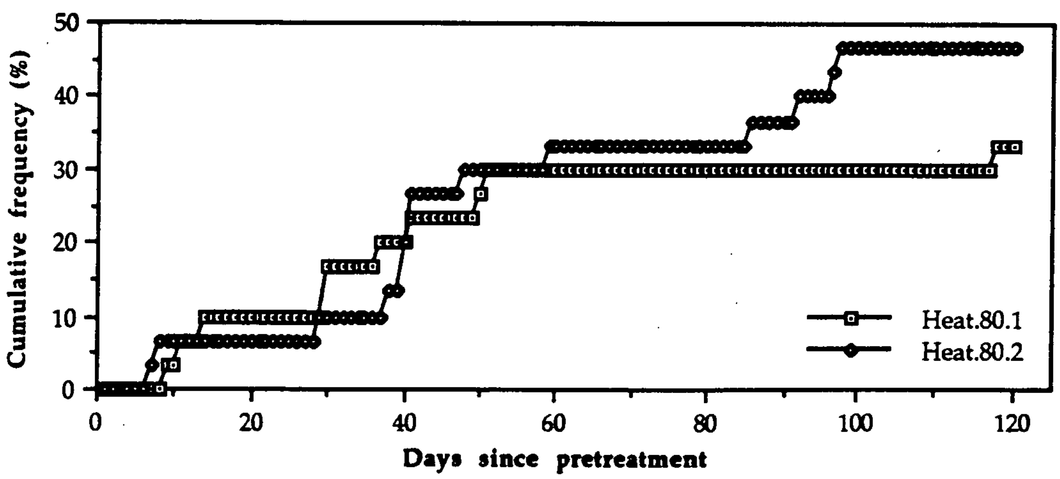


Figure 4.8: Germination response of *A. pataczekii* to pretreatment of 80°C (groups 1 and 2 represent replicate treatments).

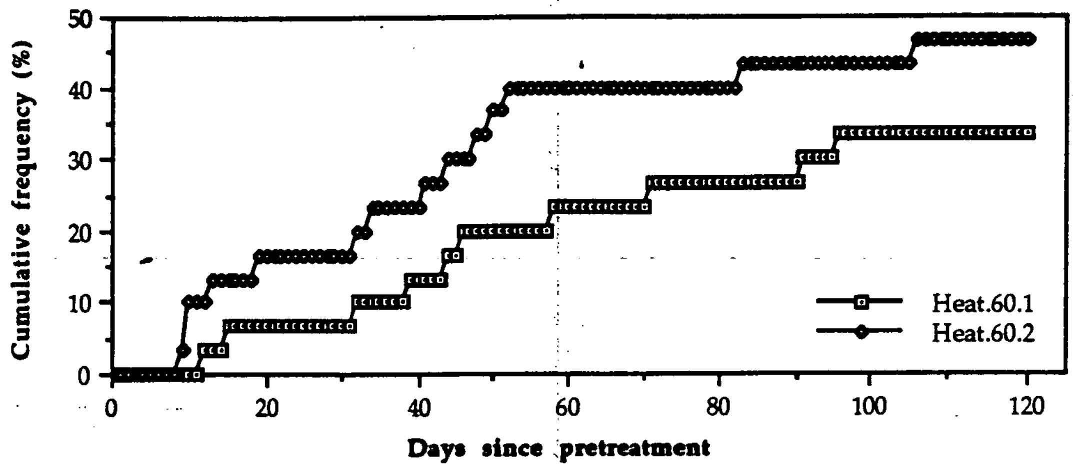


Figure 4.9: **Germination response of *A. pataczekii* to pretreatment of 60°C (groups 1 and 2 represent replicate treatments).**

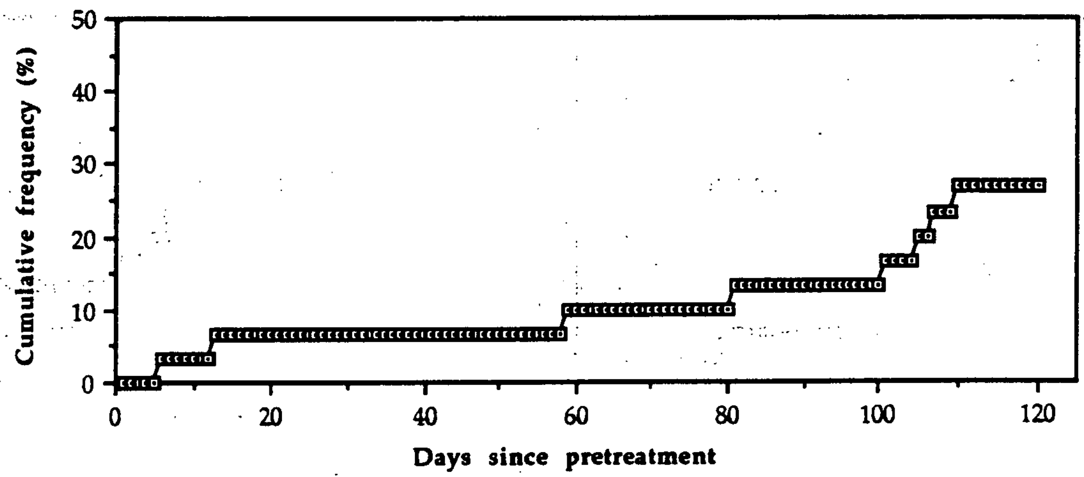


Figure 4.10: **Germination response of *A. pataczekii* to no pretreatment.**

4.6 Pollination

Two hover flies, another diptera, a thrip, and a flower spider were collected from this species when in flower in spring, 1990. The plants at the phenology site, Tower Hill, were observed on three occasions for periods of approximately six hours each. These insects were the most common. The winged insects were all in the locality of the flowers. Flower spiders were very common near the ends of branches and amongst the flowers. Midges were also observed near the shrubs on clear, sunny days. No identifications have yet been returned.

4.7 Discussion

The endemic *Acacia pataczekii* is restricted to the northern part of central eastern Tasmania. Sites are known from areas of medium to high altitude (525 - 1 060 m) on sedimentary, doleritic or granodioritic substrates, usually with shallow or skeletal, clayey soils. Often the sites may be near the boundaries between two lithologies. They occur on gullies and flats, mountain summits, slopes and plateau scarps, usually with a north to south-easterly aspect. The sites are often moist or in areas with a moderately high rainfall regime (750 mm - 1 500 mm p.a.). The occurrence of this species, however, on upslope sites with shallow soils in a part of the State occasionally afflicted by drought, implies a certain level of drought tolerance in some populations. This may be a competitive advantage of a rhizomatous species over obligate seed regenerators.

The two locations of most abundant *A. pataczekii* are at Mt. Foster and on the mid-slopes of Ben Lomond and Ben Nevis extending onto Roses Tier. Both areas have several very dense populations with thousands of "individuals" present. However, the Mt. Foster population appeared to have less variation in population structure, and also did not appear to fruit as successfully as the Roses Tier populations. The Mt. Foster populations also appeared to be the only ones suffering damage by *Acrocercops* sp. leaf miners. However, the actual number of genomes at the populations may differ markedly since the vigorous resprouting of the species (clonal reproduction), even without apparent disturbance, masks the number of genetic individuals. Vigorous suckering from rhizomes was observed at all sites, and noted to occur up to ten metres distance from a main *Acacia* stem.

The population structure analysis indicated that *A. pataczekii* recovers after fires in relatively even-aged stands. Vegetative regeneration may continue, however, in more open sites or those subject to canopy disturbance. This is possibly a response to higher light availability. Reproduction is not confined to vegetative means, since *A. pataczekii* produces a moderate amount of seed which is non-dormant. The non-dormant seed fraction for this species is higher than found for some other *Acacia* species in eastern Australian but within the range of non-dormancy levels found in other genera of Fabaceae (Auld & O'Connell 1991). Because of this level of non-dormancy in the seeds, *A. pataczekii* does not require fire for germination; an obvious and important difference from most of the other legumes considered. There is no easy, non-destructive means, however, of distinguishing taller seedlings from resprouts. Also, heat may be detrimental to the seed, as indicated by the surprisingly low response to the 100^{o}C germination trial and the concordant high proportion of seed that was killed by this treatment. This upper temperature limit is lower than expected, as the lethal temperature for many other leguminous species was found to be 120^{o}C (Auld & O'Connell 1991).

The experimental germination results indicated no significant temperature response, suggesting that fire is not a germination stimulus. The heat trials were only moderately better in effecting germination of *A. pataczekii* seed than no pretreatment. *Acacia pataczekii* does, however, have a very high seed viability (100%), and the 100% response to scarification indicates that it has a physical dormancy. The seed testa of this species is quite thick, and it may be that longer durations of heating are required to effect germination. The germination level of the control indicated no pretreatment is required. However, the positive scarification result suggested that physical disturbance of the ground may promote increased rates of germination. Factors which promote such a stimulus include treefall, mass movement and animal digging. However, scarification may not have a direct ecological analogue in the population dynamics of *A. pataczekii.*

Regeneration at most sites seems related to non-catastrophic disturbance, with most of the sites also subject to past human-induced disturbance. Higher elevation sites suffer wind-throw of canopy species along with tree-fall of over-mature trees, which creates periodic gaps with increased light levels. Such regeneration was evident along the transect up the Ben Lomond slopes. Despite the low levels of fruit produced, there has probably been sufficient seed, especially given long-term accumulation of seed stores in the soil seed bank, to survive occasional hot fires. The species also has the capability to resprout and rhizomatously shoot after cool fires. Such lack of dependence on fire may result in the unusual situation of an *Acacia* species (and mature *Leptospermum)* being part of a late successional dry sclerophyll community with increasing wet forest components *(Bedfordia, Tasmannia, Dicksonia* etc.).

The incidence of regeneration of legumes without obvious firing or disturbance remains problematical. Apparent "soft-seededness" has been recorded for species of *Acacia,* including *A. dealbata, A. melanoxylon* (Lynch, pers. obs.), *A. peuce, A. harpophylla, A. argyrodendron,* and *A. cambagei* (Cavanagh 1987). Notably, these last four species are either species predominantly of semi-arid to arid regions, or species which reproduce primarily by root or stem suckers. Similarly, *A. pataczekii,* a Tasmanian endemic which regenerates largely through vegetative means, has a high degree of soft seededness. At a site in South Africa, four percent of freshly shed seeds of *A. longifolia* germinated immediately on release, with 1.2% surviving and adding to the population (Pieterse & Cairns 1988). This may be an adaption to take advantage of any available microsite of suitable germinable environment. Communities which are less fire and disturbance prone provide fewer opportunities for obligate seed regenerators to germinate, and species which are primarily post-disturbance resprouters also do not need to rely on the longevity and viability of the soil seed bank. These species may consequently have a lesser degree of innate physical dormancy.

The high longevity of legume seed, particularly in *Acacia* species, also contra-indicates a high incidence of "natural" non-fire-related seed softening, unless the species partitions its seed production into both "soft" as well as "hard" seed. In this case, a proportion of the seed actually contributes to a transient seed bank and that year's crop of germinants as well as a persistent seed bank.

The other factor in germination of freshly dispersed seed is that impermeability develops in the last stages of drying out of the seed (Quinlivan 1971), and that immature, "green" seed can give high, although rapidly declining, levels of germination without pretreatment (Cavanagh 1987).

This species appears to regenerate and reproduce more successfully at sites or microsites with greater light availability. These conditions are artificially manifested under selective logging, small scale exploration mining and road construction. Sites are usually close to roads, partly an artefact of where people have easily travelled, but also because of the influence such disturbance has on suckering by the species. Indeed, *A. pataczekii* was noted to flower less and neither fruit nor regenerate beneath a dense *Leptospermum lanigerum* scrub canopy in *Eucalyptus delegatensis - E. dalrympleana* woodland, probably due to competition for light. However, the variable density of canopy cover at the sites and the incidence of tracks results in a variety of light levels. Therefore, inadequate light level is unlikely to be the only factor inhibiting reproduction.

Most of the populations have not been burnt for more than twenty years. The species can resprout after firing and even larger scale physical soil disturbance generated by clear-fell logging of small coupes. Clear-fell logging of larger coupes has not been attempted to date, and recovery of the population would probably depend on the level of soil disturbance and disruption of the rhizomes of the *Acacia*. Post-logging regeneration burns and fuel reduction burns should be avoided. Fire is not required for seed germination and higher temperatures (100°C) may actually kill seeds. Large amounts of logging slash may raise soil temperatures to levels lethal to rhizomes. However, some seed will germinate at higher temperatures and rhizomes should be adequately protected by their soil covering if fuel loads are not high.

The populations at Tower Hill and Mt. Foster had very low seed production. Only the populations at Ben Lomond and Ben Nevis successfully produced any quantity of fruit, and the most successful shrubs were on the roadside at the latter site. Galling of the flower heads by a larvae of a cecidomyiid gall midge has been proposed as the primary factor preventing seed formation in this shrub (Elliott & deLittle 1985). Infestation of the flowers with resultant tissue deformation has been observed, however, the prevalence of galling did not exclude successful fertilisation of flowers. It is not known why the Ben Nevis population was more successful in both seasons. The sites at Ben Lomond and Ben Nevis have higher rainfall but also have greater levels of cold air drainage from the plateau. They probably experience lower temperatures in winter than the sites at Tower Hill and Mt. Foster. It is also possible that the shrubs at the other sites are senescing, with most of the smaller shrubs being vegetative clones. The population at Fingal Tier did not appear to be as old, however, and still showed a lack of reproductive success. The restricted sampling and observations of reproductively active plants and at different populations makes speculation difficult. Assisted cross pollination had no effect, and also implies that loss of a pollinator is not the cause of the low fecundity. Many insects, some suitable pollinators, were observed to feed on the flowers. Successful fruit production did not appear to be related to the timing of flowering, as many other monitored branches and flowers which did not produce fruit appeared to have co-inciding phenological stages. The low fecundity appears, therefore, to be due to a viability problem with the reproductive mechanism.

The importance of the extrafloral nectary to the ecology of *Acacia pataczekii* is also not understood. Boughton (1981) suggested that few ants are actually attracted to the secretions, and Vanstone and Paton (1988) and Knox *et al.* (1985) support a pollination role for the nectaries. The species on which Vanstone and Paton were working, *A. pycnantha,* was found also to have very low rates of pod production, and both pod production and nectary secretion varied considerably between trees. Very few insects were observed on the nectaries, and occasionally the nectaries themselves were subject to predation. Only a few European honey-bees *(Apis mellifera)* were actually observed near flowers of *A. pataczekii.* They were also observed near a tree which was in a very early stage of budburst. The co-incidence of timing of secretion across the sampled branches implies that the process causing secretion applies to the whole tree, rather than being isolated to the particular branch. The relation to sunlight may infer that water stress affecting the entire plant leads to increased osmotic potential of the cells with associated sugar increase and release. Comparison of the activity of the Ben Nevis populations, possibly throughout the year, would be required to determine if extrafloral nectaries are at all related to the success of those populations. At Tower Hill, flowers were open between mid September and mid November, with fruit developing until early February. Nectaries were observed to be active throughout the flowering and fruiting stages, even in 1991-1992 when fruit was extremely rare.

5. *ACACIA RETINODES* Schlecht. (Wirilda)

5.1 Morphology (from Curtis & Morris 1975, Costermans 1983 and pers. obs.)

Acacia retinodes is a tall, glabrous shrub or small tree with reddish, angular branchlets and erect or spreading phyllodes. The phyllodes are narrow-linear or oblanceolate, often ashen-green and smooth, 6-12 cm long and 3-15 mm broad (Curtis & Morris 1975). The phyllode is broadest beyond its middle, while the apex is blunt, usually recurved, and ends in a short, hooked point. It has one main central vein, and either lacks a gland or may have one near the phyllode base. The flowers, of small, bright yellow, spherical heads, occur in short, axillary racemes. The pods are brown, thin, straight and flattish, 6-20 cm by 6-10 mm. The seed has a reddish funicle which encircles it twice (Costermans 1983).

Costermans (1983) recognises two varieties of *A. retinodes:* var. *retinodes,* which has larger phyllodes (8-18 cm by 5-15 mm); and var. *uncifolia,* whose foliage is smaller (3-6 cm by 4-6 mm). The morphology of specimens that I collected from Flinders Island fitted better with the smaller dimensions of var. *uncifolia,* being between 3-6.5 cm by 4-7 mm. Costermans also differentiates on flower colour: var. *retinodes,* with pale-yellow; var. *uncifolia,* with rich-yellow; as well as stating that it is only the latter variety which has the hooked apex. These characteristics, the rich-yellow flowers on specimens I collected, and the restriction of the species on Flinders Island to calcareous soils (Section 5.3), all suggest that it is *A. retinodes* var. *uncifolia* that is present in Tasmania.

5.2 Distribution and Rarity

A. retinodes is widespread in Victoria, South Australia, and the Bass Strait Islands (Figure 5.2). Galbraith (1977) also lists this species as present in N.S.W. The var. *retinodes* (Costermans 1983) occurs on poorly drained sites of Western Victoria and south-eastern S.A., especially the Mt. Lofty area; while var. *uncifolia,* has a more restricted distribution; in Victoria, in coastal areas of Wilsons Promontory, the south-eastern and south-western edges of Port Phillip Bay; and, in S.A., in the south-eastern coastal areas of the Southern Lofty Ranges, the Yorke Peninsula and the Eyre Peninsula, predominantly on calcareous sands.

Figure 5.1: Morphology of *Acacia retinodes* var. *uncifolia* (from Simmons 1988).

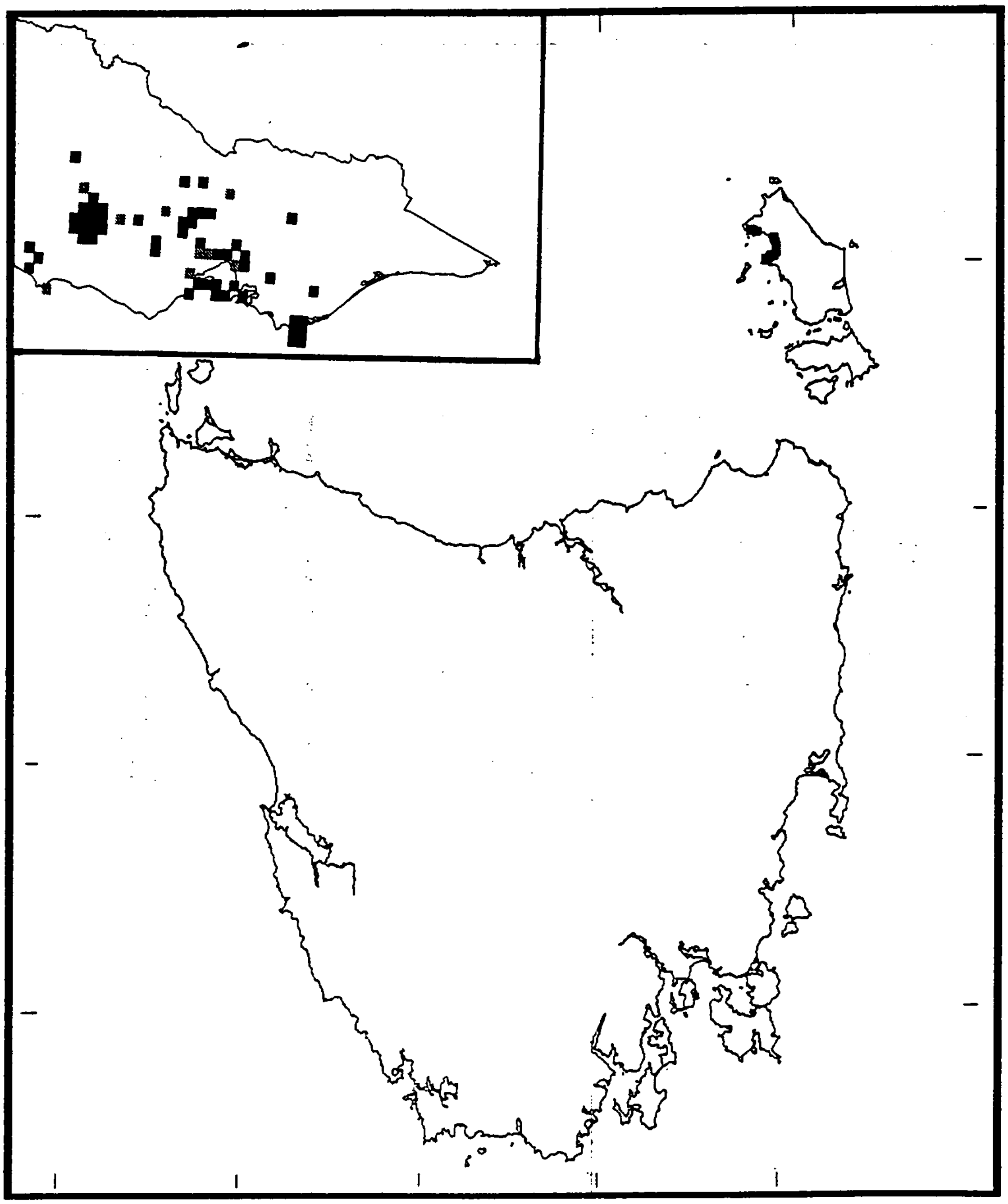


Figure 5.2: **Distribution map of recently confirmed populations of *Acacia retinodes* var. *uncifolia* in Tasmania and Victoria.**

Acacia retinodes is confined, in Tasmania, to Flinders Island. On Flinders, *A. retinodes* may be found at Killiecrankie Bay (P. Barker, pers. comm.), in the Emita district, at Wybalenna and the local coastal scrub, and to the north along the Palana Road, and the West End Road near Leeka. The total number of individuals at these populations was estimated at several thousand plants. At the species level, *Acacia retinodes* is quite common in southern Victoria and S.A. The variety *uncifolia,* however, is much more limited in abundance and extent.

A. retinodes is listed as **url** in the list of the reservation and conservation status of Tasmanian native higher plants (Kirkpatrick *et al.* 1991b). The species does, however, occur in several small reserves on Flinders Island: the Wybalenna Historic Site, and the coastal reserve west of Wybalenna, the narrow coastal reserve to the north-east of Cave Beach, Port Davies, and on the foredunes of the coastal reserve near West End.

5.3 Habitat

While quite a few records can be found for *A. retinodes* on Flinders Island (Table 5.1), the sites were confined to the coastal periphery of Marshall Bay, an area of 14 km north-south and 12 km east-west. The sites were less than two kilometres inland, and comprised variants of coastal heath communities. The distribution was restricted by the extent of the Pleistocene calcareous limestone-based soils, and hence to the central- and north-western coastal areas of Flinders Island where these soils occur.

One of the oldest sites was a closed *Leptospermum laevigatum* scrub with occasional *A. retinodes* and *Eucalyptus globulus* at the same height, as well as occasional *Allocasuarina verticillata* emergents. The site occurred south-east of Leeka, several kilometres north-west of Marshall Bay, on a spur with northern aspect and altitude of 40 m, and sloping 5-6^{o} towards the coast, 500 m away. The *Leptospermum* at the site had diameters up to 0.1 m, and there were several unburnt stags both lying on the ground and still standing. *A. retinodes* was common in this area in the scrub adjacent to the road. Farther west from this site, *Acacia retinodes* was part of a dense, but lower (two metre tall), coastal scrub dominated again by a moderate cover of *L. laevigatum*, as well as *Beyeria leschenaultii, Olearia axillaris, Leucopogon parviflorus, Pimelea serpyllifolia* and *Correa reflexa.* This site was on a south-westerly slope, of 5-6^{o}, and only 30 m from the high-tide line. There was no recent evidence of firing, but much disturbance from vehicles and strong exposure. Twenty-one *A. retinodes* plants were seen, and rhizomatous suckering was also observed. Patches of very dense older remnants were found along fencelines in the vicinity and in other uncleared areas.

A. retinodes was scattered through the heathy scrub to the east of Marshall Bay. This area was all on fine calcareous sands, some up to ten metres in depth, and underlain by limestone or granite. The dominants generally were *Leptospermum laevigatum, Allocasuarina verticillata, Banksia marginata, Beyeria leschenaultii, Correa reflexa, Acacia sophorae, Leucopogon parviflorus* and occasional *Bursaria spinosa. A. retinodes* was found in similar heaths near Emita, Port Davies and Wybalenna.

At Port Davies, at the southern end of Marshall Bay, approximately 20 *A. retinodes* individuals were observed within the Crown Reserve. The plants occupied the back-wall of the beach, that is, the very steep (60°) front of the primary dune approximately three metres from the high tide line and five metres vertically above. *A. retinodes* was suckering across the slope, large patches of which were bare. The low open scrub contained the local coastal species: *Correa alba, Acacia sophorae, Pimelea serpyllifolia, Leucopogon parviflorus, Calocephalus brownii, Disphyma crassifolium* and *Allocasuarina verticillata.* The site had an aspect of 340°.

West of Wybalenna and to the south and south-west of Port Davies, *Acacia retinodes* occurred in heathy communities with *Eutaxia microphylla* (Section 8.3). These areas had been severely disturbed; one by clearing and grazing, the other by burning and exposure to saltspray and on-shore winds. Both of these sites were within the Wybalenna Historic Site. The first of these two sites occurred in the saddle between two low hills, and was fairly flat, sloping gently to the west-south-west. It was dominated by a low open woodland of very sparse *Allocasuarina verticillata,* with *Pimelea serpyllifolia* forming a secondary sparse layer (1.5 m), along with *Leptospermum laevigatum* (5 m) and *Acacia retinodes* (2.5 m). This area did not appear to have been recently burnt, some of the *Leptospermum* reaching 0.2 m in diameter, although the soil was charcoal-rich. *Eutaxia microphylla* was an occasional component of the ground layer. Two 0.1 m suckers of *Acacia retinodes* were observed. The second site (Figure 5.3) had patchy areas of blackened tussock grasses, large expanses of bare ground, and several *A. retinodes* germinants. This low shrubland was more coastal in composition and structure, with *Correa alba, Leucopogon parviflorus, Beyeria leschenaultii* and *Myoporum insulare* present, while *Leptospermum laevigatum, Calocephalus brownii, Helichrysum paralium, Carpobrotus rossii* and *A. sophorae* occupied the unburnt areas. *A. retinodes* was occasional in both burnt and unburnt areas. The site was on a slope ($5\text{-}6^{\circ}$) facing the ocean, and with a north-western aspect. The soil comprised fine sands underlain by limestone.

Eutaxia microphylla was present, predominantly in eroded patches. It also occurred beneath a stand of *Allocasuarina* 150 m to the south-west.

Another site containing quite old specimens of *A. retinodes* was observed on a north-west facing site near the top of the hill to the west of Wybalenna. This community was a low open forest of *Allocasuarina verticillata,* with almost completely bare ground beneath. *Acacia retinodes* was scattered in occasional patches of open ground. There was no sign of recent fire within this area.

Figure 5.3: ***Acacia retinodes* var. *uncifolia* at Settlement Point, Flinders Island (centre background; *Eutaxia microphylla* in foreground).**

Table 5.1: Summary of habitat records and conservation information for *A. retinodes*.

Recent Records:	16 Sites recorded, 15 extant	
Habit:	Small tree/ tall, single stemmed shrub, up to 5 m	
Population Size:	> 1 000	
Regeneration:	Type:	Seed germination, Rhizomatous resprouting
	Present:	Sprouting at most sites, germination post-fire
Habitat:	Landform:	Gently sloping coastal sand-plain to very steep foredunes and hill and ridge slopes
	Altitude:	Sea-level to 45 m a.s.l.
	Aspect:	South-west (225^{o} - north (360^{o})
	Slope:	2 - 6^{o} (- 60^{o})
	Community:	Coastal heathy communities; from low shrubland, to closed scrub, and low, open woodland; dominants: *Allocasuarina verticillata, Leptospermum laevigatum, Correa alba, Acacia sophorae, Beyeria leschenaultii, Pimelea serpyllifolia*
Fire response:	Seed germination, probable resprouting from "cooler" fires	
Conservation	Proposed:	**r1**
Status:	Current:	**ur1** (Kirkpatrick *et al.* 1991b)
Reserve:	Wybalenna Historic Site	
Comment:	Tasmanian representatives probably of var. *uncifolia*, with distribution coastal and restricted in Victoria to Wilsons Promontory and Port Phillip Bay; and, in SA, to the Southern Lofty Ranges, the Yorke Peninsula and the Eyre Peninsula, predominantly on calcareous sands.	

5.4 Phenology

Flowering time of *A. retinodes* is quite variable (Blombery 1967, Galbraith 1977; Table 5.2). It is an activity predominantly of spring to summer (Costermans 1983), with all stages of floral development apparent at one time (Knox *et al.* 1989).

Table 5.2: Phenology of *A. retinodes*, as determined from literature and Tasmanian Herbarium records.

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Blombery (1967)	PF	F	F	F	F	F	F	F	F	F	FP	P
Galbraith (1977)	F	F	F	F	F	F	F	F				F
Costermans (1983)	F	F							F	F	F	F
Knox *et al.* (1989)	F	F									F	F
Lynch (pers. obs.)				F								
Herbarium records	F		F						b			F

b Buds present
F Flowering
P Fruit present

In Tasmania, the more southerly latitude would be expected to encourage a later flowering and fruiting time than has been recorded for Victorian populations. Flowering was apparent on some trees on Flinders Island in early April 1991. Other flowering specimens from Tasmania held at the Tasmanian Herbarium were collected 6th of March 1845, 1st of January 1978, and an early flowering specimen of 7th December, 1982. One specimen in bud was collected 22nd September, 1990. These records would seem to indicate that the Tasmanian populations are summer to mid-autumn flowerers. No fruiting material has been collected. The stigma of *A. retinodes* is receptive from the moment the flower opens, and effective pollination may occur from this time onward (Knox *et al.* 1989). Cross pollination is essential for seedset, since this species is highly self-incompatible (Kenrick & Knox 1989).

5.5 Discussion

Tasmanian *Acacia retinodes* have been shown to belong to the variety *uncifolia.* This variety has smaller foliage, rich-yellow flowers, and a hooked apex. It is represented in coastal areas of southern Victoria and of south-eastern South Australia, predominantly on calcareous sands. This edaphic restriction is similarly manifest in Tasmania, where this species is confined to Flinders Island, also on coastal, calcareous soils. On Flinders Island, *A. retinodes* is largely confined to the coastal periphery of Marshall Bay, an area of 14 km north-south and 12 km east-west, with some populations also at Killiecrankie Bay. The sites are less than two kilometres inland. This distribution accords with the distribution of near-coastal, Pleistocene, limestone-based soils.

A. retinodes occurs in Tasmania in communities varying between low shrubland to closed scrub and low, open woodland. These communities are usually dominated by *Allocasuarina verticillata, Leptospermum laevigatum, Correa alba, Beyeria leschenaultii* and *Acacia sophorae. Acacia retinodes* is common throughout these communities on calcareous sands, but is only reserved on Flinders Island in several small reserves and narrow, coastal reserves. Large areas of heath on Flinders Island have been cleared, while much of the remainder is grazed and frequently burnt (Kirkpatrick 1977). Habitat of *A. retinodes* has been lost due to clearing and subdivision, with much of the remainder being along roadsides or on private land; areas vulnerable to fire and damage from recreation activities. Some degree of disturbance may, however, be beneficial for regeneration by this species. It was observed to sucker in foredune communities prone to blowouts as well as in some areas where tracks had been cut through the heath.

Fire is part of the ecology of this species. Most communities were mature and were composed of species adapted to a regime of occasional firing. *A. retinodes* should resprout after moderate burns, with seed regeneration occurring also. However, while the species may persist in areas which are frequently burnt, it is not known for how long it can survive in such conditions, that is, whether the species can survive long term with only vegetative regeneration. Longer fire intervals with moderate to hot temperature fires are probably required to enable regeneration from seed.

6. *BOSSIAEA OBCORDATA* (Vent.) Druce (Spiny Bossiaea)

6.1 Morphology (from Curtis & Morris 1975, Woolcock 1991 and pers. obs.)

Bossiaea obcordata is a small, rigid but twiggy and prickly shrub. In Tasmania, it takes a prostrate form; in contrast to the populations in Victorian and N.S.W. which are morphologically similar but with an erect habit. The branches are pubescent and spreading, ending in spines. It has small, broadly obcordate or obovate leaves, blunt with a slightly recurved tip, or emarginate. The leaves are alternate, 2-6 mm long and wide, glabrous above and with scattered hairs below. The flowers are greyish-yellow with a reddish back, and are solitary or paired in the axils of upper leaves. They are small; to five millimetres long. The fruit consists of a tough, flat, glabrous to pubescent pod, up to 15 mm long and five millimetres broad, which dehisces unsynchronized along both sides. Each pod contains 2-3 light brown, reniform seeds of 1.5-3 mm by 1-1.5 mm.

The morphology of this species is typical of its genus, which is typified by shrubs with small, simple leaves, often reduced to small scales or absent, and with flattened or winged stems, which are sometimes spiny.

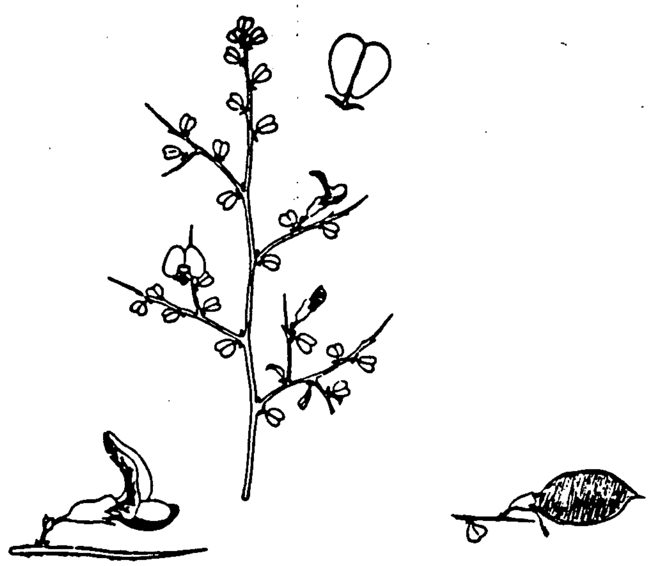


Figure 6.1: Morphology of *Bossiaea obcordata* (from Woolcock 1991 and Costermans 1983).

6.2 Distribution and Rarity

Bossiaea obcordata is a species widely distributed in temperate mainland Australia; being represented in Victoria (Figure 6.2), in the Melbourne region (*sensu* Beauglehole 1980) and throughout the south-east and alpine regions (*sensu* Beauglehole 1980), and in N.S.W., through the coastal and tableland regions, as well as in the Warrumbungles, in the North-Western Slopes (Jacobs & Pickard 1981). Both Willis (1972) and Harden (1991) list the species as also present in Queensland, and the Australian National Botanic Gardens record it from the Wallangarra area of Queensland.

In Tasmania (Figure 6.2), the real extent of this species has only become apparent during the course of this project. In fact, prior to discovery of the Cox 10 population at Tower Hill in 1971, the species had only previously been collected once, from "rocks near New Norfolk" by L. Rodway in 1898; taken to be "The Rocks" (Curtis & Morris 1975). Recent searches have not been successful in relocating the species in the New Norfolk district (F. Duncan, pers. comm.). At the commencement of this study, this plant was only known from one extant population in Tasmania, the Cox 10 site of approximately 50 plants. Since then, it has been discovered at seven more locations. Three of these sites are within the Tower Hill dry sclerophyll system: one within 2.5 km of the Tower Hill site, on the Golden Gate Road; and two sites at the southern end of Tower Hill Road. One population occurs south-west of Mangana, in a very similar community to the Tower Hill populations. Two of the other sites are at Fingal Tier: one approximately 20 km south-east of Tower Hill at Fehres Marsh, the other 15.5 km south at Barway Spur; while the last site is 30 km north-east of Tower Hill, in State forest west of Upper Scamander.

The estimated total number of plants at these sites is greater than 1 000 plants. The Golden Gate population is the largest, comprising approximately 1 000 plants in itself. The plants are healthy, and were observed to produce a large quantity of seed in 1991. The Cox 10 population consists of less than 45 plants, many of them suffering from increased grazing pressure from native wildlife which have lost their habitats as a result of felling of local corridors of remnant *Eucalyptus*-dominated vegetation. The position of this population within a radiata pine dominated area exacerbates the problem due to the local sparsity of edible vegetation. The other populations, while healthy, each consist of less than 100 plants. One of the sites at the southern end of Tower Hill Road consists of only a few scattered plants (M. Neyland, pers. comm.).

Bossiaea obcordata is accorded a conservation and reservation status of vulnerable and unreserved (**uv**) by Kirkpatrick *et al.* (1991b). This classification was based on the knowledge of only two of the newly discovered populations. However seven sites are now known, and there is a strong possibility of finding more in State forests of the Fingal - Scamander district.

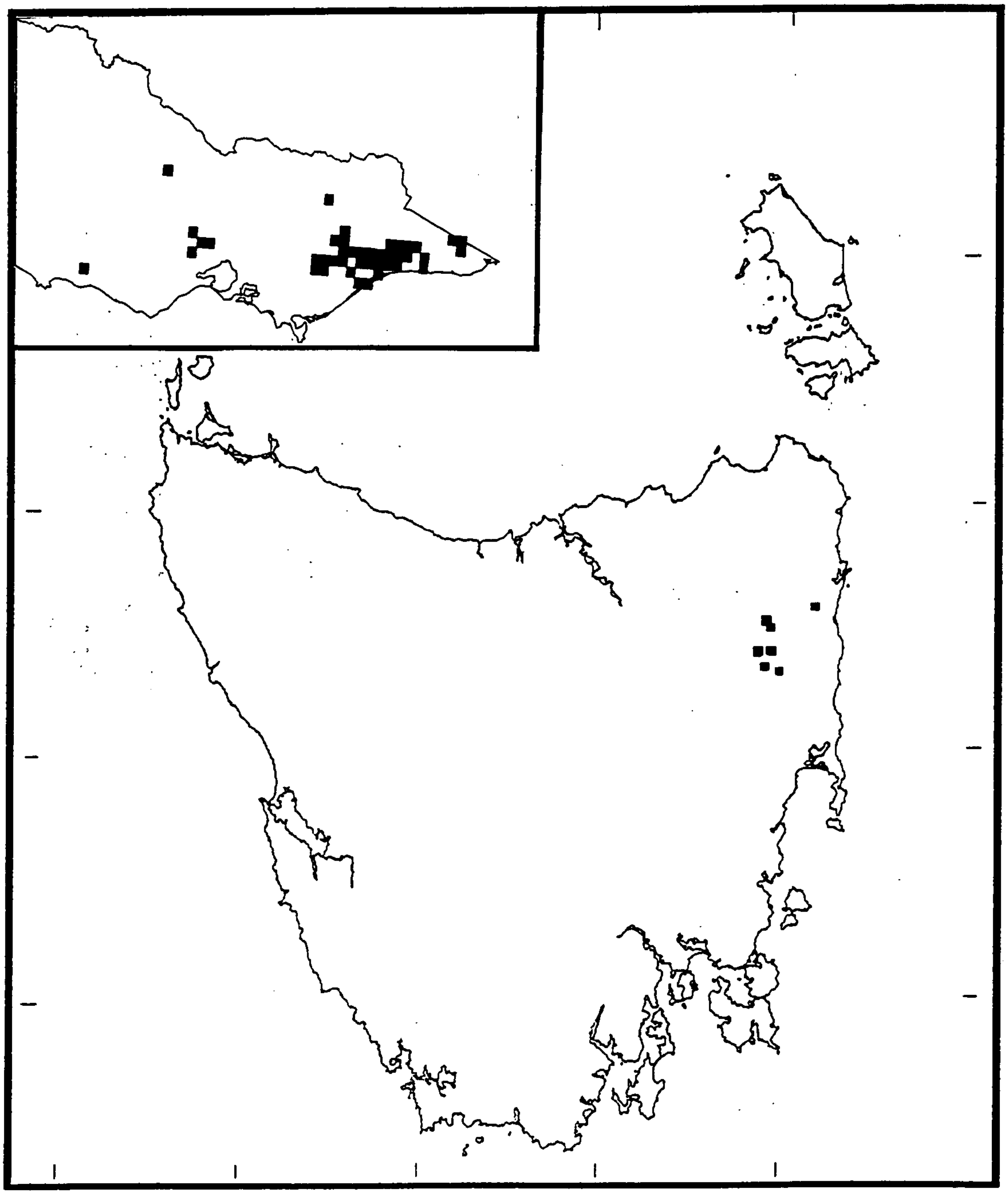


Figure 6.2: **Distribution map of recently confirmed populations of *B. obcordata* in Tasmania and Victoria.**

6.3 Habitat

Several references refer to the habitat of this species. Galbraith (1977) states that *B. obcordata* occurs in forests, usually dry, often hilly "coastal" regions of Victoria and south-eastern New South Wales. Costermans (1983) agrees that it is a "near-coast" species, mostly on sandy or rocky soils. The preference for sandstone-based soils is supported by Harden (1991), who also describes the species as widespread in N.S.W. in dry sclerophyll forest and heath. Willis (1972) reports it to be an uncommon species in Victoria.

Most Tasmanian populations of *B. obcordata* occur on a substrate of siliceous Cambrian Mathinna shales, however, one site is known from dolerite. The sediments are themselves restricted in distribution, to the north and north-east of Tasmania, and it is probably a similar restriction of low nutrient, drought-stressed sites which confines the species to coastal Victoria and N.S.W. The plant community on such sites is primarily *Eucalyptus sieberi* dry sclerophyll woodland with a sparse heathy ground cover.

The population on the Golden Gate Road (Figure 6.3) was midslope on a steep (10-15^{o}), north-west facing ridge-side, the population not extending below the break in slope at the base of the ridge. It is burnt at approximately five year intervals in fuel reduction burns by the Fingal district of the Forestry Commission, who manage all sites where the *Bossiaea* occurs in Tasmania. The site was burnt about 1984 (M. Miller, pers. comm.), and most of it was burnt in 1991. The area supported *E. sieberi* woodland over a sparse cover of *B. obcordata*, along with scattered individuals of *Acacia terminalis, A. dealbata, Daviesia ulicifolia, Stylidium graminifolium, Epacris impressa, Gonocarpus tetragynus, Tetratheca glandulosa, Amperea xiphoclada* and *Lepidosperma lineare.* The soil was skeletal and clayey, with a surface layer of fragmented shale clasts usually less than 0.2 m across. The shales were very weathered and brittle. They are derived from the early Devonian - Silurian Mathinna quartzwacke turbidite sequences of interbedded sandstone, siltstone and mudstone.

The Tower Hill Road sites were similarly on Mathinna shales, and were last burnt approximately seven years ago. They were south- to north-westerly (225^{o}, 310^{o}) in aspect, and quite steep (12^{o}), being upper slope positions. Both sites supported *E. sieberi* woodland with occasional *Allocasuarina littoralis,* over *Acacia terminalis, Pultenaea gunnii, Daviesia ulicifolia, Dianella revoluta* and *Gonocarpus tetragynus.* One of the sites had only a few scattered *Bossiaea.*

Figure 6.3: Typical habitat of *B. obcordata;* Tower Hill.

The Barway Spur population again was located on a rocky, skeletal slope (14^{o}) with much bare ground, and a westerly aspect (240^{o}). It was burnt approximately ten years ago, and had a sparse ground cover of only 40% in total.

The Scamander site was close to sea-level (60 m a.s.l.), well below most of the sites in elevation (360 - 520 m a.s.l.), although it was still nine kilometres west of the coast. It occupied the lower part of a broad north to north-westerly ridgeline. The gradient varied between 3-8^{o}, and the Mathinna sediments underlay a skeletal soil which was gravelly and had a high proportion of bare ground (50%). The site was an *E. sieberi* heathy woodland regenerating after logging in 1984. The *Bossiaea* cover was less than 2%, but the plants were healthy and scattered across the ridgeline, particularly the drier upper part. Logging slash had protected some of the *Bossiaea* from grazing. Other heath components were *Acacia genistifolia, Pultenaea gunnii, Hibbertia empetrifolia, Astroloma humifusum, Amperea xiphoclada, Xanthosia pilosa* and *Gonocarpus tetragynus.*

The exception in habitat categorisation of *B. obcordata* was the population at Fehres Marsh, Fingal Tier. This site differed from the others in being an *E. delegatensis* woodland, as well as being on a substrate of Jurassic dolerite. It was also the highest in elevation (670 m a.s.l.), being 150 m above the range of the majority of sites (360-520 m a.s.l.). The site also was not very steep ($3\text{-}4^{o}$), being in the woodland marginal to the marsh community. There was a high percentage of rock present at the ground surface, and a predominantly low (less than one metre tall) heathy understorey, characteristics typical of all sites.

Table 6.1: Summary of habitat records and conservation information for *B. obcordata*.

Recent Records:	10 Sites recorded, 10 extant	
Habit:	Prostrate prickly under-shrub with spinous branch ends	
Population Size:	> 1 000 plants	
Regeneration:	Type:	Seed germination, Basal resprouting
	Observed?:	Limited germination; post-fire resprouting observed
Habitat:	Landform:	Ridgeslopes, marsh bowl boundary (1 site)
	Altitude:	60 m (1 site), 360 - 520 m (8 sites), 670 m (1 site)
	Aspect:	SW (225^{o}) - N (0^{o})
	Slope:	3 - 25^{o}, (10 - 15^{o} for 5 sites)
	Community:	Predominantly *Eucalyptus sieberi* dry sclerophyll woodland with sparse heathy ground cover, site at highest elevation in low, heathy *E. delegatensis* woodland
Fire response:	Resprouting after firing observed, germination possible, germination after disturbance observed (Section 4.2.3)	
Conservation Status:	Proposed:	**url**
	Current:	**uv** (Kirkpatrick *et al.* 1991b)
Reserve:	-	
Comment:	Predominantly restricted to steep slopes on skeletal, siliceous Cambrian Mathinna shale based soils in sparse low heath under *E. sieberi;* population at Fehres Marsh varies in being the highest in elevation, in *E. delegatensis* woodland, as well as on Jurassic dolerite	

6.4 Phenology

None of the specimens of *B. obcordata* held at the Tasmanian Herbarium hold flowers. One specimen, however, does hold pods. It was collected from New Norfolk in December, 1898. The other two records are from the depauperate (numerically) and stressed Tower Hill site. They were collected 9th March, 1971, and 25th November, 1985. The latter specimen should have contained fertile material, however, this population was probably either too stressed from over-grazing to produce inflorescences or any that it had produced had already been browsed. Other sources which report a flowering or fruiting period are summarised in Table 6.2.

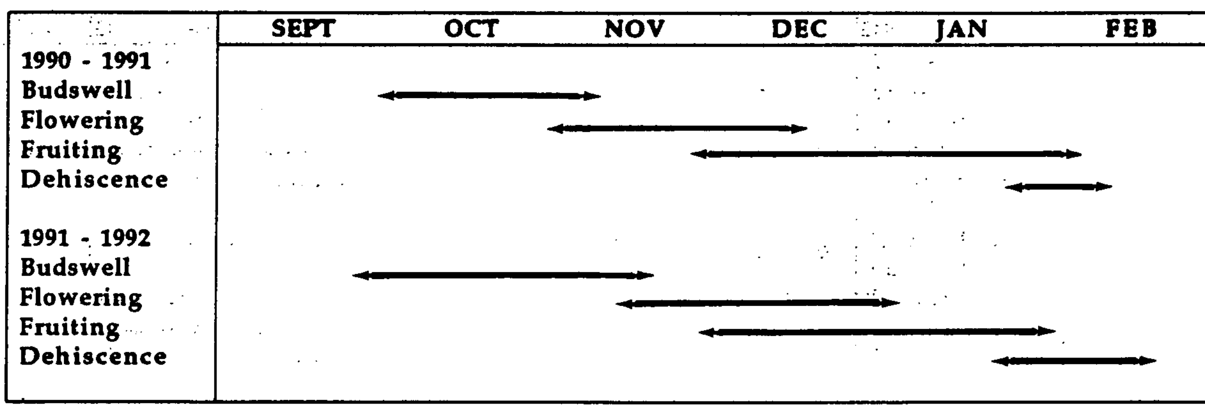
Table 6.2: Phenology of *B. obcordata*, as determined from literature and Tasmanian Herbarium records.

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Blombery (1967)					F	F	F	F	F	F	FP	P
Harden (1991)									F	F		
Woolcock (1991)											F	F
Herbarium records												P

F Flowering
P Fruit present

Field observations of the population at Cox 10, Tower Hill, indicated that the phenology of this species is one of flowering late spring - early summer, with subsequent fruit production in early - mid February (Table 6.3). In spring, 1990, buds began to develop in late September and continued until early November. Budburst, followed by earliest flowering, began in early November. Flowering continued until mid-December. Fruit developed through the flowering period and into early February. Pods dehisced from late January over a period of approximately two weeks. The pattern in spring, 1991, was similar, with buds and flowers developing over similar lengths of time. Pod development took longer in this season, with fruit being present on shrubs until approximately mid-February, 1992. A rare flower was observed in late January. Flower and fruit production was much greater on shrubs either on roadsides or under canopy gaps. Less fruit was produced overall in the 1991 - 1992 season, possibly a response to low rainfall over the summer.

Table 6.3: Field observations of phenological activity, spring to summer, 1990 - 1991 and 1991 - 1992, at Cox 10 site, Tower Hill.



6.5 Propagation

Germination trials were not conducted for this species, despite ample quantities of seed, because of the recent work conducted by Auld and O'Connell (1991) which included *B. obcordata* in a study of the germination requirements of 35 N.S.W. legumes. The study tested *B. obcordata* in germination trials with a range of heat treatments (40, 60, 80, 100, 120^{o}C) and a range of exposure periods (1, 5, 10, 30, 60, 120 minutes). They found a 99.0% viability of the seed lot with 8.6% non-dormant. There was a trend towards increasing germination with increasing duration of exposure for 100^{o} treatment up to 30 minutes, with death of seeds at longer exposures. Germination was greatest after a heat treatment of 100^{o}C for thirty minutes, and was also high after five minutes exposure. Germination also tended to increase with increasing length exposures at 80^{o}C, to a peak after 120 minutes. All exposures to 120° resulted in death of the seeds. A small component of seeds was killed at both 80 and 100°C, while the ungerminated remainder were viable and dormant. Treatments of 60° and 40° were largely ineffectual, and seeds remained viable but dormant. Auld and O'Connell (1991) state that *B. obcordata* may resprout after fire, but is fire-sensitive.

The authors used these results to predict the response from simulated low (L) and moderate (M) intensity simulated burns at one centimetre intervals to a depth of eight centimetres. These results are reproduced in Table 6.4.

Table 6.4: Predicted percentage germination of *B. obcordata* under two fire intensities (L Low, M Moderate) for a range of soil depths (after Auld & O'Connell 1991).

Depth/ Intensity	1 cm	2 cm	3 cm	4 cm	5 cm	Total seed bank
L	12.7	1.3	0	0	0	1.8
M	27.7	50.4	12.7	7.0	3.0	13.1

The results indicate that significant germination is achieved during moderate intensity fires to depths of four centimetres, and also at low intensity fires at depths of one centimetre. During moderate intensity fires, temperatures of 60°C are experienced down to four centimetres depths and 80°C to two centimetres. During low intensity fires, temperatures of only 40°C are reached in the upper two centimetres of the soil profile. Data for the cool burns most resembles fires at the top end of the low intensity fire scale (<500 kWm^{-1}), while hot burns resemble fires of moderate intensity (1 500 kWm^{-1}). The assumption used for seed presence in the soil profile was that seed was distributed evenly within each depth range: 0-5 cm (64.5% of seed), 5-10 cm (20%) and > 10 cm (15.5%; Auld & O'Connell 1991).

Propagation by vegetative cuttings of this species was attempted, however, none of the cuttings were successful. They were taken in March and pretreated with 2 000 ppm I.B.A. The ease of seed germination recommends it as the best means of propagation for this species.

6.6 Disturbance

The trial for this species was terminated on 28th January, 1992; approximately one year after initiation. At this time only three of the four plots could be relocated. The star pickets marking the corners of three of the plots had been stolen, and one of these plots could not be relocated. The vegetation at the site is so sparse that the positions of the other sites could be easily determined.

These three plots all contained germinants, although predominantly only low numbers of them. The results were:

Plot 1 - not relocated;	Control 1 - not relocated;
Plot 2 - 1 germinant;	Control 2 - 0 germinants;
Plot 3 - 1 germinant;	Control 3 - 0 germinants;
Plot 4 - 7 germinants;	Control 4 - 0 germinants.

The control plots did not contain any germinants, however, the low numbers of germinants in the trial plots belie the significance of the result. The indications are that disturbance does aid germination since no other germinants were located outside the plots, except, quite notably, for several located downslope of a drainage culvert beneath the road. The soil and surficial rock clasts were heavily disturbed in the wash channel. A large number of wombat and possibly echidna diggings can be seen on the slope; some *Bossiaea* plants present inside depressions have evidently germinated after creation of the hole.

6.7 Discussion

Bossiaea obcordata is a species widely distributed in south-eastern Australia, however, the Tasmanian populations show a distinctive prostrate form. It has a characteristic environment: dry sclerophyll forest and heath in hilly "coastal" regions of Victoria, south-eastern N.S.W.; sandy or rocky soils in Tasmania. In Tasmania, *B. obcordata* is predominantly restricted to very dry, northerly slopes with shallow sedimentary soils on siliceous Cambrian Mathinna shales in the north-east of the State. These sites are usually low nutrient, drought-stressed environments occupied by *Eucalyptus sieberi* woodland with a sparse, heathy ground cover. This vegetation is frequently burnt and quite depauperate. The population at Fehres Marsh differs in being the highest in elevation, in *E. delegatensis* woodland, as well as being based on a substrate of Jurassic dolerite. Another interesting exception to this habitat generalisation may have been the 1898 record from "rocks near New Norfolk", south-eastern Tasmania, a location disjunct from the other populations, and with a different climate and geology.

Concern for the survival of the Tasmanian gene-pool of this species has diminished with recent "discoveries" of seven new sites. These records, from Tower Hill (Golden Gate Road, Tower Hill Road), south-west of Mangana, Fingal Tier (Fehres Marsh, Barway Spur) and Upper Scamander, total approximately two thousand individuals. The Golden Gate population is the largest and healthiest, and produced a large quantity of seed in 1991. The other populations, while mostly healthy (except the over-grazed Cox 10 population), each consist of less than 100 plants, and sometimes only a few scattered plants. All of the known populations occur in State forest.

Significant germination has been predicted to occur after moderate intensity fires, with seeds to depths of four centimetres being affected, and also after low intensity fires with seeds to depths of one centimetre being affected (Auld & O'Connell 1991). These are predicted if temperatures of 80^{o}C (two centimetres depth) and 60^{o}C (four centimetres depth) are reached during moderate intensity fires, and temperatures of 40^{o}C (two centimetres depth) during low intensity fires, are reached in the upper two centimetres of the soil profile (Auld & O'Connell 1991).

The majority of fires in the environments where *B. obcordata* occurs would be low intensity because of the low fuel loads and sparse vegetation. The sparse and patchy nature of the ground litter has enabled the survival of the species in an area of frequent fuel reduction burning by, firstly, preventing the fire from spreading right across the slope, and secondly, by being so minimal as to only support a low intensity burn. The trial plots all escaped firing. However, those plants that do burn would not all escape with a cool burn since many accumulate a reasonable degree of *Eucalyptus* litter either amongst their branches or in an arcuate cloak upslope. Some observed, blackened *Bossiaea* stems were probably incinerated due to such a localised hot-spot of litter concentration. It is expected, however, that germination of new individuals will succeed at such spots as the litter also provides a trap where seeds accumulate. *B. obcordata* has the ability to resprout following cool fires, as observed at the Golden Gate site following a Forestry Commission fuel reduction burn.

Limited germination of *Bossiaea* seed occurs after physical disturbance of the soil. Germinants were observed in drainage channels, on eroding slopes, to a limited extent via animal digging, and also beside roads. Factors associated with disturbance which enhance germination include abrasion of the seed coat, disaggregation of the soil, and on a larger scale, increased light levels and surface soil temperatures.

The sites with a predominantly north to north-western aspect may also experience germination in summer, when seed dormancy is broken with enhanced soil heating on clear, low wind days. Survival of such germinants is, however, dependent on subsequent rain events. Almost all seed is viable, and the 20% germination response to heating of 60^{o}C may be sufficient to replenish losses of senescent or fire-killed plants. Just under 10% of seed of a Sydney seed stock of this species was found to be non-dormant (Auld & O'Connell 1991), and rain soon after seed release from the pod may recruit germinants from this "soft" seed, before the innate dormancy increases.

Active removal of seed by ants has been personally observed and recorded in the literature (Hughes & Westoby 1990). There is much movement of soil downslope, and seeds may similarly be washed downslope to be restributed into new environments (dispersed) or lost. However, there were no plants present on the flatter parts of the foot of the slope.

7. *DESMODIUM GUNNII* Hook.f. (Southern Tick-trefoil)

The taxonomy of this species follows Hacker (1990), which is currently in use at the National Herbarium of Victoria, as well as the Herbarium of the Australian National Botanic Gardens, A.C.T. Buchanan *et al.* (1989) lists this species as *Desmodium varians* (Labill.) Endl. var. *gunnii* (Hook.f.) Benth. Most Victorian and all Tasmanian populations are referable to the var. *gunnii*, distinguished by its broadly obovate to almost orbicular, not oblong-linear, leaflets (Willis 1972). This species has, in the past, been confused with *Glycine* species. It is, however, distinguished by its hairless stems, and flattened, lobed seed pod.

7.1 Morphology (from Curtis & Morris 1975, Hacker 1990)

Desmodium gunnii is a small, perennial herb with slender, trailing branches either prostrate or ascending, and between 15 and 50 cm in length. The stems are hairless. Its leaves are pinnate with three leaflets, which appear to be digitate, and are long-stalked. The leaflets are obovate tending to orbicular, 10-15 mm long, and with sparse short hairs on both surfaces. It has a triangular stipule, 2-3 mm long, at the base of the leaf petiole. The pea-flowers are small, 5-6 mm long, and blue, lilac or pink. The flowers occur singly or in pairs on slender, few-flowered terminal racemes. The flattened pods (13-25 mm long by 2 mm wide) are densely covered in minute hooked hairs, and are distinctively lobed; the upper margin is slightly indented between the 2-6 articles while the lower margin is deeply indented.

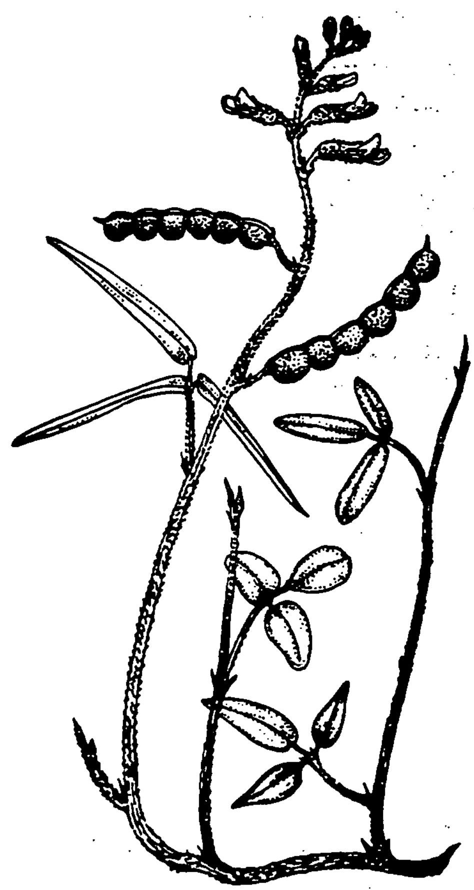


Figure 7.1: Morphology of *D. gunnii* from Kirkpatrick *et al.* 1988).

7.2 Distribution and Rarity

Desmodium gunnii is the most widespread geographically of the species considered in this study. Its distribution extends from Tasmania to all eastern Australian states: Victoria, N.S.W., A.C.T. and Queensland; while Hacker (1990) states that the species occurs in Papua New Guinea and Willis (1972) includes New Caledonia in his distribution list.

In Victoria, *D. gunnii* is scattered throughout the eastern areas, except for the alpine, and right across southern Victoria, although it is much less common to the west of the Melbourne region (Figure 7.2). The species tends to occur in open and closed forests, but may also be found as a "weed" in lawns of subcoastal districts (Hacker 1990).

In Tasmania, Curtis and Morris (1975) give the distribution of *Desmodium gunnii* as rare on the North-west coast; the distribution also given by Rodway (1903). There are no supporting records currently in the Tasmanian herbarium, and Kirkpatrick *et al.* (1988) state that, in recent years, it has only been sighted on Tasmania's East Coast. Recent collections have been made from Radio Mast Hill, near Bicheno (1981), and from Mt. Peter, Freycinet Peninsula (1985). A site containing one plant only was located in the Griffin Forest Reserve (Kirkpatrick *et al.* 1988), however, this plant has since disappeared (J. Kirkpatrick, pers. comm.). In the course of this study, four other sites have been discovered: Bells Bottom, 12 km south-east of Ross; in the south-eastern border of the Douglas-Apsley National Park, north-west of Bicheno; at Dogs Head Hill, in the Mole Creek district; and in the Gog Range, to the north of Mole Creek. It is possible that *D. gunnii* is more widespread, and that other extant populations have been overlooked. Surveys of suitable similar habitat were not conducted during this study.

Desmodium gunnii is listed as vulnerable and unreserved (**uv**) in Kirkpatrick *et al.* (1991b). This classification follows from its lack of reservation, and from the knowledge by the authors of only three extant populations.

7.3 Habitat

Hacker (1990) purports that *Desmodium* can be found in open and closed forests, and sometimes as a weed in lawns in subcoastal districts. Galbraith (1977) suggests a preference of *Desmodium varians* for sheltered places, which Willis (1972) supports, stating that the species tends to be scattered in forest land and along

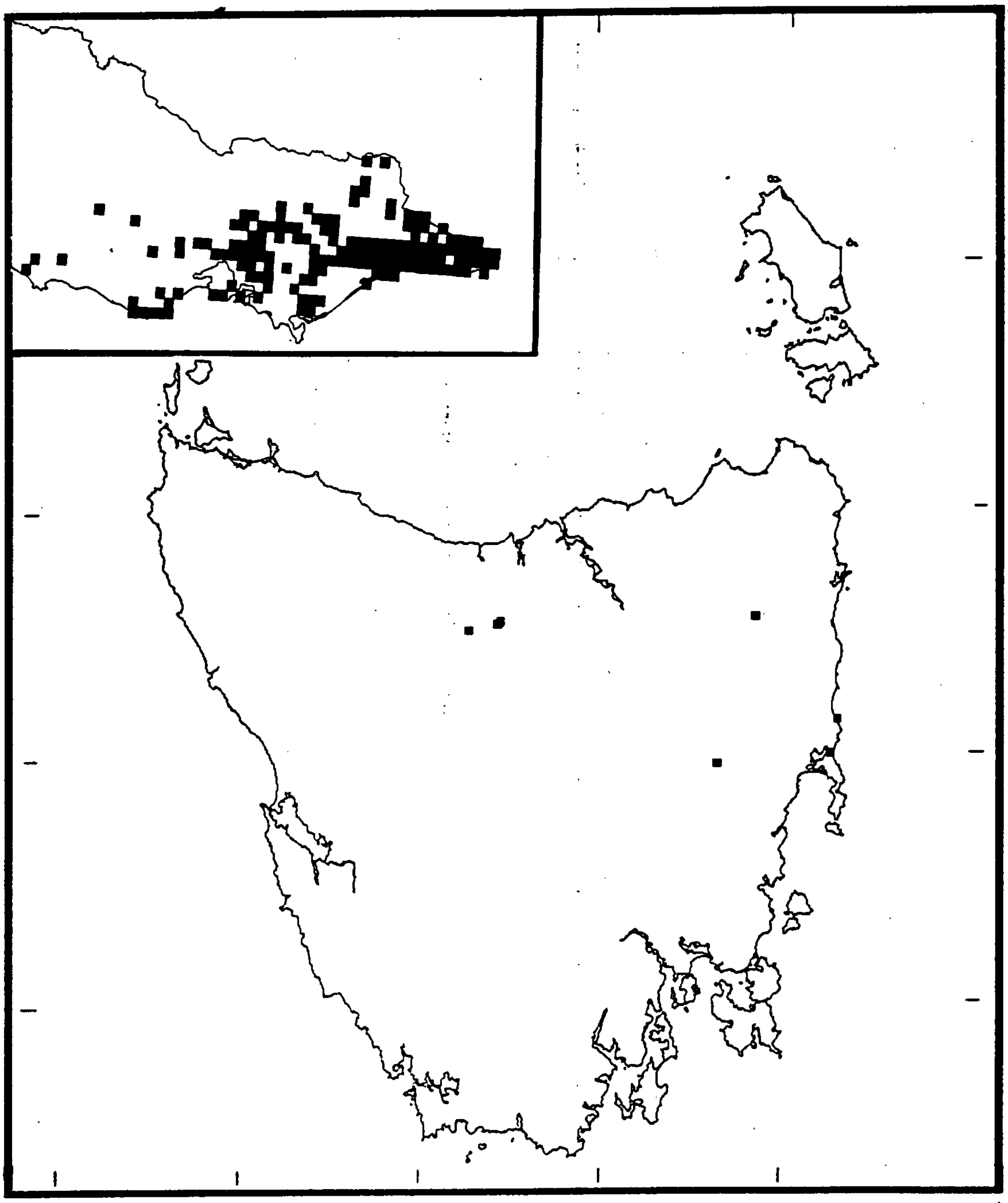


Figure 7.2: Distribution map of recently confirmed populations of *D. gunnii* in Tasmania and Victoria.

shaded valleys. Three of the easternmost Tasmanian sites, at Bicheno, Blindburn Creek Ridge, and Bells Bottom, are sheltered sites, although they vary in their drainage characteristics.

The site at Bicheno was midslope (60 - 140 m) on the eastern aspect of a moderately steep (10^{o}), granite hillside. The vegetation comprised *Eucalyptus viminalis* and *E. globulus* dominating a young tall, open forest with a grassy, heath understorey. *Callitris rhomboidea* had a very sparse cover, but appeared to be regenerating continuously, and had reached eight metres in height. The shrub layer was dominated at three to four metres by a sparse cover, and at one to two metres by a very sparse cover, of *Cassinia aculeata, Acacia melanoxylon,* and *A. terminalis.* The lower layer had abundant *Pteridium esculentum* and *Lomandra longifolia, Agrostis* sp., *Poa* sp. and litter. *Dendrobium* sp. and *Microsorum diversifolium* were present on the side of a granite boulder, and *Glycine microphylla* was also present. *Desmodium gunnii* had only an occasional cover, however, in an area of 100 m down the hill by 50 m around the contour, there was estimated to be over 1 000 individuals. The soils at this site were very shallow, coarse, and quartz-rich, being derived from decayed granite. The site did not appear to have been disturbed for at least 20 years.

At the northern end of the dolerite ridgeline east of Blindburn Creek, north-west of Bicheno, *D. gunnii* was located over a small area of less than six metres^{2}. It was located beneath a dry sclerophyll woodland with a *Callitris rhomboidea* dominated sub-canopy. The site was moderately steep (8^{o}), with an eastern aspect, and sited on the lower part of the slope at an altitude of approximately 100 m. The population was on the south-eastern boundary of the Douglas-Apsley National Park.

The vegetation at Bells Bottom comprised *Eucalyptus rodwayi* woodland with an open, low shrub cover of *Leptospermum lanigerum, Hakea microcarpa, Lomatia tinctoria, Hibbertia serpyllifolia, Cyathodes glauca,* and *Lissanthe montana.* The ground cover was dominated by *Poa labillardieri* and the herbs *Acaena novae-zelandiae, Gonocarpus tetragynus, Oxalis corniculata,* and *Oreomyrrhis eriopoda.* The site was located on a low, east-facing rise (altitude 340 m), on dolerite, with a shallow gradient (3^{o}), and at one side of a grassy valley containing the Glen Morriston Rivulet. The area was grazed by sheep.

Dogs Head Hill, to the north of Mole Creek, has been proposed for a forest reserve, based on botanical (Duncan 1989) and geomorphological (Kiernan 1989) values. The botanical significance of the site was based partly on the presence of *G.*

latrobeana. Collections from this site made in late January, 1992, did not, however, locate *G. latrobeana*, but did locate *G. microphylla* and *D. gunnii* (Section 9.3) within the proposed reserve; these species classified as rare and vulnerable respectively in Tasmania (Kirkpatrick *et al.* 1991b).

The site containing *D. gunnii* at Dogs Head Hill was in *Eucalyptus obliqua* dominated tall open forest with *E. viminalis,* and occurred on the midslope (altitude 330 m, gradient 15^{o}) of the residual limestone hill. This site occupied a northern aspect, which was relatively dry and frequently fired. A tall but very sparse shrub layer at three metres comprised *Acacia melanoxylon* and *A. dealbata.* A moderately dense lower shrub layer at 1.2-2 m was dominated by *Senecio linearifolius* and *Olearia lirata,* and also included *Goodia lotifolia* and *Pteridium esculentum. Coprosma quadrifida* was the low shrub dominant; a relatively sparse layer which also included *Pultenaea juniperina, Lomandra longifolia* and *Lepidosperma laterale.* The ground layer included *Geranium potentilloides, Oxalis corniculata, Themeda triandra, Poa* spp., *Danthonia* spp., *Microlaena stipoides* and *Glycine microphylla.* Both *G. microphylla* and *Desmodium gunnii* were locally common. There was also a medium rock cover and dense litter cover.

Two sites in the Gog Range were recently found to contain *D. gunnii:* both on upper midslopes east of the Gog Plantation, on soils based on Middle Upper Cambrian greywacke sequences. The first site was in shrubby *E. amygdalina* open forest, co dominated by *E. obliqua* and *E. viminalis.* A secondary canopy of *A. melanoxylon* and *Bursaria spinosa* was present. The shrub layer, at 0.5-0.75 m, was dominated by *Pultenaea gunnii, Pimelea curviflora* var. *gracilis* and *Lomatia tinctoria.* Other species included *Pultenaea juniperina, Notelaea ligustrina, Billardiera scandens* and *Indigofera australis.* The ground cover was dominated by *Lomandra longifolia* and *Pteridium esculentum,* but was also herb-rich, predominantly with *O. corniculata* and *Viola hederacea,* but also *Helichrysum apiculatum, Hydrocotyle sibthorpioides, Lagenifera stipitata, Goodenia lanata, Geranium potentilloides* and *Desmodium gunnii.* The site was at an altitude of 220 m, has a south-westerly aspect, and a moderate slope of 12^{o}. The site had not been logged, and had not burnt recently.

The second Gog Range site was similar, being upper mid-slope at an altitude of 250 m, on a slope of gradient 15^{o} and aspect north-north-west, and in grassy *E. amygdalina* open forest. The forest was codominated by *E. obliqua* and *E. viminalis,* with a secondary canopy of *A. melanoxylon* and *A. dealbata.* A low shrub layer was dominated by *Pultenaea juniperina* and *Indigofera australis,* with *Acrotriche serrulata* and *Bossiaea cordigera,* while the ground cover was dominated by *Themeda triandra, Poa rodwayi, Ehrharta stipoides, Deyeuxia monticola* and *Holcus lanatus. Pteridium* *esculentum* was also present, along with *Lepidosperma laterale, Lomandra longifolia, Dianella revoluta,* and the herbs *Stellaria pungens, Acaena novae-zelandiae, Centaurium erythraea, Hypochoeris radicata, Viola hederacea, Gonocarpus tetragynus* and *Geranium potentilloides.* This site was heavily grazed by sheep, cattle and wallabies and the *Desmodium* often occurred in protected microsites, such as at the base of logs. There was no evidence of recent burning.

One plant of *D. gunnii* was observed in the Griffin Forest Reserve in native grassland planted with trees (Kirkpatrick *et al.* 1988), but has since disappeared (J. Kirkpatrick, pers. comm.). This site was not surveyed during this study.

Table 7.1: Summary of habitat records and conservation information for *D. gunnii*.

Recent Records:	7 Sites recorded, 7 extant	
Habit:	Small perennial herb with trailing branches and pinnate leaves of three leaflets	
Population Size:	> 1 000	
Regeneration:	Type:	Presumed seed germination post-fire
	Observed?:	Observed at Bicheno site
Habitat:	Landform:	Base of slope above valley bottom, to upper midslope on hillsides
	Altitude:	100 m a.s.l. (coastal) - 220 to 340 m (inland)
	Aspect:	(NNW) - N to E
	Slope:	$(3^{o}-)\ 8 - 15^{o}$
	Community:	Grassy to heathy woodlands
Fire response:	Presumed seed germination post-fire and resprouting after cool fires; most sites not burnt in recent past	
Conservation	Proposed:	**u*v**
Status:	Current:	**uv** (Kirkpatrick *et al.* 1991b)
Reserve:	-	
Comment:	No apparent geological fidelity (granite, limestone, dolerite) * A very small population occurs on the boundary of the Douglas-Apsley National Park, however this reservation is not adequate	

7.4 Phenology

Two sources refer to a flowering time for this species, one of which actually includes it within *D. varians.* These are summarised in Table 7.2. Two plants at the Bicheno site were flowering when visited 28th of November, 1991. The plants at Bells Bottom held pods when visited on 13th of February, 1991, as did specimens collected from the Gog Range in late February, 1992. One of the Tasmanian Herbarium specimens collected at Bicheno in January, 1981, was in flower. No fertile material was present at the ridge site east of Blindburn Creek on 28th of May, 1991, or at Dogs Head Hill in late January, 1992.

Table 7.2: Phenology of *D. gunnii*, as determined from literature and Tasmanian Herbarium records.

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Woolcock (1991)	F	F							F	F	F	F
Rodway (1903)											F	F
Lynch (pers. obs.)		P									F	
Herbarium records	F											

F Flowering
P Fruit present

7.5 Discussion

Desmodium gunnii displays a wide environmental tolerance, both climatic and edaphic. It is a widespread species, ocurring in eastern Australia from Tasmania to Queensland, and possibly extending to New Caledonia (Willis 1972) or Papua New Guinea (Hacker 1990). It tolerates a wide range of substrate variation; being known in Tasmania from sites on dolerite, limestone, greywacke sediments and granite. The species is common in Victoria and New South Wales. However, only a small number of sites are known in Tasmania. Tasmania may, therefore, be on the limits of the species' ecological range and tolerance.

Desmodium gunnii is a species of grassy to heathy woodlands in Tasmania's southern Midlands and east coast. Grassy woodlands are one of Tasmania's most threatened communities. However, there is only one extant record of the species from the Midlands, and so it is not justifiable to extrapolate the species' rarity to that of the community. The rarity of the species appears to have been partly due to lack of recognition of the plant. It is quite probable that this inconspicuous herb has often been passed over, or confused with other trifoliate plants. With greater recognition of its characteristics and of the taxonomic characters differentiating similar looking plants, other populations of *D. gunnii* may be located in the near future.

Its rarity is also partly due to an unknown limitation across its distribution, despite the species' innate broad ecological tolerance. This tolerance should enable *D. gunnii* to occur in a variety of habitats, and yet the species is only occasional across its distribution. *D. gunnii* may be limited by its competitive ability, by predation, or by too high levels of disturbance or fire. Another possibility is that Tasmania's grassy woodlands are too dry for this species' competitive tolerances.

In Tasmania, *D. gunnii* tends to occur in grassy to heathy woodlands on well-drained sites that have not been recently disturbed. The sites occur at low altitudes on the coast, and higher inland. They tend to have northerly to eastern aspects. Some of the sites are relatively sheltered, and although sometimes being on the upper reaches of moderately steep slopes, they do not appear to get moisture stressed. Some disturbance was apparent at all sites, whether from grazing or firing, although most of the sites had not burnt recently. The species does occur in one area subject to frequent firing. However, these were probably "cool" burns, after which the plants may have resprouted. The sites do not appear to have been logged, and the effects of forestry activities are unknown.

8. *EUTAXIA MICROPHYLLA* (R.Br.) J.Black (Common Eutaxia)

8.1 Morphology (from Curtis & Morris 1975 and pers. obs.)

Eutaxia microphylla is a procumbent, spreading, twiggy shrub with crowded branches ending in spines. Its habit, however, varies between two forms. The first is a prostrate form with fine, linear to linear-lanceolate leaves, 1.5-5 mm long and 0.5-1.0 mm wide (var. *microphylla).* The second form is an erect, non-spinescent, 1-1.5 m tall plant with longer, broader leaves (lanceolate to ovate or obovate) of 3-12 mm length and 1-3 mm width (var. *diffusa* (F. Muell.) Court; Jessop & Toelken 1986). These two varieties have recently been split into separate species *(E. microphylla* and *E. diffusa* respectively; Porteners 1991), and it is *E. microphylla (E. microphylla* var. *microphylla)* which occurs in Tasmania.

Figure 8.1: Morphology of *E. microphylla* (from Woolcock 1991).

In Tasmania, *E. microphylla* has 2-5 (-7) mm long, oblong leaves with an acute apex; they are arranged oppositely and decussately. The plant is hairless, except that the calyx may occasionally be fringed (Galbraith 1977). It has yellow pea-flowers with red veining, and a deep red keel, although the entire flower may be yellow. The flowers are spread along the stems, occurring solitary or paired in the leaf axils. The pods are ovoid to obovoid, and about 3-5 mm long. They contain one to two dark brown, reniform seeds, each of 1.25-1.5 mm by 0.75-1 mm.

8.2 Distribution and Rarity

Eutaxia microphylla is a species of unusual distribution. It is the only member of its genus (comprising eight species) which is not confined to Western Australia. *E. microphylla* does occur in Western Australia but is also widespread in all south-eastern States. In South Australia, it occurs in the South and South-East; including the Flinders Ranges, Lofty Ranges, Kangaroo Island, Yorke Peninsula, and the Murray and South-eastern districts (Jessop & Toelken 1986). In Victoria, populations may be found to the north and also to the west of the Melbourne district; in the Mallee, Wimmera, Murray Valley, North-central, North-east and northern parts of the South-west and Ballarat areas (Figure 8.2). This distribution extends north into south-western N.S.W.; in the mallee and Mugga Ironbark communities and woodlands of the Central and South Western Slopes, the South Western Plains, and the South Far Western Plains; and into south-east Queensland (Porteners 1991). Ewart (1930) stated that *E. microphylla* occurs on the Silurian sediments, basalts and red sand areas of north-west and south-west Victoria and near Melbourne.

In Tasmania, *E. microphylla* is very occasional in coastal communities from the north-east to the south-east (Figure 8.2). It occurs on the limestone-based soils of Flinders Island: near Wybalenna, at Killiecrankie Bay, Settlement Point, Trousers Point, and also on Prime Seal Island; at Pittwater Bluff, 17 km east of Hobart; at Cape Portland, on the north coast of Tasmania; and at Chronicle Point, on the Tasman Peninsula, south-eastern Tasmania. It is most extensive and abundant on Flinders Island.

Eutaxia microphylla is listed as rare (r2) in Kirkpatrick *et al.* (1991b). It qualifies for this classification based on its restriction, in Tasmania, to Flinders Island and only another three widely scattered sites. It is securely reserved only at Trousers Point, one kilometre west of the main part of Strzelecki National Park.

8.3 Habitat

Eutaxia microphylla is regarded as preferring dry open forest (Galbraith 1977). SGAP (undated) gives the following notes on the horticultural requirements of this species: that it can tolerate full or partial exposure to sun; is a drought tolerant plant and therefore suitable for dry areas; and although it prefers a well drained soil, it will withstand extended periods of wetness.

On Flinders Island, *E. microphylla* occurred in the north-west at Killiecrankie Bay, on the central west coast to the east and south of Marshall Bay, on Prime Seal Island off the central west coast, and in the far south-west at Trousers Point. Prime Seal Island was not visited during this survey, however, the population was known to comprise more than 1 000 plants. The plants are situated on moderately steep slopes of north-western aspect, and up to 60 m altitude on the south-western part of the island (S. Harris, pers. comm.). An old record (1966) comes from the

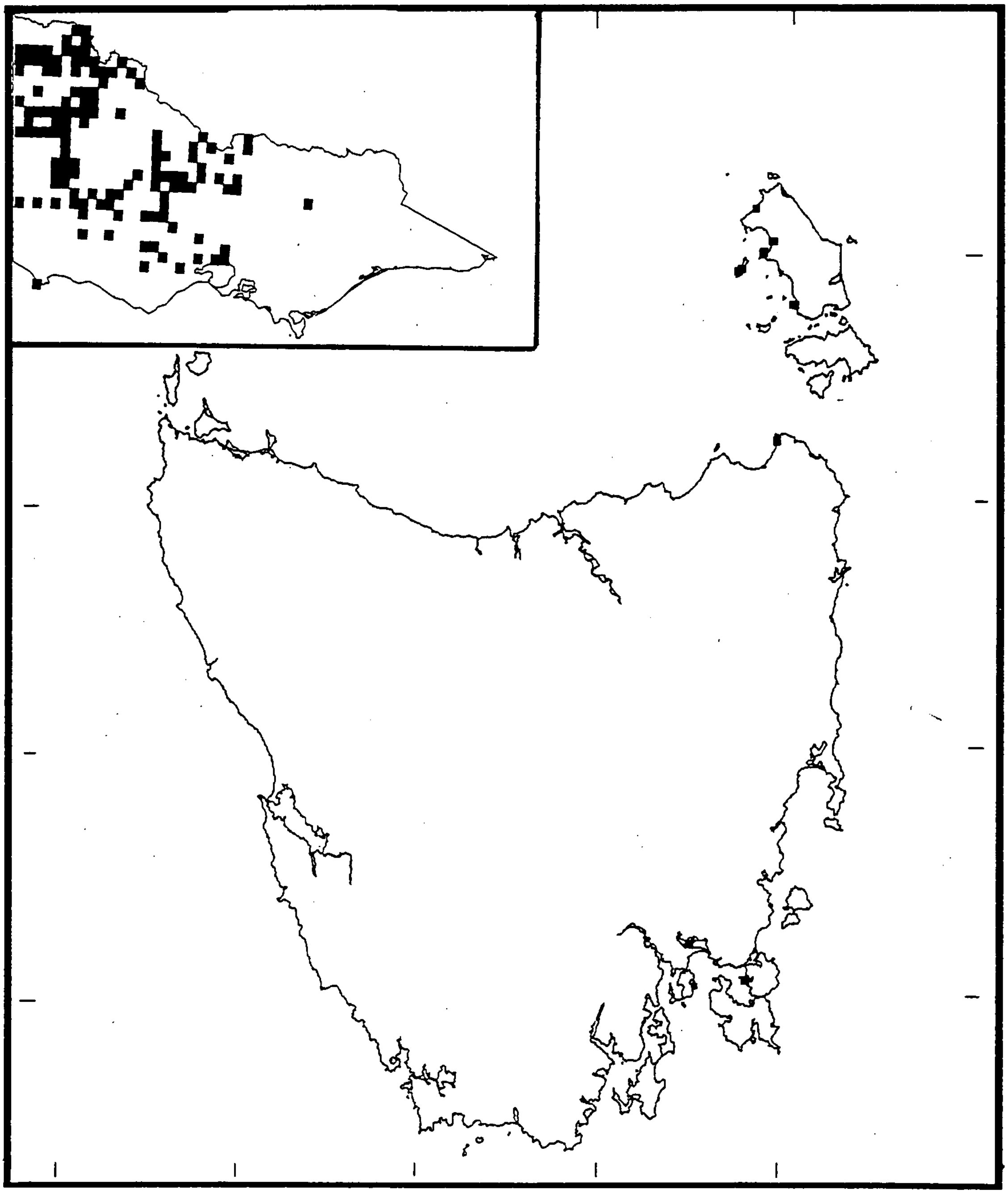


Figure 8.2: Distribution map of recently confirmed populations of *E. microphylla* in Tasmania and Victoria.

Lughrata area to the east of Marshall Bay, however, this site also was not relocated during this survey.

At Killiecrankie Bay, approximately 50 *Eutaxia* plants were confined to an exposed, narrow band of limestone (Figure 8.3). The limestone sloped west-north-west at approximately 8^{o} down the 20 m to the water's edge, and was sited between a granite contact and granite tors in the wave zone. Farther upslope, and on the granite, was an *Allocasuarina verticillata* low open forest. The vegetation of the *Eutaxia* site was very sparse since the site was exposed to wind-shear and salt spray, and most of the site consisted of exposed rock with a minor amount of quartz crumbs. The dominant species occupying the few available sites were *Leucopogon parviflorus, Coprosma hirtella* and *Myoporum insulare,* the latter two reaching heights of 1.2 m. Other species present included *Correa reflexa, Leptospermum laevigatum, Oxalis* sp., *Hypochoeris radicata, Disphyma crassifolium* and *Carpobrotus rossii.*

Figure 8.3: The distribution of *E. microphylla* on Flinders Island is closely related to the extent of coastal limestone deposits.

Farther to the south, south of Marshall Bay and west of Port Davies, *E. microphylla* was occasional amongst an open grassy heath on a gently sloping site with a north-eastern aspect. The dominant heath species were *Leucopogon* *parviflorus, Correa alba* and *Pimelea serpyllifolia*, while the most common grass was a sparse cover of *Festuca* sp. *Carpobrotus rossii, Myoporum insulare, Hypochoeris radicata, Swainsona lessertiifolia* and *Calocephalus brownii* were also present. Wallabies, wombats and tiger snakes inhabited the area, which did not show signs of recent burning. A site on Cave Beach, at Port Davies, was described as containing *Eutaxia* amidst an open heath of *Beyeria leschenaultii* and *Lasiopetalum* sp. It was only five metres in altitude, and sited on skeletal soils based on limestone.

South of Port Davies, *Eutaxia* occurred in heathy communities with *Acacia retinodes* (Section 5.3). The first site, a low open forest of *Allocasuarina verticillata* with *Leptospermum laevigatum* and *Pimelea serpyllifolia* in a saddle was described in Section 5.3. This site was within the Wybalenna Historic Site. The *Eutaxia* were only occasional (less than 20 plants) but appeared to be healthiest when beneath other shrubs. Much of the non-shrubby ground was bare or marked by animal trails (wallaby and snake tracks were observed in the sandy, charcoal rich soil). Six *Eutaxia* plants were located nearby tolerating a dense canopy of *Allocasuarina* and *Leptospermum* with a dense litter cover on the ground.

The second site which also contained *Acacia retinodes* (described in Section 5.3, Figure 5.3) occurred in a low coastal shrubland on a north-western slope facing the ocean, and which had recently been partially burnt, some tussock grasses still being blackened. Large expanses of ground were bare, and *E. microphylla* predominantly occupied eroded patches.

Eutaxia was also surveyed at two sites midway between Port Davies and Settlement Point. The south-western site was on a primary foredune, two metres vertically and three metres horizontally above the high tide mark, with an aspect of 255^{o} and slope of 8^{o} (Figure 8.4). Much of the site was bare, with the remainder dominated by *Correa alba, Beyeria leschenaultii, Festuca* sp., *Leucopogon parviflorus*, and also *Acacia sophorae, Eutaxia microphylla, Pimelea serpyllifolia* and *Swainsona lessertiifolia*. The site was on a limestone outcrop overlying granite. The plants were subject to wind shear and salt spray, grazing by wallabies and wombats, and recreational activities, including 4WD vehicle use (mostly by fishermen). This site was within the coastal reserve.

The north-eastern site was a similar site, and also occurred within the coastal reserve. It was located near the top of a foredune, and sloped gently to aspect 295^{o}. The cover of *Eutaxia* was sparse, in an open heath dominated by *Acacia sophorae, Leucopogon parviflorus, Beyeria leschenaultii* and *Correa alba*. This site showed no sign of recent fire, the trunk of one *Leucopogon* reaching 0.1 m diameter.

Figure 8.4: Typical habitat of *E. microphylla;* Settlement Point, Flinders Island.

At Trousers Point, west of the main part of Strzelecki National Park, *Eutaxia* again occupied a very localised site (ten by ten metres) on exposed dunes approximately 60 m from the high tide mark. About 33 plants were located on the moderately steep (8^{o}), south-westerly slope of sandy soils of limestone underlain by granite. Much bare ground was evident, colonised by *Calocephalus brownii, Olearia axillaris, Beyeria leschenaultii, Leucopogon parviflorus, Myoporum insulare* and *Eutaxia microphylla. Isolepis nodosa, Sarcocornia quinqueflora* and *Swainsona lessertiifolia* were also present. Some of the shrubs (all less than 0.8 m) and tussocks of *Spinifex* had died on their seaward sides. Sixty metres farther inland, and at the top of the slope, was a low open *Allocasuarina verticillata* forest.

On the Tasmanian mainland, *E. microphylla* occurred in the far north-east at Cape Portland, in the south-east at Pittwater Bluff, and in the far south-east at

Chronicle Point on the Forestier Peninsula. The Cape Portland site was in a low saltmarsh near the shore (S. Harris, pers. comm.), but was not surveyed in this study. The site occurs within the Cape Portland Wildlife Sanctuary. Several searches for the species at Pittwater Bluff in 1991 proved fruitless. Survey notes from the collection at Pittwater Bluff, however, indicated that *Eutaxia* was rare in a remnant uncultivated open *Eucalyptus viminalis* woodland with an understorey of *Acacia dealbata, Astroloma humifusum* and *Dodonaea viscosa.* The ground cover consisted of *Pteridium esculentum, Lomandra longifolia, Poa poiformis* and *Carpobrotus rossii.* The site, at an altitude of 20 m and on sandy soils, was subject to grazing and a high fire frequency.

Chronicle Point was an exposed site on the western side of the Peninsula. Facing west-south-west, it was exposed to onshore winds, and *Eutaxia* occupied open ground amongst a low *Allocasuarina littoralis* woodland. The site was ten metres above and 15 m from the high tide mark, and extended a farther 30 m up the 4° slope and approximately 100 m around the hillside. A dense cover of *Allocasuarina* litter blanketed the ground, while approximately 200 individuals of *Eutaxia* occurred in open areas accompanied by *Astroloma humifusum, Correa alba, Leucopogon parviflorus, Brachyloma ciliatum, Helichrysum obcordatum* and *Allocasuarina* juveniles. *Eutaxia* also occurred beneath a full *Allocasuarina* canopy with a complete ground litter cover. The site was unusual in being on a brown loam soil and a dolerite substrate.

Total abundance of the species in Tasmania was greater than 1 000 individuals, scattered between 12 sites, and with only two sites (Chronicle Point and Prime Seal Island) containing more than 100 plants. The Prime Seal Island population alone comprised more than 1 000 individuals.

Table 8.1: Summary of habitat records and conservation information for *E. microphylla*.

Recent Records:	12 Sites recorded, 12 extant	
Habit:	Procumbent, spreading, twiggy shrub with crowded branches usually ending in spines	
Population Size:	100 - 1 000	
Regeneration:	Type:	Germination of seed
	Observed?:	Observed at Settlement Point
Habitat:	Landform:	Exposed foredunes and coastal slopes, also near-coastal saddle
	Altitude:	0 - 20 m (- 60m)
	Aspect:	(45°-) 230 - 355°
	Slope:	2 - 8°
	Community:	Open *Acacia* or *Correa* heath to low, open *Allocasuarina* woodland or forest
Fire response:	Presumed fire sensitive	
Conservation	Proposed:	**r2**
Status:	Current:	**r2** (Kirkpatrick *et al.* 1991b)
Reserve:	Trousers Point (Strzelecki National Park), Wybalenna Historic Site	
Comment:	Restricted to limestone on Flinders Island, but known to occur on dolerite in South-east Tasmania	

8.4 Phenology

The main flowering period for *E. microphylla* is spring (Table 8.2). Several plants at a protected site on Flinders Island still held pods with seeds on 5th April, 1991, however, the majority of plants observed on the Island did not. Plants at the Chronicle Point site on Tasman Peninsula held ripe pods on 17th of January, 1992. Collections of flowering specimens held at the Tasmanian Herbarium for this species were collected on 23rd of September, 1984, 2nd of October, 1972 and 27th of November, 1966. One specimen with both flowers and pods was collected on 19th of November, 1966, while material with fruit only was collected on 16th of December, 1975 and 11th of December, 1988. Vegetative material was collected on 17th of January, 1965.

Table 8.2: Phenology of *E. microphylla*, as determined from literature and Tasmanian Herbarium records.

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Jessop & Toelken (1986)								F	F	F		
SGAP (undated)								(F)	F	F	F	
Woolcock (1991)									F	F	F	
Lynch (pers. obs.)	P			P								
Herbarium records									F	F	FP	P

F Flowering
(F) Intermittent Flowering
P Fruit present

8.5 Discussion

On Flinders Island, *Eutaxia microphylla* is locally common on sandy soils with a calcarenite substrate. The Chronicle Point site in south-eastern Tasmania is unusual in being on a brown loam soil and a dolerite substrate, rather than on the usual calcareous sands of the Flinders Island populations. This population is also notable by the much less spiny nature of the branch tips. Presumably, the other mainland Tasmania sites are also not calcareous, so a comparison of both the substrate and plant morphology may quantify some intraspecific variation.

The Tasmanian sites generally occur on exposed foredunes and coastal slopes with patches of open ground. The exposed nature of the sites may also be a factor in the distribution of *E. microphylla* by limiting the competitive ability of other species. Most of the sites are very exposed to wind-shear and saltspray. The site at the Wybalenna saddle is more protected but is also subject to soil disturbance, primarily through animal trampling and digging. Most of the exposed sites are of south-west to north aspect, the exception being the site at Port Davies wharf.

However, this site, an open grassy heath, was easily accessible by road and consequently was subject to disturbance from humans and their vehicles.

Vegetation at the sites usually consists of open heath or low open *Allocasuarina* woodland with an open heath understorey. The dominant species are typical of such communities, and include *Correa alba, Leucopogon parviflorus, Leptospermum laevigatum* and *Carpobrotus rossii.* Heathland generally is fire-adapted, however, the open nature of most *Eutaxia* sites appeared to be primarily maintained by exposure to strong, salt-laden on-shore winds. The species has, however, been recorded from Pittwater Bluff, south-eastern Tasmania, at a grazed site with a high fire frequency.

9. *GLYCINE LATROBEANA* (Meissn.) Benth. (Clover Glycine, Purple Glycine)

9.1 Morphology (from Tindale 1986, J. Grace and T. Brown, pers. comm. and pers. obs.)

Glycine latrobeana has commonly been confused in Tasmania with the other *Glycine* species and also with *Desmodium gunnii*. Similar confusion within the *Glycine* genus has been noted in South Australia (Davies 1986). Field identification of *Glycine* species is difficult because they are usually grazed, because they lack flowering or fruiting characters for much of the year, and also because of their ability to reproduce via both chasmogamous and cleistogamous inflorescences. As a result, the extent of *G. latrobeana* in Tasmania has been overestimated.

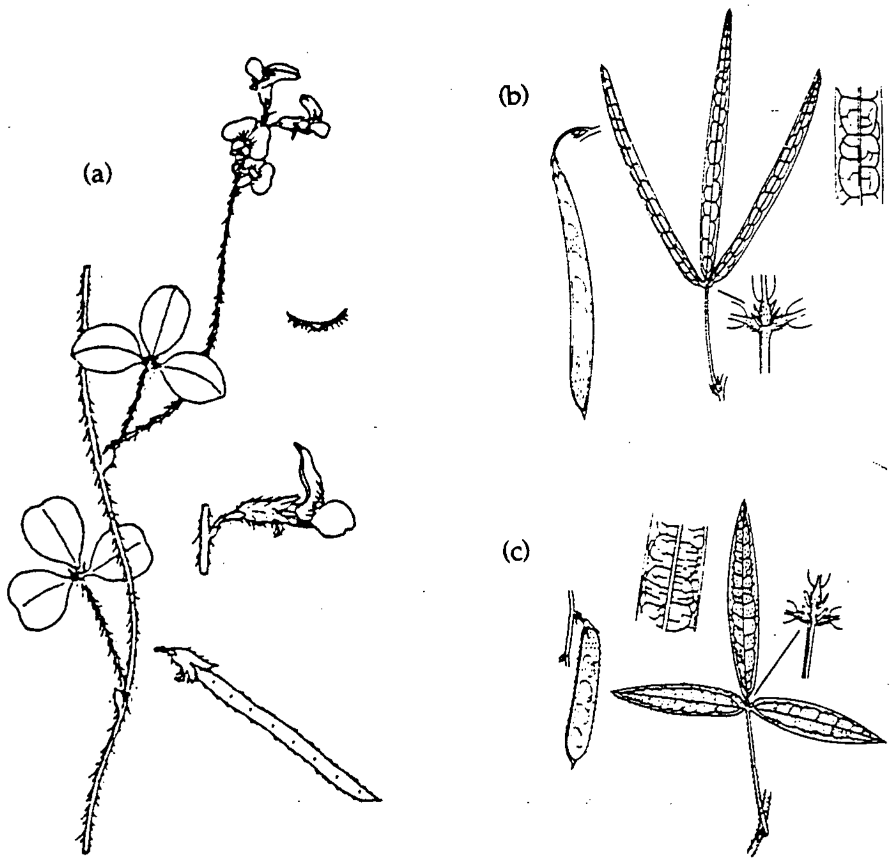


Figure 9.1: **(a) Morphology of *G. latrobeana* (from Woolcock 1991, (b) *G. clandestina* and (c) *G. microphylla* (from Harden 1991).**

Three species of *Glycine* occur in Tasmania: *G. clandestina* J.Wendl., *G. latrobeana* (Meissn.) Benth. and *G. microphylla* (Benth.) Tind. (Figure 9.1). These species are all small, perennial trifoliolate herbs which may become trailing or twining if protected from grazing. Like many leguminous plants, they are palatable, and the species are restricted to dry sclerophyll woodlands where the populations are usually grazed by native herbivores. Consequently, wild plants tend to be small, comprising only a few short stems (up to 0.1 m length). In Tasmania, the three *Glycine* species can adopt similar habits, even if not intensively grazed, making identification difficult (see key to identification, Appendix 23.2). *G. tabacina* has also been thought to occur in Tasmania, but has not been positively identified (J. Grace and A. Brown, pers. comm.).

These four *Glycine* species can be split into two groups. *G. microphylla* and *G. tabacina* have stoloniferous stems, very finely reticulate veins within the larger areolae of the leaflets, and also possess a stipel on the median petiolule. The other two species, *G. clandestina* and *G. latrobeana,* have non-stoloniferous stems, coarsely reticulate veins within the larger areolae of the leaflets, and the stipel of the median petiolule is either absent or minute. *G. latrobeana* is distinguished from *G. clandestina* in having trailing rather than twining stems, in that it may spread rhizomatously, and also in having orbicular to obovate leaflets rather than digitately trifoliate leaflets (although this characteristic is highly variable in Tasmanian specimens of *G. clandestina,* which may also have orbicular leaflets, especially when stems are young). On *G. clandestina,* the stipel of the median petiolule is always absent, whereas on *G. latrobeana,* the petiolules are densely covered with antrorse to reflexed hairs, obscuring the stipels, which are minute, and caducous, tending to fall.

Desmodium gunnii is similar in appearance to *G. latrobeana* but is distinguishable by its hairless stems and lobed pod.

The chasmogamous flowers of the *Glycine* species are small, either purple or pink pea-flowers ascending in racemes from the axils of the upper leaves on long peduncles. Cleistogamous flowers are often solitary, frequently in the lower axils, and on very short peduncles. These flowers do not open but self-fertilise. The inflorescence of *G. latrobeana* is more compact than *G. clandestina,* being crowded near the ends of the peduncles rather than spread along the upper half. The pods of *G. latrobeana* are about 20-25 mm by 5 mm and contain 3-5 cylindrical-shaped seeds, whereas the pods of *G. clandestina* are c. 12-30 mm by 3-4 mm and contain 4-8 seeds (Weber 1986).

9.2 Distribution and Rarity

The *Glycine* genus can be found in the tropical and warm temperate regions of the Old World, and in all States of Australia. The six to seven Australian species comprise four endemics, 3 native species and one cultivated species (Morley & Toelken 1983). *Glycine* species tend to be small twining and prostrate plants, widespread in grassland communities (Galbraith 1977).

G. latrobeana is an uncommon species which usually occurs in the open grasslands of south-eastern Australia (Mt. Lofty Ranges and south-east region of S.A., throughout Victoria except for the north-west quarter, the far eastern section and the districts of Shepparton and Albury; Davies 1986).

Records in Tasmania older than 25 years (Figure 9.2) placed the species in the north-west at Circular Head (1836, 1837), and in the Midlands (Folly Lagoon near Ross 1964) extending south to Runnymede (1848) and the Derwent Valley (Plenty 1839). None of these records have been verified recently. The current Tasmanian distribution of the species (Figure 9.2) appears to be in the Midlands: from north of Epping Forest (Powranna Road 1991), at Stockers Bottom (1981), and at Pig Farm Hill in the Bothwell area (1982); on the Central Plateau, at two sites along the Ouse River (1980, 1984); and at two near-coastal sites at Cape Portland, in the far north-east of the State (1983, 1991). Specimens of *G. latrobeana* from Pig Farm Hill and the upper Ouse River were identified by CSIRO Plant Industry researchers Dr. A. Brown and Dr. J. Grace from field collections by Dr. M. Brown and F. Duncan. Two other sites without supporting specimens have also been recorded for *G. latrobeana:* Hummocky Hills in the Midlands (M. Cameron, pers. comm. 1992) and Dogs Head Hill, north of Mole Creek in northern Tasmania (Duncan 1989).

As previously mentioned, taxonomic distinction between species has been difficult, and many past records in Tasmania have been of *G. clandestina* and *G. microphylla.* Several new locations of *G. microphylla* were discovered: at Dogs Head Hill, near Mole Creek in the north of the state, on the Upper Ouse River, with *G. latrobeana,* and at Radio Mast Hill, behind Bicheno, on the central east coast.

Glycine latrobeana was listed nationally as rare (3RCa), with a distribution over more than 100 km, and considered adequately reserved (Briggs & Leigh 1988). More populations have been found in Victoria (J. Grace, pers. comm.), however, the species is still considered nationally to be vulnerable (ANZECC 1993). In Tasmania, there are seven populations recently recorded, two of which need collection of specimens for the Tasmanian Herbarium. There are also two other sites which need to be confirmed. The sites are widespread but extremely restricted, usually over areas of tens of metres. They also tend to contain less than 60 plants at a site. The species is unreserved, and should be upgraded from rare

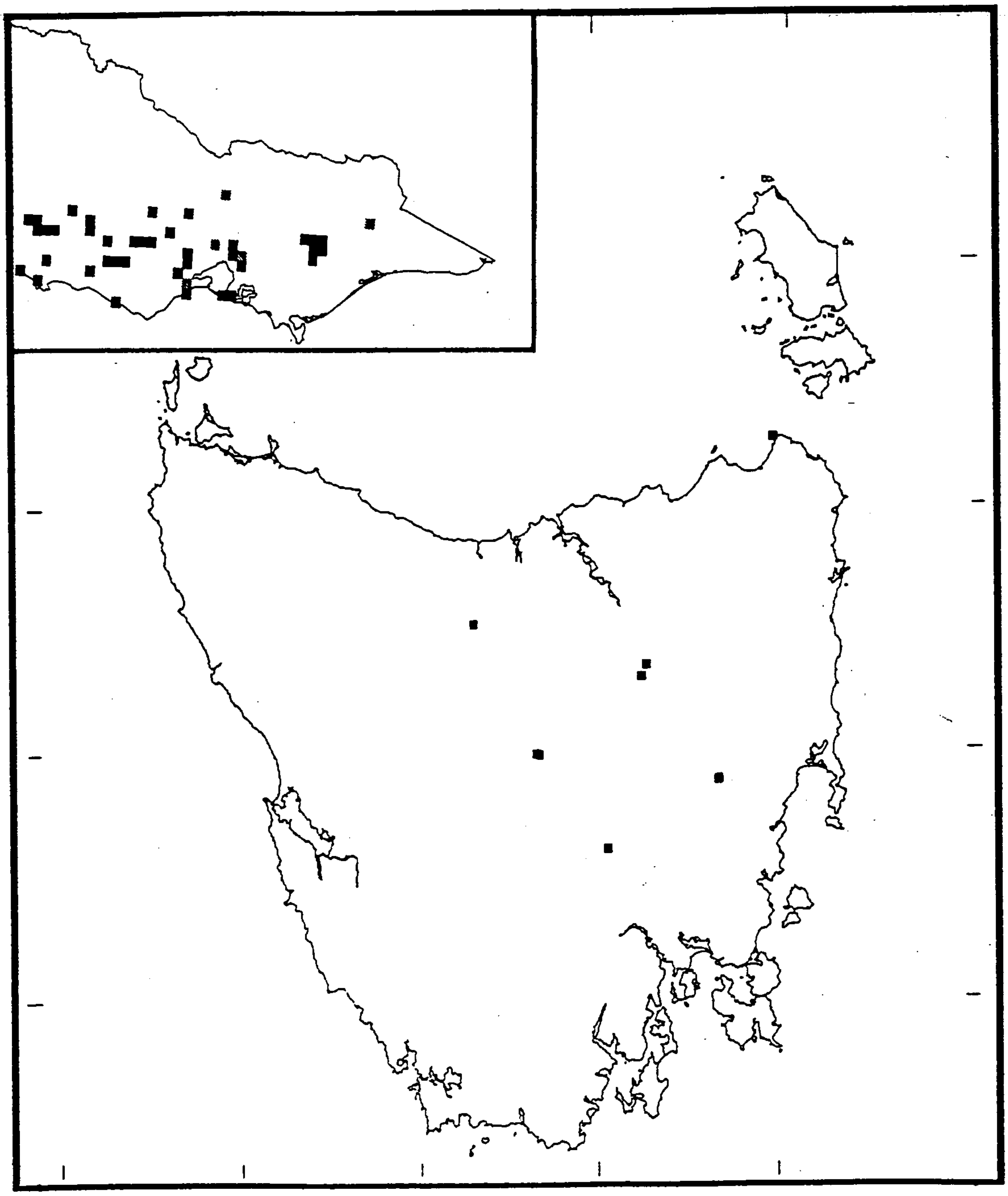


Figure 9.2: Distribution map of recently confirmed populations of *G. latrobeana* in Tasmania and Victoria.

(Rr3; Kirkpatrick *et al.* 1991b) to vulnerable at both the State and National levels (Vuv).

9.3 Habitat

Approximately 60 *Glycine* plants were observed on private land on the Powranna Road at the northern end of Epping Forest, Midlands Tasmania, in 1991. The site was very small (ten m by five m). It was located on a gentle slope above a poorly drained area of cleared native pasture and sedges, at an altitude of 170 m. This site faced south-east, and was situated on sandy loam on dolerite, amidst a *Eucalyptus pauciflora* and *E. viminalis* open woodland with a moderately dense, shrubby understorey. The understorey was dominated by *Acacia dealbata* and *Pteridium esculentum*. The ground layer was grassy, dominated by *Themeda triandra, Poa sieberiana, Ehrharta stipoides, Stipa* sp., *Danthonia* sp. and *Aira caryophyllaea,* and also with *Lissanthe strigosa, Astroloma humifusum, Centaurium erythraea, Hypochoeris glabra, Plantago varia, Goodenia lanata, Brunonia australis* and *Pimelea humilis.* The area was grazed by sheep, and also subject to woodcutting and frequent firing. The ground species were under considerable grazing pressure, with little regeneration observed of *Brunonia australis* and none of *Glycine latrobeana* (A. Pyrke, pers. comm.). The weed gorse, *Ulex europaeus,* occurs near the site. *G. latrobeana* has also been reported to occur five kilometres to the south-west, at Hummocky Hills (M. Cameron, pers. comm.).

Two *Glycine* species have been collected in the Stockers Bottom locality. *G. clandestina* was identified from one site (A. Brown & J. Grace, pers. comm.), while one kilometre east, *G. latrobeana* has been collected. The *G. latrobeana* site was located on an undulating plateau at 420 m altitude on Triassic sediments. The community was localised and composed of a *Eucalptus viminalis - E. dalrympleana* open forest marginal to a *E. ovata - E. pauciflora - E. rodwayi* frost hollow. The site had a high fire frequency, reflected in the heathy grassland understorey, which was dominated by the shrubs *Acacia dealbata, Lissanthe strigosa, Acrotriche serrulata* and *Astroloma humifusum,* the grasses *Microlaena stipoides, Danthonia* sp. and *Poa rodwayi,* and the herbs *Viola* spp., *Pimelea humilis, Acaena echinata, Plantago varia* and *Bossiaea prostrata.* The site had been selectively logged and was grazed.

The site at Pig Farm Hill in the Bothwell district was also located on private land. The site was on the moderately sloping, northern aspect of a broad knoll at an altitude of 660 m. The local rock-type was Jurassic dolerite, and the soils shallow. The vegetation community was a *Eucalyptus rubida* and *E. dalrympleana* woodland with a shrubby understorey, primarily of *Acacia dealbata* and regenerating *E. rubida*. The ground cover consisted of moderately dense *Lomandra longifolia*, with *Lissanthe montana*, and a dense cover of the grasses *Poa labillardieri*, *P. rodwayi* and *Danthonia* sp. The herbs *Pimelea humilis*, *Dichondra repens*, *Lagenifera stipitata*, *Geranium potentilloides* and *Senecio minimus* were also present. This site had a frequent firing regime, and was grazed by sheep.

Glycine latrobeana has been collected from a high altitude site (900 m) on the upper Ouse River, Miena district (1984). This site was a flat to undulating site on the top of a broad ridge above the river, near the Monpeelyata Canal. It comprised *Eucalyptus pauciflora* woodland over a mid-dense low shrub layer of *Cyathodes parvifolia*, *Leucopogon hookeri* and *Lomatia tinctoria*, and a predominantly grassy ground cover of *Poa gunnii*, *Elymus scabrus*, *Danthonia penicillata*, *Deyeuxia quadriseta* and *Dichelachne rara*. The following herbs also contributed cover: *Plantago paradoxa*, *Acaena novae-zelandiae*, *A. echinata*, *Geranium sessiliflorum* and *Glycine clandestina*. The local geology was dolerite, and the site was fired at reasonably frequent intervals (F. Duncan, unpublished data).

Closer to the Ouse River and near Remarkable Rock, *G. latrobeana* has been collected in flower and fruit (1980). This site was located in small meadows above the river at an altitude of 850 m.

Two collections of this species have been made close to sea-level at Cape Portland, in the far north-east of Tasmania. The first site was located on the neck of the Cape Portland headland in the Cape Portland Wildlife Sanctuary (1983). *Glycine* was, however, extremely rare. It was located in pasture dominated by *Zoysia*, *Trifolium*, *Cerastium*, *Plantago* and *Lomandra*. The second site (1991) was located four kilometres farther south, at Petal Point on the border of the Wildlife Sanctuary. *G. latrobeana* was localised and growing in sandy soil on a grassy flat.

One record exists of *G. latrobeana* at Dogs Head Hill, north of Mole Creek, on limestone at about 350 m elevation (Duncan 1989). This population was not relocated in late January, 1992, although *G. microphylla* and *Desmodium gunnii* were collected. *G. latrobeana* may still be present at the site, since these two *Glycine* species are in coexistence on the Upper Ouse River; it was described as common on the north-facing lower and mid-slopes amidst grassy *Eucalyptus amygdalina* woodland (Duncan 1989). These slopes were frequently fired. The low-to-medium understorey was dense and included *Acacia dealbata*, *A. melanoxylon*, *Pultenaea juniperina*, *Lomatia tinctoria*, *Bossiaea riparia* and *Acrotriche serrulata*. The ground layer was also dense, comprising *Pteridium esculentum*, *Lomandra longifolia*, *Lepidosperma laterale, Dianella* sp., and the grasses *Elymus scabrus, Danthonia pilosa, Themeda australis, Poa* sp., *Ehrharta stipoides, Dichelachne rara* and *Deyeuxia quadriseta.*

Table 9.1: Summary of habitat records and conservation information for *G. latrobeana.*

Recent Records:	13 Sites recorded, 7-(9) extant	
Habit:	Small, perennial trifoliate herb, trails across ground if protected from grazing	
Population Size:	100 - 1 000 (lower end)	
Regeneration:	Type:	Presumed from soil-stored seed
	Observed?:	Not observed,
Habitat:	Landform:	(Flat ridgetops) - gentle slopes of plains, ridgelines, valleys
	Altitude:	Near sea-level - 900 m
	Aspect:	North to south-east
	Slope:	Gentle (usually < 10°)
	Community:	Dry sclerophyll shrubby to grassy woodland *(Eucalyptus viminalis, E. pauciflora, E. dalrympleana)*, may be in pasture
Fire response:	May resprout, significant seed germination of G. clandestina after moderate intensity burns (Auld & O'Connell 1991)	
Conservation Status:	Proposed:	**Vu*v**
	Current:	**V** (ANZECC 1993); **Rr3** (Kirkpatrick *et al.* 1991b); **3RCa** (Briggs & Leigh 1988)
Reserve:	None	
Comment:	* Collected in the Cape Portland Wildlife Sanctuary, but was extremely rare Herbarium specimen not collected from site at Dogs Head Hill, Mole Creek (proposed reserve), and population may actually have been *G. microphylla*	

9.4 Phenology

The main flowering period for *G. latrobeana* is in spring, with fruiting following until mid summer (Table 9.2). Specimens held at the Tasmanian Herbarium with fertile material were collected November, 1826 (flowers), November, 1837 (flowers), 14th of December, 1980 (flower and pod) and 8th of October, 1983 (flowers).

Table 9.2: Phenology of *G. latrobeana,* as determined from literature and Tasmanian Herbarium records.

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Blombery (1967)									F	F	P	P
Woolcock (1991)									F	F	F	
Lynch (pers. obs.)	P									b	F	FP
Herbarium records										F	F	FP

b Buds present
F Flowering
P Fruit present

Field observations were made of a population of this species which occurs on the Powranna Road, at the northern end of Epping Forest. These observations generally agree with the literature records. The plants die back over winter, to reshoot from the thickened tap root in October. The stems develop, and then purple-tinged buds with long black hairs form. This population flowered from about 12th of November until about the 4th of December, 1991. The peak of the flowering occurred between approximately 14th - 24th of November. Pods were not observed on this population, however, it is expected that production occurred from mid-November until early January. The plants were grazed by sheep during January, and were no longer apparent.

9.5 Propagation

One of the features of this species which can make identification more difficult is that cross-pollination is partially suppressed, with reproduction being via both chasmogamous and cleistogamous inflorescences. Chasmogamous flowers on *G. latrobeana* are axillary racemes of 8 - 20 flowers crowded near the end of an erect peduncle of up to ten centimetres length, and are fertilised through cross-pollination. Cleistogamous flowers are often single flowers, frequently in the lower axils, and on very short (0.5-1 mm) peduncles. These flowers do not open, but self-fertilise, and correspondingly are clonal of the parent plant. Greenhouse maintained stock of *G. clandestina* developed good quantities of cleistogamous fruit through all seasons except winter, but chasmogamous fruit was only produced in summer. Pods could be picked while still green, and seed would then store okay. One pod which opened while still attached to the plant and filled with water, was observed to have successful germination of all seeds while still in the pod.

Statistically adequate quantities of seed were not available for germination trials, due to the confusion about species identification, and also the very limited quantities of seed produced in the wild. A simplified test was, therefore, conducted using genetically confirmed seed held at the Division of Plant Industry, C.S.I.R.O., Canberra. The seed had been collected more than five years previously and stored in air-tight containers at room temperature. Five seeds each of the *G. latrobeana* populations on the Upper Ouse River and Pig Farm Hill were surface sterilised and then scarified (Section 2.2.6). Five seeds were also treated of *G. microphylla* from the Upper Ouse River, and of *G. clandestina* from the Lagoon of Islands population. Seeds of *G. latrobeana* from plants grown in the La Trobe University glasshouse, Melbourne, were also treated. All seeds germinated within one week of scarification, except for the La Trobe seeds which took nine days.

Auld and O'Connell (1991) tested *G. clandestina* in germination trials with a range of heat treatments (40, 60, 80, 100, 120^{o}C) and a range of exposure periods (1, 5, 10, 30, 60, 120 minutes). They found a 99.6% viability of the seed lot with 4.2% non-dormant. The germination response had a restricted pattern compared to other species tested. Germination was greatest after a heat treatment of 80^{o}C for more than ten minutes, with a trend towards increasing germination with increasing duration of exposure. Germination was highest for short temperature exposures (<10 minutes) at 100°C, with about 80% response after one minute of heat treatment. Longer durations of exposure resulted in decrease in resultant germination and after ten minute exposures in death of the seeds. A component of seeds was killed at both 80° and 100°C, while the ungerminated remainder were viable and dormant. Treatments of 60° and 40°C were largely ineffectual. Auld and O'Connell (1991) state that *G. clandestina* probably resprouts after fire.

The authors used these results to predict the response from simulated low and moderate intensity simulated burns at one centimetre intervals to a depth of eight centimetres. These results are reproduced in Table 9.3. They indicate that significant germination is only achieved during moderate intensity fires, and only at depths of two centimetres or less, where temperatures of 80°C are experienced. Low intensity fires induce temperatures of only 40°C at these depths. The assumption used for seed presence in the soil profile was that seed was distributed evenly within each depth range: 0-5 cm (64.5% of seed), 5-10 cm (20%) and >10 cm (15.5%).

Although it cannot be assumed that *G. latrobeana* would respond to heat trials to the same degree as *G. clandestina*, the scarification trial suggests that germination is inhibited only by the seed coat. Heat trials and firing patterns should, therefore, also result in germination of this species, and quite possibly to a similar extent.

Table 9.3: Predicted percentage germination of *G. clandestina* under two fire intensities (L Low, M Moderate) for a range of soil depths (after Auld & O'Connell 1991).

Depth/ Intensity	1 cm	2 cm	3 cm	4 cm	5 cm	Total seed bank
L	3.4	1.2	0	0	0	0.6
M	19.3	22.8	3.4	2.3	1.4	6.4

9.6 Discussion

The Tasmanian species of *Glycine, G. latrobeana, G. clandestina* and *G. microphylla*, as well as *G. tabacina*, have commonly been confused. They are all palatable trifoliate herbs restricted to grassy and shrubby woodlands, and usually grazed back to a few short stems. These communities occur in the Midlands, on the Central Plateau, and in occasional near-coastal sites. They therefore tend to be on private land and also grazed, usually by sheep. The implications of this are that the sites usually are fired reasonably frequently, and the native vegetation may be under considerable pressure from grazing of flowers, fruit, germinants and new shoots. The sites may at some stage come under the threat of clearance and even ploughing or fertilising to improve the quality of pasture. *G. latrobeana* is of sparse distribution across its range, and intraspecific competition is another possible limit to its abundance.

The preferred habitat of *G. latrobeana* appears to be on well-drained and well-insolated sites with a dolerite substrate or sandy soils, usually on flats or gentle slopes of plains, ridgelines, or valleys. The sites vary from near sea-level to 900 m altitude, but tend to be in dry sclerophyll shrubby woodland, often with a dense grass component of the ground layer, and dominated by *Eucalyptus viminalis, E. pauciflora* or *E. dalrympleana.* The species may also occur in grasslands. Some overstorey cover appears to be required in the Midlands populations, so a balance must be achieved between regeneration of canopy species with maintenance of an open shrubby to grassy understorey.

Its regeneration ecology appears to be typical of dry sclerophyll species. The species produces hard seeds which may join the soil-stored seed bank and germinate after mild to hot fires. Seed of *Glycine latrobeana* has been observed to germinate without treatment on plants in the greenhouse. However, the precise level of non-dormancy has not been determined. *Glycine latrobeana* may also resprout, a characteristic enhanced by its thickened tap-root. This tap-root enables the species to lie "dormant" through winter, and reshoot, flower and fruit in late spring to early summer. The timing of grazing is, therefore, very important to the survival of this species. Although the seed persists in the soil, spring-summer grazing over many years, combined with frequent firing, will deplete the seed bank and the capacity of the species to persist. The seed has a high viability and probable longevity but is not known to be easily or commonly dispersed. The sites are usually very localised and most are subject to frequent firing and grazing. All sites are, therefore, important to the survival of the genetic diversity of this species in Tasmania.

Importance has already been given to the genetics of this species with its inclusion in a programme run by the Division of Plant Industry, C.S.I.R.O., hybridising native *Glycine* species with the cultivated soybean, *Glycine max.* It is hoped that successful hybridisations could transfer desirable properties such as frost and drought tolerance to the soybean, and thereby translate to increased hardiness.

Glycine species may also find another use in environmental management. Experimental trials on *G. clandestina* indicate that it's germination response has a restricted pattern which may make it useful as an indicator species to predict fire response in other legumes (Auld & O'Connell 1991). This may benefit rare *Glycine* species where they co occur with *G. clandestina* by indicating suitable management practices to maintain these species. Caution should be applied, however, until germination trials are conducted on *G. latrobeana* itself and its comparative response determined.

10. *HARDENBERGIA VIOLACEA* (Schneev.) Stearn.
(False Sarsparilla, Purple Coral-pea, Happy Wanderer)

10.1 Morphology (from Curtis & Morris 1975, Gardner 1991)

Hardenbergia is a genus of three species, all endemic to Australia, and occurring in all States except the Northern Territory. They consist of twining and trailing herbs or subshrubs that are sometimes upright in growth.

H. violacea is a trailing or twining, glabrous shrublet commonly known for the robust and prolifically sprouting cultivar "Happy Wanderer". The "native" version has much fewer stems and tends, in Tasmania, to be grazed back to the tough, usually reddish stems of less than about 60 cm length. The leaves are dark green, glabrous, firm, alternate, ovate to lanceolate, with a rounded and mucronulate apex, and strongly reticulate upper and lower surfaces. The flowers are small, violet to royal purple or sometimes pink or white pea-flowers with a yellow flare at the base of the standard. They are about eight millimetres across, and grouped in twos or threes on axillary peduncles in long racemes. There are five short calyx lobes, nine united stamens and one upper free one. The fruit is a flat, oblong pod of 20 - 45 mm length, and usually contains six to eight seeds of 4 - 5 mm length.

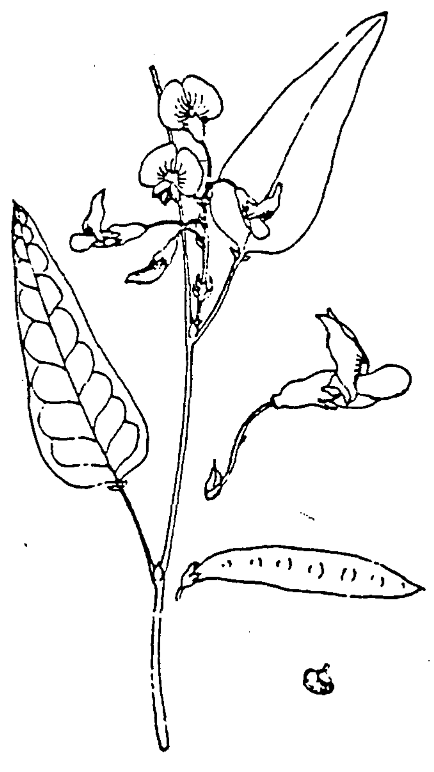


Figure 10.1: Morphology of *H. violacea* (from Woolcock 1991).

10.2 Distribution and Rarity

H. violacea is widespread in eastern Australia. Populations may be found from south-east Queensland, through all divisions of N.S.W., except the South Far Western Plains, south to Victoria, where it occurs in all regions except the Mallee, Wimmera and Corangamite (Figure 10.2). It is also distributed through south-east

South Australia. In Tasmania, this species has long been recorded by J.D. Hooker from a record of A. Oldfield: in "rocky hills, near Frogmore, Richmond" (Curtis & Morris 1975). Curtis suggests that the plants may have been introduced to this estate. It still occurs at two sites, close together on the eastern slopes of the Pontos Hills, to the north of Penna, south-east Tasmania (Figure 10.3). No other populations have been located in Tasmania, despite its widespread and abundant distribution right through south-eastern Australia. The total abundance of the species in Tasmania comprises less than 100 plants. It is possible that other extant populations of *H. violacea* have been overlooked. Surveys of suitable similar habitat were not conducted during this study.

Hardenbergia violacea is listed as unreserved and vulnerable (**uv**) in Kirkpatrick *et al.* (1991b). Both sites in the Pontos Hills are on private land, grazed by sheep, and the continuing survival of the species in Tasmania is dependent on the management practices of one landholder.

10.3 Habitat

The nomination of a robust cultivar of *H. violacea* as "Plant of the Year" in the early 1980's has resulted in the subsequent proliferation of this species in Tasmanian gardens. The native stock of this species is, however, much wirier and trailing, rather than a bushy climber. Its nitrogen fixing capacity makes the species prone to grazing of both leaves and stems.

In Victoria, *H. violacea* is widespread in open forest, and often forms rich purple carpets on dry ground (Galbraith 1977). Jessop and Toelken (1986) state that *H. violacea* is common in forests and undisturbed areas while Gardner (1991) states that the species is present in a variety of habitats. However, Conabere and Garnet (1987) agree with Galbraith that the preferred habitat is open, as found in roadside cuttings, lightly timbered places and stony grasslands. My own observations were that the species was abundant in Victoria on roadsides and in frequently burnt, open dry sclerophyll forest. It also appeared to be quite drought tolerant, often inhabiting dry ridgelines and hilltops. The plant was also more vigorous or less grazed, in Victoria, and trailed over the ground or twined up through other shrubs and trees.

In Tasmania, the two sites containing *H. violacea* were both on small sandstone outcrops on the lower eastern slopes of the Pontos Hills. The overstorey at the northern site was dominated by a low woodland of *Eucalyptus viminalis* and *Allocasuarina verticillata,* with rare *Exocarpos cupressiformis.* A sparse shrub cover at

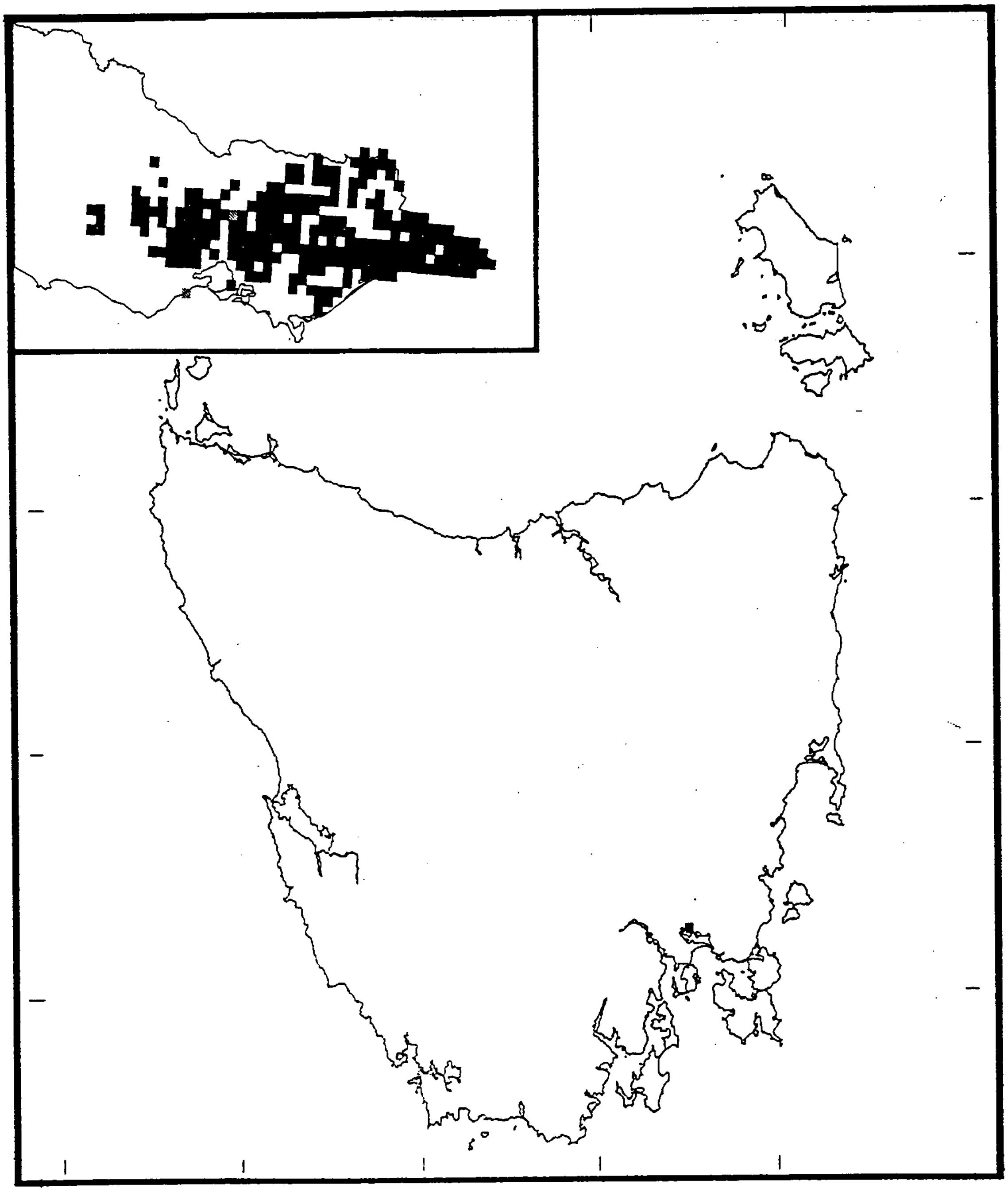


Figure 10.2: Distribution map of recently confirmed populations of *H. violacea* in Tasmania and Victoria.

1-1.5 m height comprised *Boronia anemonifolia,* with occasional *Helichrysum obcordatum.* At ground level, was a very high rock cover, a moderate cover of *Allocasuarina* litter, and occasional *H. violacea* (less than 20 plants), *Acrotriche serrulata, Astroloma humifusum, Dianella revoluta, Gonocarpus tetragynus* and *Poa* sp. The site had a north-eastern aspect, a moderately steep gradient of up to 10^{o}, and a skeletal soil. Grazing of the *Hardenbergia* was evident, probably by rabbits, sheep and insects, and many of the plants were located beneath other shrubs or amongst fallen timber. Some of the *Allocasuarina, Eucalyptus* and *Hardenbergia* were dying, apparently of old-age. Regeneration was rare.

The southern site (Figure 10.3) was similar, with a low, open cover of *E. viminalis* dominating a sub-canopy of *Acacia mearnsii* and *Allocasuarina verticillata,* with occasional *Exocarpos cupressiformis.* The site had a north-eastern aspect, a gradient of 3^{o}, and skeletal soil. An open shrub cover at 1-1.5 m was dominated by *Dodonaea viscosa, B. anemonifolia and Helichrysum obcordatum.* The ground layer had a very high rock cover, and sparse area of bare ground. Ground vegetation consisted of occasional *Poa* sp., *Hardenbergia violacea* and *Lomandra longifolia.* Sheep grazing was evident to 1.5 m up some trees. Less than ten plants were noted at the site.

Table 10.1: Summary of habitat records and conservation information for *H. violacea.*

Recent Records:	2 Sites recorded, 2 extant	
Habit:	Trailing shrub, usually grazed back to a few stems	
Population Size:	10 - 100 plants total in Tasmania	
Regeneration:	Type:	Presumed seed germination
	Observed?:	Not observed
Habitat:	Landform:	Sandstone ledge on side of dolerite hill
	Altitude:	150 - 170 m
	Aspect:	North-east
	Slope:	3 - 10^{o}
	Community:	Low open, *Eucalyptus viminalis* - *Allocasuarina verticillata* woodland over sparse heath
Fire response:	Presumed seed germination, resprouts after fire	
Conservation	Proposed:	**ue**
Status:	Current:	**uv** (Kirkpatrick *et al.* 1991b)
Reserve:	-	
Comment:	Confined to private land Old community with overstorey and *H. violacea* dying of old-age Regeneration rare due to grazing by rabbits, sheep and insects	

Figure 10.3: The Pontos Hills, south-eastern Tasmania; a habitat island for *H. violacea* in a sea of pastureland.

10.4 Phenology

Hardenbergia violacea usually flowers from late July until November, with pods developing through December (Table 10.2). Two Tasmanian Herbarium specimens of flowering material from the sites at Pontos Hills were collected 8th of August, 1981. These sites were visited on 28th of July, 1990, at which time almost all plants had buds present, while occasional plants had already reached budburst.

Table 10.2: Phenology of *H. violacea*, as determined from literature and Tasmanian Herbarium records.

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Blombery (1967)									F	F	P	P
Conabere & Garnet (1987), Gardner (1991)									F	F	F	
Jessop & Toelken (1986)							F	F	F	F	F	
Rodway (1903), Woolcock (1991),									F	F	F	
Lynch (pers. obs.)							b					
Herbarium records								F				

b Buds present
F Flowering
P Fruit present

10.5 Discussion

Proliferation of the popular garden cultivar of *Hardenbergia violacea* belies the actual health and abundance of the species in Tasmania. The "native" stock is much wirier and trailing, rather than a bushy climber, and tends to be grazed back to the tough, usually reddish stems of less than about 60 cm length.

Although widespread and abundant in south-eastern Australia, only two sites in Tasmania have ever been located. These sites, close together and still extant on the eastern slopes of the Pontos Hills, south-east Tasmania, have been suggested to have been where the species was introduced to the estate. There is no evidence to support such an introduction, however, other than the species' extreme localisation in Tasmania. The habitats themselves are quite localised, and there is no sign of past habitation nearby. It would have been unusual for a species to be directly introduced well away from the homestead. Bird dispersal of this species is possible, but has not been recorded in the literature. The nearest known representative of the species is a large plant in a garden at Richmond, five kilometres to the north-west.

H. violacea may be restricted in Tasmania by competitive exclusion from other habitable areas. *H. violacea* may be like *Desmodium gunnii* in having a wide range but being in Tasmania at the edge of its realisable range. Ecological tolerances or competition may then exclude them from sites, otherwise apparently habitable.

Both sites comprise small sandstone outcrops, with remnant low woodlands of *Eucalyptus viminalis* and *Allocasuarina verticillata,* and an open heath understorey dominated by *Boronia anemonifolia* and *Helichrysum obcordatum.* The sites are grazed and damage to the *Hardenbergia* was evident. The community also appears to be senescing, and is in need of regeneration.

11. *HOVEA CORRICKIAE* J.H.Ross (Corrick's Hovea, Glossy Hovea)

Hovea corrickiae is a newly recognised species, having only been recently described in 1990. Four species of *Hovea* are currently known to occur in Tasmania: *H. corrickiae, H. "lanceolata", H. linearis* and *H. montana*. *Hovea corrickiae* has been confused with *H. longifolia* and *H. lanceolata*. The former does not occur in Tasmania, being a distinct species with a narrow distribution almost entirely within the central coast area of New South Wales. *Hovea lanceolata* is a widespread species of New South Wales, Queensland and Tasmania, although the Tasmanian material tends to look different and shows different ecological preferences. *Hovea montana* is a common species of alpine Victoria, New South Wales and Tasmania. *Hovea corrickiae* can be distinguished from *H. lanceolata* on the basal bract being inserted some distance below the paired bracteoles (Figure 11.1), rather than close together on the pedicel (J. Ross, pers. comm. and Ross 1990).

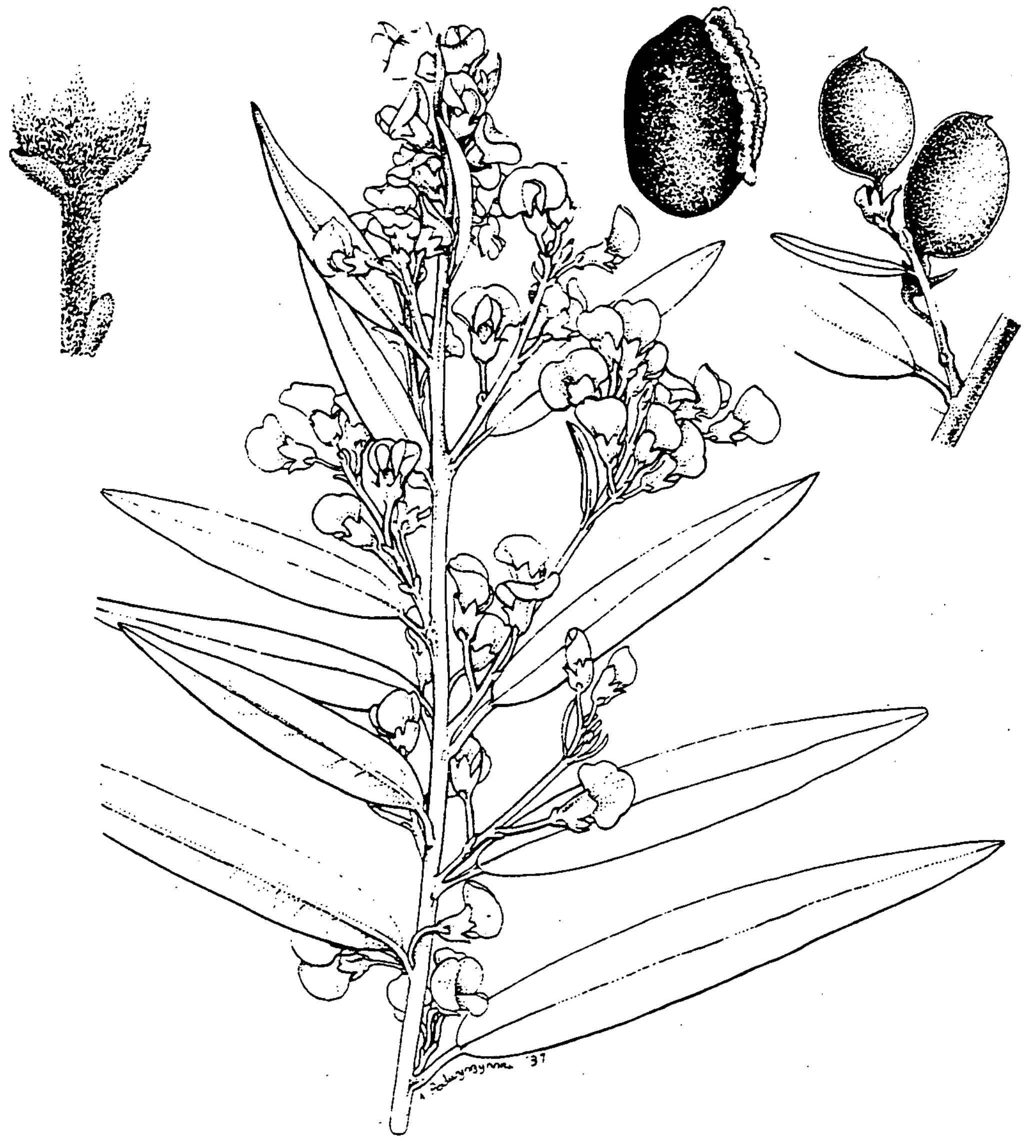


Figure 11.1: Morphology of *H. corrickiae* (from Ross 1990).

11.1 Morphology (from Ross 1990 and pers. obs.)

Hovea is a genus of approximately twenty species found in all States of, and endemic to, Australia. They are usually shrubs or undershrubs, often hairy with simple leaves of an oval, lanceolate or linear shape, and purple to violet and white pea-flowers.

Hovea corrickiae is a tall shrub or slender tree to five metres in height. The leaves are narrow ovate in Tasmania, are (1.7-) 3-11.4 cm long (0.5-) 0.7-2 cm wide, with an obtuse or acute apex and short mucro. Their upper surface is glossy, dark green and the lower surface is densely clothed with coiled or curled pale yellowish-white to rust-coloured hairs. The leaves spread almost at right-angles to the stem. The flowers occur in axillary clusters, on 5-9.5 cm pedicels with a bract inserted 4.5-8 mm below the bracteoles. The upper two calyx lobes are united, and the lower three are free. The standard is almost circular and notched, and the stamens are united. In Tasmania, the standard and wings tend to be white (the Victorian specimens pale to deep mauve), and the standard has a greenish-yellow basal flare. This species is a prolific flowerer, and the trees may appear to be glowing with the abundance of pale flowers. The fruit is an oval, inflated pod which explosively dehisces to release two large, brownish-black seeds with a white aril. The seeds are dark brown in colour, reniform in shape, and of dimensions 4.5-6 mm by 3-3.5 mm. The seeds of *H. corrickiae* are significantly larger than either the other papilionoid seeds or the mimosoid seeds of other species of this study (Appendix 23.3).

11.2 Distribution and Rarity

Hovea corrickiae occurs at several sites of high rainfall in the Grampians, western Victoria, and in the nearby Black Range. In Tasmania, it is known from only four extant populations, all in north-eastern Tasmania (Figure 11.2). One population occurs on a steep ridgeline in the Lower Marsh Creek Forest Reserve, south-east of St. Marys. Another is found along the roadside on more gently sloping hills above the South George River, in the St. Columba Falls State Reserve, north-west of St. Helens. The other two populations are riparian; on the George River, north-east of St. Helens, and Constable Creek, south-west of St. Helens. These areas are high rainfall areas, with the St. Marys area subjected to cloud-drizzle and also heavy rain with resultant flooding. One very old collection (October 1878) was made from the Georges River. This may actually have been from the South or North Georges River, or may have been from the Georges River to the north-east of St. Helens. Another Tasmanian collection of this species held at

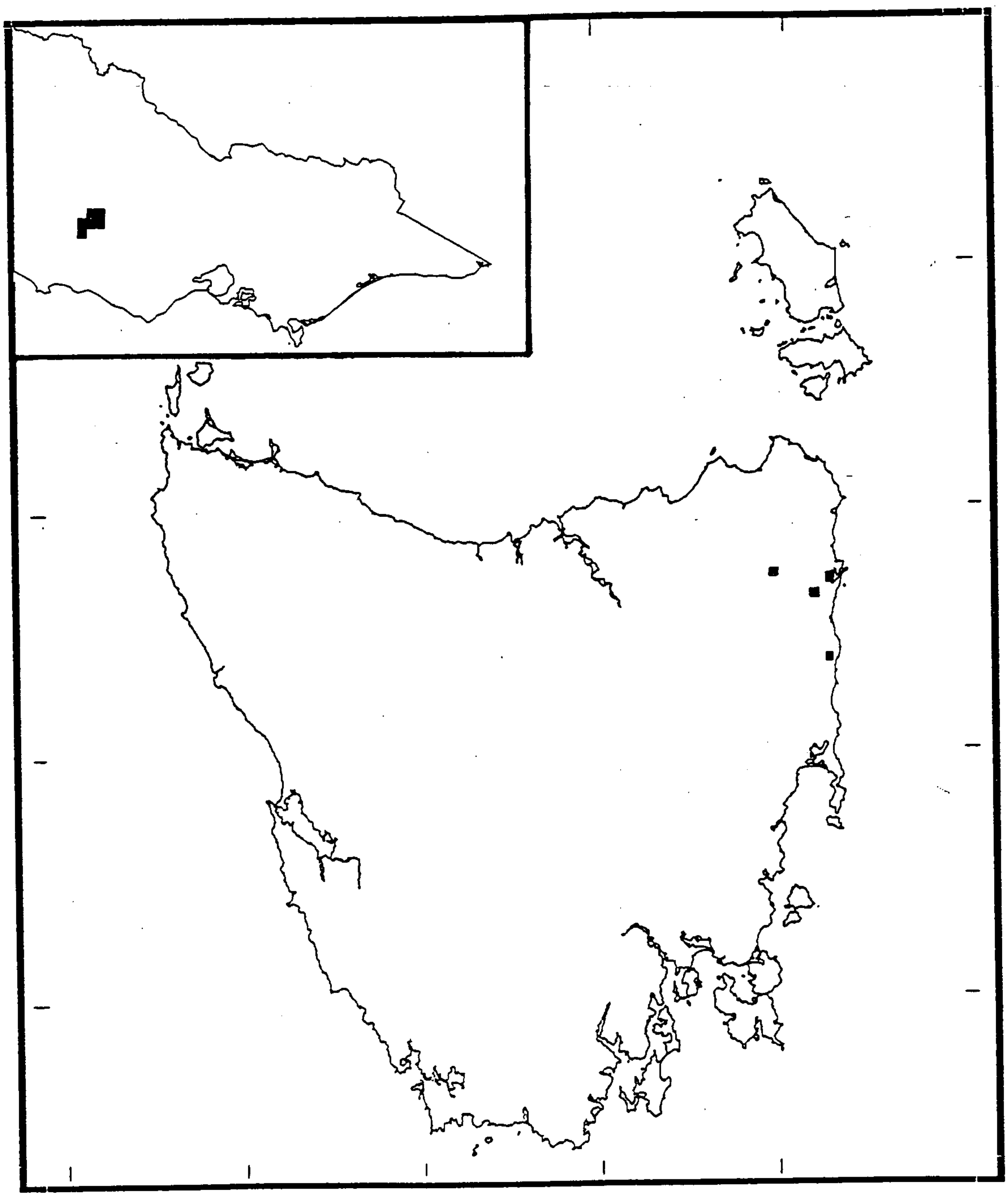


Figure 11.2: Distribution map of recently confirmed populations of *H. corrickiae* in Tasmania and Victoria.

the Victorian Herbarium is from the banks of the Douglas River, on the east coast. It was collected on 26th of October, 1848, from an isolated, tall shrub of slender, upright and six feet stature. It is possible that *H. corrickiae* is more widespread, and that other extant populations have been overlooked. Surveys of suitable similar habitat were not conducted during this study.

H. corrickiae is listed as rare (**r1**) in Kirkpatrick *et al.* (1991b). Because two Tasmanian populations and the Victorian populations are reserved, the conservation status of this species is secure. It is, however, a species of interestingly disjunct and discrete, localised populations. *H. corrickiae* should qualify for rarity status in Victoria (M. Corrick, pers. comm.), in Tasmania, and nationally because of this narrow and limited distribution.

11.3 Habitat

A species listed as *Hovea* sp. aff. *longifolia,* and supposedly *H. corrickiae,* is stated by Woolcock (1991) to occur in wet, lower to mid altitudes of the southern Victoria Range of the Grampians, south-western Victoria. In Victoria, *H. corrickiae* has been collected in the Victoria and William Ranges of the Grampians, and the nearby Black Range (Ross 1990). These sites have a moderate rainfall (500 - 600 mm p.a.). They occur on sedimentary substrates of Cambrian to Middle Devonian sandstones.

The Victorian sites tend to be in tall open *Eucalyptus cypellocarpa* and/ or *E. obliqua* forest with a dense heath understorey, and on a reddish clay soil. Associated species in the Victoria Range include *Acacia paradoxa, A. melanoxyylon, Banksia saxicola, Correa aemula, Pteridium esculentum, Pultenaea scabra, A. myrtifolia, Goodia lotifolia, Spyridium parvifolium, Goodenia ovata, Olearia asterotricha, Senecio linearifolius, Coprosma hirtella* and *Astrotricha asperifolia. Hovea* is rare at one site in the Black Range, and occurs on a sandstone substrate with *Howittea trilocularis* and *Westringia glabra.* In the Mt. William Range, *Hovea* is locally not uncommon around a gorge above falls. It is also known from the Grasstree Creek Reference Area.

No details are known of the Tasmanian site on the Douglas River, not even a more precise location. The George River population may be the same as the one collected in 1878 or may be a newly discovered one. The Constable Creek site was first located in 1988 from a bouldery talus slope (A. Buchanan, pers. comm.). The other sites were both recent collections; Lower Marsh Creek on 16th of May, 1983, and St. Columba Falls on 8th of June, 1983. Details with the specimens stated that they were located in open *Eucalyptus obliqua* and/ or *E. sieberi* forest and from *Acacia dealbata - Pomaderris apetala* or *Pomaderris apetala - Cassinia trinerva* dominated scrub, respectively (Ross 1990).

Figure 11.3: ***H. corrickiae* in *E. sieberi* open forest at Mt. Elephant.**

At Mt. Elephant, within the Lower Marsh Creek Forest Reserve, *Hovea* was locally abundant and regenerating without fire (Figure 11.3). It occurred in an open forest community of *E. sieberi* with *E. viminalis,* and an open scrub understorey of *Bedfordia salicina, H. corrickiae, Pomaderris apetala, Notelaea ligustrina* and *Cassinia aculeata* between 2-5 m height. Other shrubs included *Exocarpos cupressiformis, Olearia phlogopappa, O. lirata, Acacia terminalis, A. verniciflua* and *Correa reflexa.* The ground cover had a moderate to dense component of litter, and comprised *Lomatia tinctoria, Microsorum diversifolium, Dianella tasmanica, Lepidosperma* sp. and *Stellaria flaccida. Hovea* was most abundant on the south-eastern aspect of the steep (40^{o}) ridgeline, but also occurred on the crest of the ridgeline and on a steep cliff slope farther west. The ground vegetation was quite open, and many seedlings were observed amongst the scree. The geology consisted of clasts of dark, argillaceous Mathinna sediments with occasional conglomerate lenses farther along the ridge. The site although appearing dry, had a moist substrate protected by the shaded aspect, scree and litter cover, and an afternoon sea-breeze coming up the Lower

Marsh Creek valley. Cloud-lie is common along this easternmost range, and very heavy rainfall occasionally occurs. Several hundred plants were evident at this site.

The population structure analysis of plants observed along a transect on the ridgeline (which was more open and had more regeneration) accorded with a reverse-J shape (Figure 11.4). This indicated that the population was regenerating continuously, with many seedlings germinating and exponentially fewer surviving to maturity. Many of the seedlings were within four metres of the bole of a mature shrub.

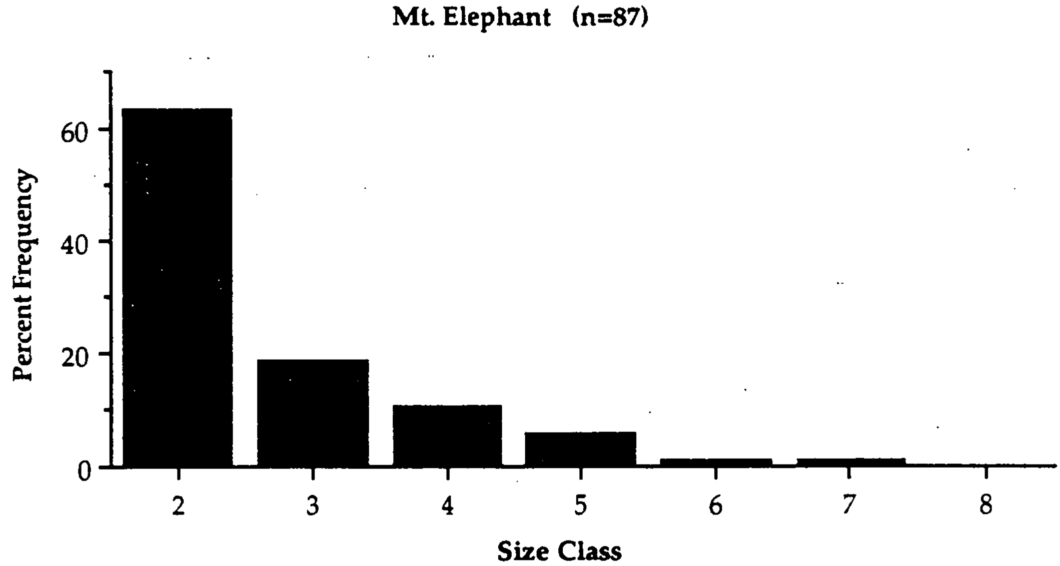


Figure 11.4: Population structure using centimetre size classes of *H. corrickiae* on a ridge site at Mt. Elephant (area surveyed was approximately 20 m by 60 m).

At the St. Columba Falls State Reserve, *Hovea corrickiae* occurred on the roadsides and upslope into the *Eucalyptus obliqua* dominated open forest, also with *E. sieberi* and occasional *E. regnans*. The open heath understorey was dominated by *Pteridium esculentum, Cassinia aculeata, H. corrickiae* and *Acacia verniciflua*. The ground layer was dominated by *Gonocarpus teucrioides* and *Lomandra longifolia*, and there was a sparse component of fallen timber. Other species present included *Acacia dealbata, Olearia lirata, Bursaria spinosa, Pultenaea juniperina, Goodenia ovata, Lomatia tinctoria, Stylidium graminifolium, Lepidosperma laterale* var. *angustifolium, Viola hederacea, Clematis aristata, Hypochoeris radicata* and *Comesperma volubile*. The *Hovea* occurred on north-east and north-west aspects of valley slopes with gradients up to 10°. The substrate was Quaternary siliceous sediments, and there was much charcoal within the soil. Many *Hovea* seedlings of various sizes were present, despite a paucity of mature plants within the forest; they were most prevalent along the roadside. The forest appeared to be frequently burnt by cool fires, and regeneration was probably from soil-stored seed. This site extended over an area of approximately 90 m by 70 m upslope, and other scattered populations occurred within the forest. Mature plants would total less than 100, however, regenerating individuals add another few hundred.

Hovea corrickiae co-occurs with the endangered *Phebalium daviesii* on the bank of the George River, north-east of St. Helens (Lynch 1994). The community occurs at low altitude (10-15 m a.s.l.) and consists of a riparian *Eucalyptus viminalis* woodland. The understorey is dominated by heath and wet sclerophyll species, such as *Allocasuarina littoralis, Pomaderris apetala, Zieria arborescens, Micrantheum hexandrum* and *Leptospermum lanigerum.* The presence of *Pterostylis pedunculata* and *Adiantum aethiopicum* indicate that the site is not moisture stressed. The site is moderately steep (about 8°), with coarse, sandy soil and exposed granite boulders. It is sheltered and humid, being close to the river and of south-eastern aspect. Disturbance has occurred through flooding, trampling by stock, and fires in approximately 1983 and 1969 (Lynch 1994). The *Hovea* probably regenerated after the most recent fire (Lynch 1994). The site is private property.

H. corrickiae has also been recently collected from Constable Creek near Mt. Echo, south-west of St. Helens (P. Barker, pers. comm.). This area also contained a population of *P. daviesii* in 1892 when it was collected by Rodway.

Table 11.1: Summary of habitat records and conservation information for *H. corrickiae*.

Recent Records:	5 Sites recorded, 4 extant	
Habit:	Tall shrub or slender tree to 5 m in height, with narrow-ovate leaves with a glossy, dark green upper surface and a pale to rust-coloured tomentose lower surface	
Population Size:	> 1 000	
Regeneration:	Type:	Germination from seed without, and after, fire
	Observed?:	Abundant at Mt. Elephant and George River sites
Habitat:	Landform:	Steep ridgeline and slopes, or valley slopes
	Altitude:	10 - 240 m
	Aspect:	South to south-east, north-east to north-west
	Slope:	10 - 40°, 6 - 10°
	Community:	*Eucalyptus sieberi/ E. obliqua +/- E. viminalis/ E. regnans* open forest over open scrub/ open heath of *Allocasuarina littoralis, Micrantheum hexandrum, Cassinia aculeata, Acacia verniciflua, Lomatia tinctoria, Dianella* sp.
Fire response:	Germination of seed, may survive cool burns (Victorian sites)	
Conservation Status:	Proposed:	**Rr1 / 3RCa**
	Current:	r1 (Kirkpatrick *et al.* 1991b)
Reserve:	St. Columba Falls State Reserve, Lower Marsh Creek Forest Reserve	
Comment:	Occurs on argillaceous or siliceous sedimentary or granitic soils in high rainfall areas (> 1 000 mm p.a.)	

11.4 Phenology

Hovea sp. aff. *longifolia,* supposedly *H. corrickiae,* is stated by Woolcock (1991) to be a spring flowering species. Flowering specimens lodged at the National Herbarium of Victoria were collected in the Grampians district on the following dates: 4th of October, 1929, 14th of September, 1963, September 1977, 1st and 5th of September, 1983, 22nd of September, 1984, 28th of September, 1985, 11th of October, 1986 and 9th of September, 1986. Fruiting material at various stages of development was collected on 24th of February, 1957, 14th of October, 1983, 17th of December, 1983, 9th and 15th of January, 1984, 2nd of December, 1986 and 7th of March, 1987. Vegetative material with small buds present was collected on 4th of March, 1948 and 14th of April, 1957.

Herbarium records of the Tasmanian populations show flowering was in progress in October, 1878, and more precisely on 26th of October, 1848. Specimens with buds present were collected 8th of June, 1983, 16th of May, 1983, and 21st of February, 1989 (Table 11.2).

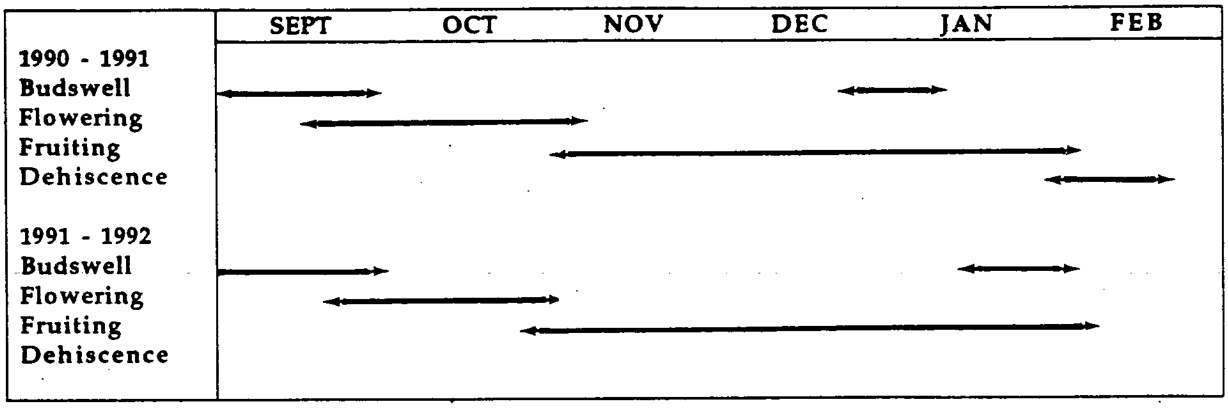
Table 11.2: Phenology of *H. corrickiae*, as determined from literature and Tasmanian Herbarium records.

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Woolcock (1991)									F	F	F	
Herbarium records (Vic.)	P	P	Pb	b					F	FP		P
Herbarium records (Tas.)		b			b	b				F		

b Buds present
F Flowering
P Fruit present

Field observations of the population at Mt. Elephant, Lower Marsh Creek Forest Reserve, indicated that the phenology of this species is one of flowering in early to mid spring, with subsequent fruit production in early - mid February (Table 11.3). In spring, 1990, buds began to enlarge in late August to mid September. Budburst, followed by earliest flowering, began in mid September. Flowering continued until late October. Fruit developed throuth the flowering period and into early February. Pods dehisced during February, and very small buds developed. The spring - summer, 1991 - 1992, phenological pattern was very similar, although the secondary flowering occurred later in this season, that is, early February, 1992, compared to early January, 1991. This comprised three of the tagged trees developing a small quantity of flowers while fruit production continued. The survey trees were checked again in spring - summer, 1992 - 1993. However, *H. corrickiae* produced very few flowers or seed in this season. Longer term monitoring is necessary to determine how variable fruit production actually is, and how normal was the prolific production of 1991 and 1992.

Table 11.3: Field observations of phenological activity, spring to summer, 1990 - 1991 and 1991 - 1992, at the Mt. Elephant site.



Flower and fruit production was much greater on shrubs on the roadside at St. Columba Falls than farther into the woodland under a closer canopy. Large quantities of seed were produced in both seasons, however, there was less in the 1991 - 1992. A large proportion of seed was lost to parasitism by a Lepidopteran caterpillar (D. Bashford, pers. comm.), the eggs of which were inserted into the young pod. Larvae developed within the pod, feeding on the seeds. Many of these pods were aborted early.

11.5 Propagation

Germination trials for this species included the dry heat trials of two minutes exposure to 100°C, 80°C, and 60°C, as well as a scarification trial and control. An initial test scarification of fresh seed conducted prior to the germination trials effected 100% germination, implying a high seed viability for this species.

All pretreatments conducted on *H. corrickiae* resulted in very good germination response. However, there was no germination without pretreatment. There was significant variation between all trials including the control ($p < 0.00001$, d.f. = 4, $F = 269.98$), and significant difference between the control and all other trials (Figure 11.5, Table 11.4). All seeds (mean 100%) germinated in the 80°C trial (treatment 3) and the scarification trial (treatment 1). However, there was no significant variation between these two trials and the 100°C trial (treatment 2) in which a mean of 93.4% of seeds germinated. These three trials formed one homogeneous group, with the 100°C trial result also being not significantly different from the 60°C trial (treatment 4, mean 90%).

Table 11.4: Scheffe multiple range test of variation between treatment means.

Treatment	Trial	N	Homogeneous Groups		
5	Control	30	X		
4	60°C	60		X	
2	100°C	60		X	X
1	Scarified	60			X
3	80°C	60			X

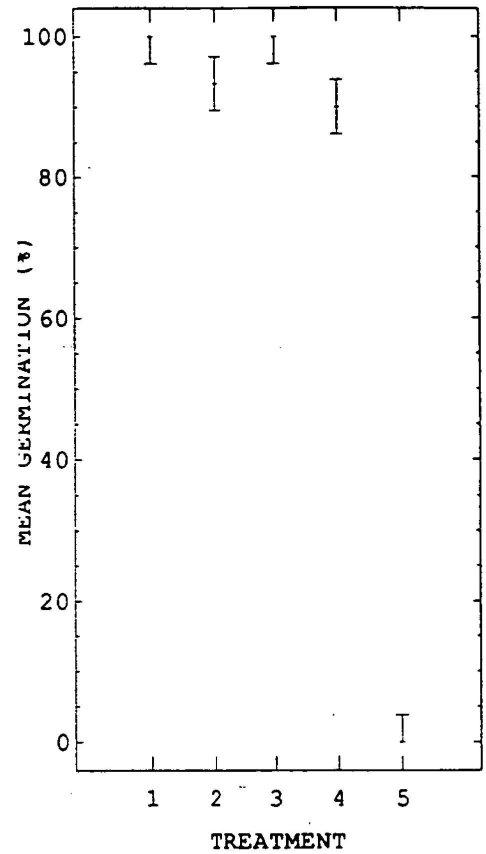


Figure 11.5: Range of mean results for germination trials with standard errors.

The response to the scarification trial was very rapid as well as effective; all seeds germinating within 12 days (Figure 11.6). Response to the heat trials proved much slower, with minimal germination inside 40 days (Figures 11.7 - 11.9). Peak germination for the heat trials occurred between 40 - 100 days after trial initiation.

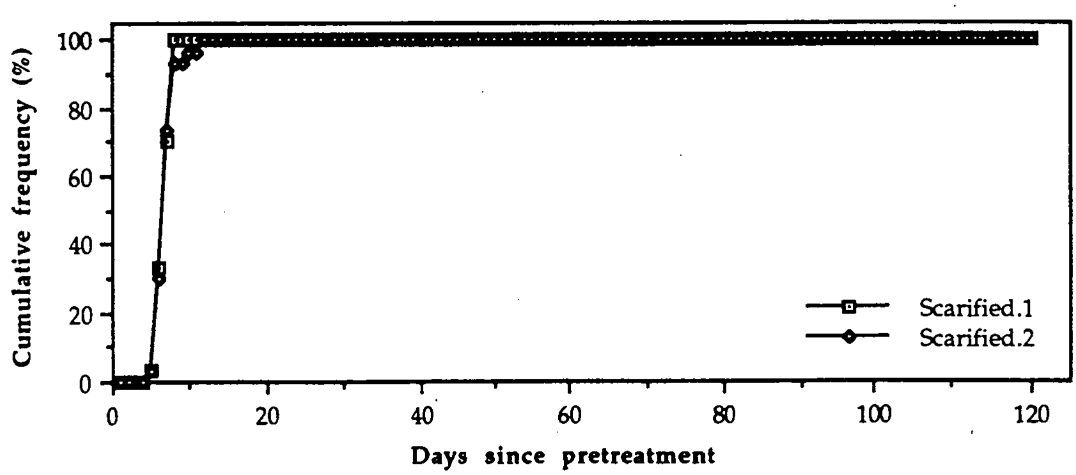


Figure 11.6: Germination response of *H. corrickiae* to scarification pretreatment (groups 1 and 2 represent replicate treatments).

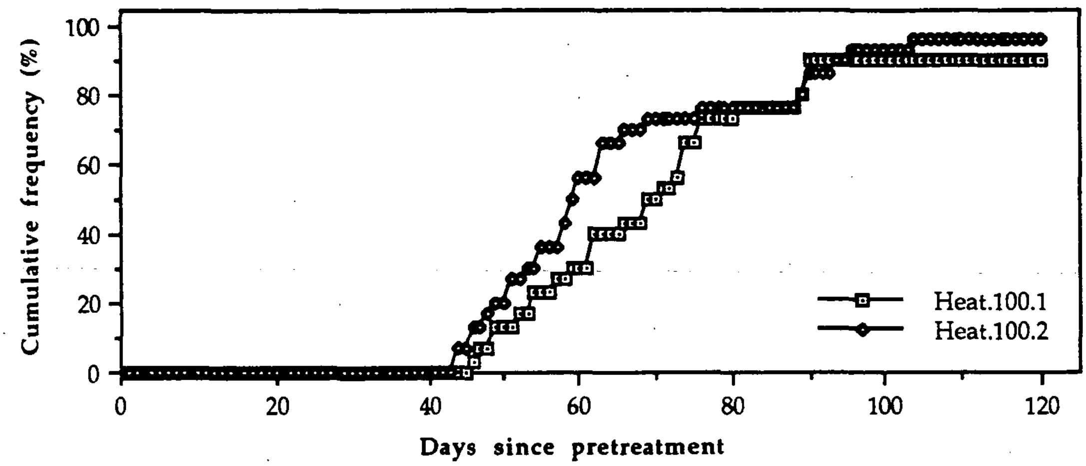


Figure 11.7: Germination response of *H. corrickiae* to pretreatment of 100°C (groups 1 and 2 represent replicate treatments).

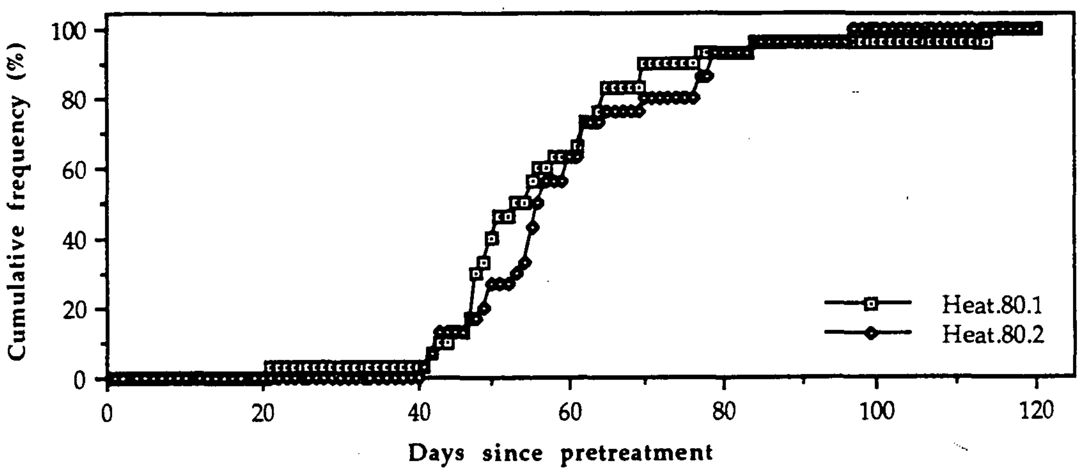


Figure 11.8: Germination response of *H. corrickiae* to pretreatment of 80°C (groups 1 and 2 represent replicate treatments).

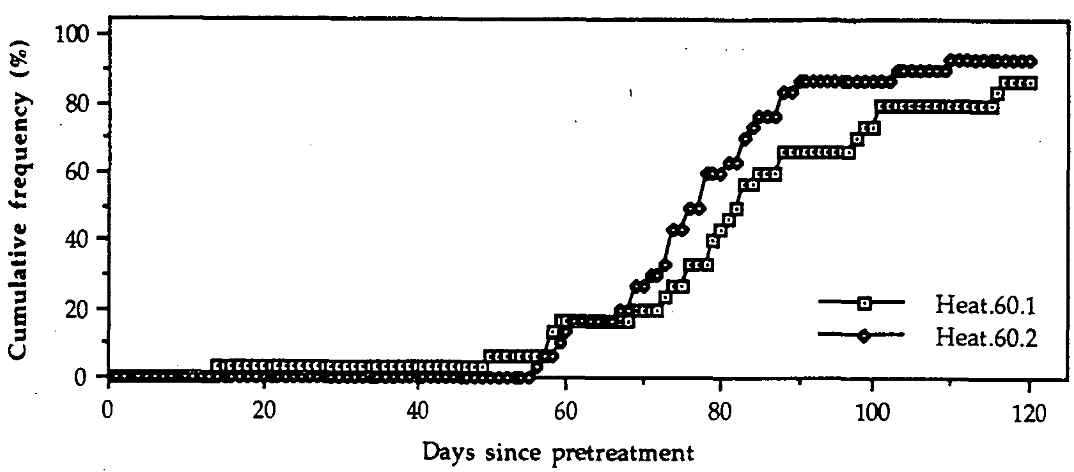


Figure 11.9: Germination response of *H. corrickiae* to pretreatment of 60°C (groups 1 and 2 represent replicate treatments).

11.6 Age of First Flowering

Approximately twenty seedlings of *H. corrickiae* were grown on in pots maintained initially inside a glasshouse and then outdoors at sea level in Hobart. After 2 years 4 months since treatment of the seed, or in their third spring season, one plant flowered. However, no fruit subsequently developed.

11.7 Pollination

The plants at the phenology site, Mt. Elephant, were observed on three occasions for periods of approximately eight hours. Two diptera, one small, the other with a long tail, were collected from this species when in flower in spring, 1990. These insects were observed on the flowers. Insects were very infrequently observed, and there did not appear to be any likely pollinator observed. The flowers of this species, however, have a very high rate of fertilisation.

11.8 Discussion

Hovea corrickiae and *H. lanceolata* both occur in Tasmania, and have similar morphologies. The genus *Hovea* is taxonomically confusing since many species have overlapping characteristics, and despite a different "look" in the field, it may be hard to separate determining features (J. Ross, pers. comm.). The Tasmanian populations of *H. lanceolata* tend to look different and show different ecological preferences to the mainland populations. Similarly, Tasmanian specimens of *H. corrickiae* differ slightly from Victorian ones in having a slightly shorter and more tightly coiled indumentum on the branchlets, in that the indumentum of the lower surface of the leaves is slightly sparser and often discontinuous, the indumentum of the calyx is shorter, and the flowers are slightly smaller (Ross 1990). Tasmanian and Victorian populations of *H. corrickiae* do, however, appear to occur in similar habitats.

Hovea corrickiae occurs at sites of moderate rainfall (500 - 600 mm p.a.) in western Victoria and high rainfall in Tasmania. Both the St. Helens and the St. Marys area receive more than 1 000 mm of precipitation per annum, with the latter also subjected to cloud-drip and occasional very heavy rain. The populations of both States occur on sandy substrates: Cambrian to Middle Devonian sandstones with clay soils in Victoria; Silurian - Devonian argillaceous, Quaternary siliceous sediments or Devonian granites in Tasmania. They are also in low to mid altitude hilly environments, in dry sclerophyll forest of *Eucalyptus* with a heath or scrub understorey. The sites generally are humid and poorly-insolated.

The conservation status of this species is very good, since many of the populations are reserved. It is, however, a species of interestingly disjunct and discrete, localised populations, with possible genetic diversity across its range. *H. corrickiae* should qualify for rarity status in both States and Nationally.

Regeneration of *Hovea* does not require fire. Seedlings were commonly observed at the Mt. Elephant site, regenerating mostly within four metres of the bole of a mature shrub. The size-class distribution of plants at this site indicates continuous regeneration. Regeneration appeared to be more common where the canopy was more open, such as along the ridge crest. There was no evidence of recent firing. Many *Hovea* seedlings of various sizes were also present at the St. Columba Falls site, despite a paucity of mature plants within the forest. They were most prevalent along the roadside. The forest appears to be frequently burnt by cool fires, and regeneration is probably from soil-stored seed. On the George River, *H. corrickiae* probably regenerated after firing ten years previously. Fire is therefore a part of the environment, but is not required for the maintenance of the species.

This species can produce abundant quantities of seed, which germination trials showed to have a very high viability and to have a dormancy engendered by the physical barrier of the seed coat. Disturbance of the seed coat through scarification or moderately high levels of heating resulted in very high germination response, with even 60^{o}C heating being sufficient to result in germination of 90% of seeds. None of the untreated seeds germinated, and the high incidence of germination without fire in wild populations is, therefore, somewhat problematic. The seed coat is quite thick and would need a severe degree of scarification to induce germination. Such severe scarification is possible but unlikely to occur in quantities equivalent to the number of seedlings at the sites. Little is known, however, about the incidence of natural scarification of seeds, and the number of seedlings is, in actuality, a very small proportion of the number of seeds produced by a population. The seeds were observed to incorporate quite easily into the scree and soil layer. Other possible explanations for the level of non-dormancy in *Hovea* are that there is a high level of non-dormant seeds released which was not detected in the experimental trials, or that some trigger such as cold stratification releases the seeds from dormancy. Further trials are required to determine the actual mechanism. It is very unlikely that the scree - soil ground layer would reach temperatures approaching 60^{o} or even 40^{o} without the incidence of fire, due to the sheltered nature and aspect of the sites. It could be expected that there is a large quantity of seed present in the soil-stored seed bank, and that a cool to hot fire would be the most effective method of regenerating a senescing population.

H. corrickiae is an early to mid-spring flowering species, with subsequent fruit production in early - mid February. A limited number of shrubs also display a secondary flowering. These shrubs develop a small quantity of flowers during the normal period of fruit production. This phenomenon was also observed in *Bossiaea obcordata* (Section 6.4). The fertilisation and fruiting of these flowers was not monitored. Flower and fruit production was much greater on shrubs on the roadside at St. Columba Falls than farther into the woodland under a closer canopy. It is possible that this is an artefact of the road, which may be a vector for migration of the pollinators. The more open canopy at the roadside also allows higher light levels. This in turn may allow plants greater assimilation of nutrients and a consequently greater reproductive effort, hence greater fruit production.

Large quantities of seed were produced in both seasons monitored, however, there was less in the 1991 - 1992 season than the previous year. This was proposed in the case of *B. obcordata* to be related to the drier conditions of the later year (Section 6.4). Greater moisture stress may have been a factor in this case also, although the *Hovea* sites are not as susceptible as the *Bossiaea* sites. The climatic conditions (e.g. temperature, light, precipitation) may generally not have been as suitable for plant growth and, subsequently, reproduction. Other factors affecting seed production are the relative success of the pollinators and of the predatory caterpillars. The pronounced paucity of flowers and fruit in the 1992 - 1993 season highlights the irregularity of fruit production.

12. *PSORALEA ADSCENDENS* F.Muell. (Mountain Psoralea, Dusky Scurf-pea)

12.1 Morphology (from Curtis & Morris 1975, Norris & Harden 1991, pers. obs.)

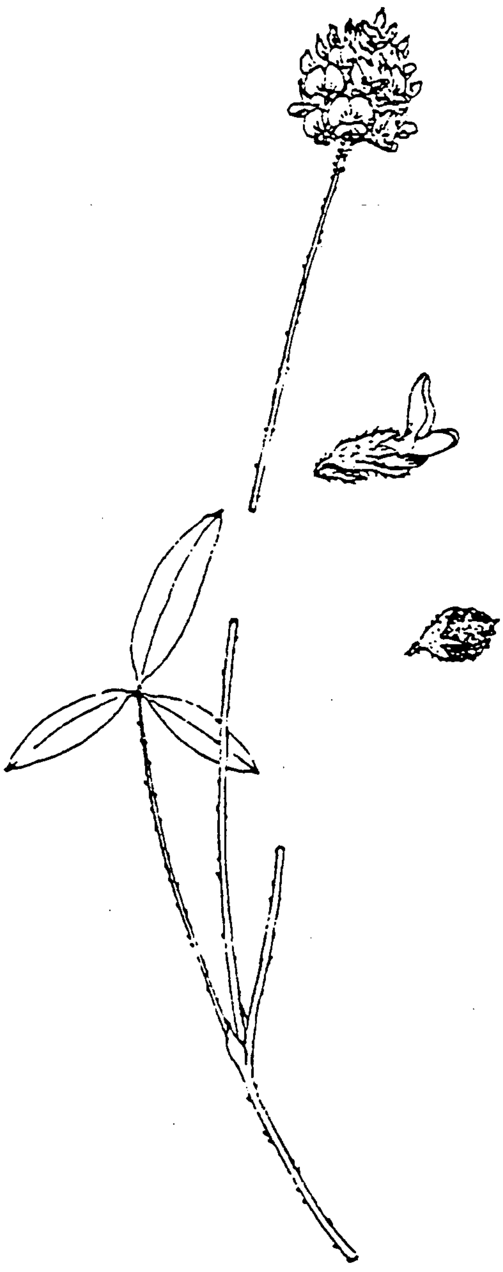


Figure 12.1 (a): Morphology of *P. adscendens* (from Woolcock 1991);

Psoralea adscendens is a small, slender, straggling to prostrate, perennial herb or, in Victoria, a small shrub. It has palmately trifoliate leaves of up to 15 cm length and with a 4-10 cm petiole. The leaves ascend on long-stalks of 30-80 cm length from the lower part of the stem. The stems are usually clothed with sparse more or less appressed dark hairs. The upper leaflets are lanceolate or elliptical, 2-5 (-7) cm long and 10-20 mm wide, the lower ones smaller and broader. The apices of the leaflets are acute, while their upper surface is dotted with dark glands. (The generic name comes from the Greek *psoraleos*, meaning scabby, and referring to these immersed glands; Jessop & Toelken 1986). The flowers terminate the stems on 20-35 cm peduncles in one or more small, dense ovoid or cylindrical spikes, 2-9 cm long. The flowers may be purplish-pink to white and 5-7 mm long, with ridged, dark-hairy calyces. The pod is black and ovoid, about three millimetres in length, glabrous, ridged or wrinkled, and indehiscent. The seeds are grey, reniform and 2.5-2.75 by 1.5-2 mm.

12.2 Distribution and Rarity

This cosmopolitan genus of approximately 150 species has a distribution concentrated in tropical and temperate regions, particularly South Africa (Norris & Harden 1991). It occurs in all States of Australia, represented by 18 species, two of which are naturalized (Norris & Harden 1991). The genus is currently under revision by J. Grimes of the New York Botanical Gardens.

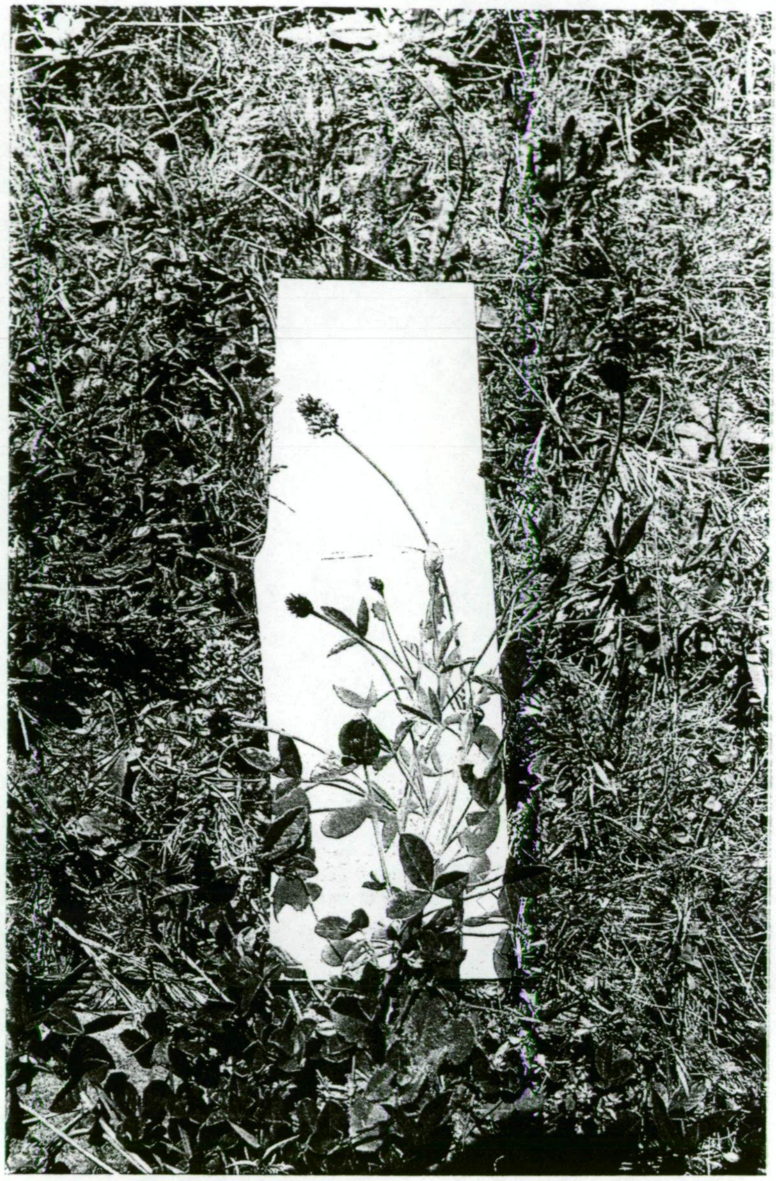


Figure 12.1 (b):

P. adscendens **at Sarah Anne Rocks, north-western Tasmania.**

Psoralea adscendens is widespread in all South-east Australian States. It can be found in the extreme south-east of South Australia, the Southern Tablelands of N.S.W., south from Queanbeyan, as well as in Victoria and Tasmania. In Victoria, it occurs in all districts except for South Gippsland, the Murray Valley, Mallee and Wimmera (Woolcock 1991, Figure 12.2). It is generally considered widespread but uncommon (Galbraith 1977), and more common at higher altitudes (Jessop & Toelken 1986). It usually occurs, in Victoria, on the more fertile soils of volcanic or basalt outcrops (D. Tonkinson, pers. comm.).

The common name of Mountain Psoralea is rather incongruous for this species considering its Tasmanian distribution, which is usually at sea-level on the North-west coast (Figure 12.2). It has been recorded by both Rodway (1903) and Curtis and Morris (1975) as present at Woolnorth, but that the populations are only local and not widespread (Curtis & Morris 1975). One other collection, in 1941, located the species at Conical Harbour, on the west coast. Interestingly, Rodway also reports this species from St. Marys, on the central east coast. There are only three recent collections of this species in Tasmania: from Sundown Point, Sarah Anne Rocks, and from Couta Rocks, all on the North-west coast. These populations are quite restricted, being confined to small headlands, of either sedimentary or weakly metamorphosed rock, in the predominantly sandy and orthoquartzite - mudstone sequences of this region of the coastline.

Psoralea adscendens is listed as rare (**r1**) in Kirkpatrick *et al.* (1991b). One population is reserved at the Sundown Point Aboriginal Site. The first degree State rarity status is a function of the species being restricted to an area of less than 100 km by 100 km in Tasmania. The populations are fairly small, and the total numbers of individual plants would be just into the 100 to 1 000 category. Less than 100 individuals would be reserved.

12.3 Habitat

Jessop and Toelken (1986) state that *P. adscendens* prefers shaded sites in higher altitude forest, with Norris & Harden (1991) agreeing that its chief distribution is in woodland at higher altitudes. Galbraith (1977) suggests a habitat of cool places, supported by Woolcock (1991) who is more expansive, stating that it is usually found along water-courses and on wet forested slopes of the eastern Victorian highlands, or wet forest edges in southwest Victoria. All of these sources refer to Victorian populations, as the Tasmanian ones are coastal, and are subsequently quite exposed.

The Sundown Point site was on a well-drained, low, rocky knoll about 20 m above the high tide mark. *Psoralea adscendens* was scattered in coastal heath amongst rocks near the top of the knoll, and slightly to leeward, where it was more protected. The site had a western aspect, moderate slope of 10°, and was situated on sedimentary rock. There was a moderate cover of rock and low shrubs, with a sparse grass cover, and occasional herbs. The shrub layer, at 0.4 m, was dominated by a dense cover of *Cyathodes abietina*, with sparse *Correa alba*, and very sparse *Acacia sophorae* and *Pultenaea dentata*. The ground layer was dominated by *Lomandra longifolia, Poa poiformis, Trifolium dubians*, and rare *Psoralea adscendens, Coprosma hirtella, Acaena novae-zelandiae, Cynosurus echinatus, Pentapogon quadrifidus, Hemarthria uncinata, Agrostis aemula, Stellaria* sp. and *Isolepis nodosa*. The vegetation was subject to wind pruning and grazing by wallabies. Indications of recent fire were not evident.

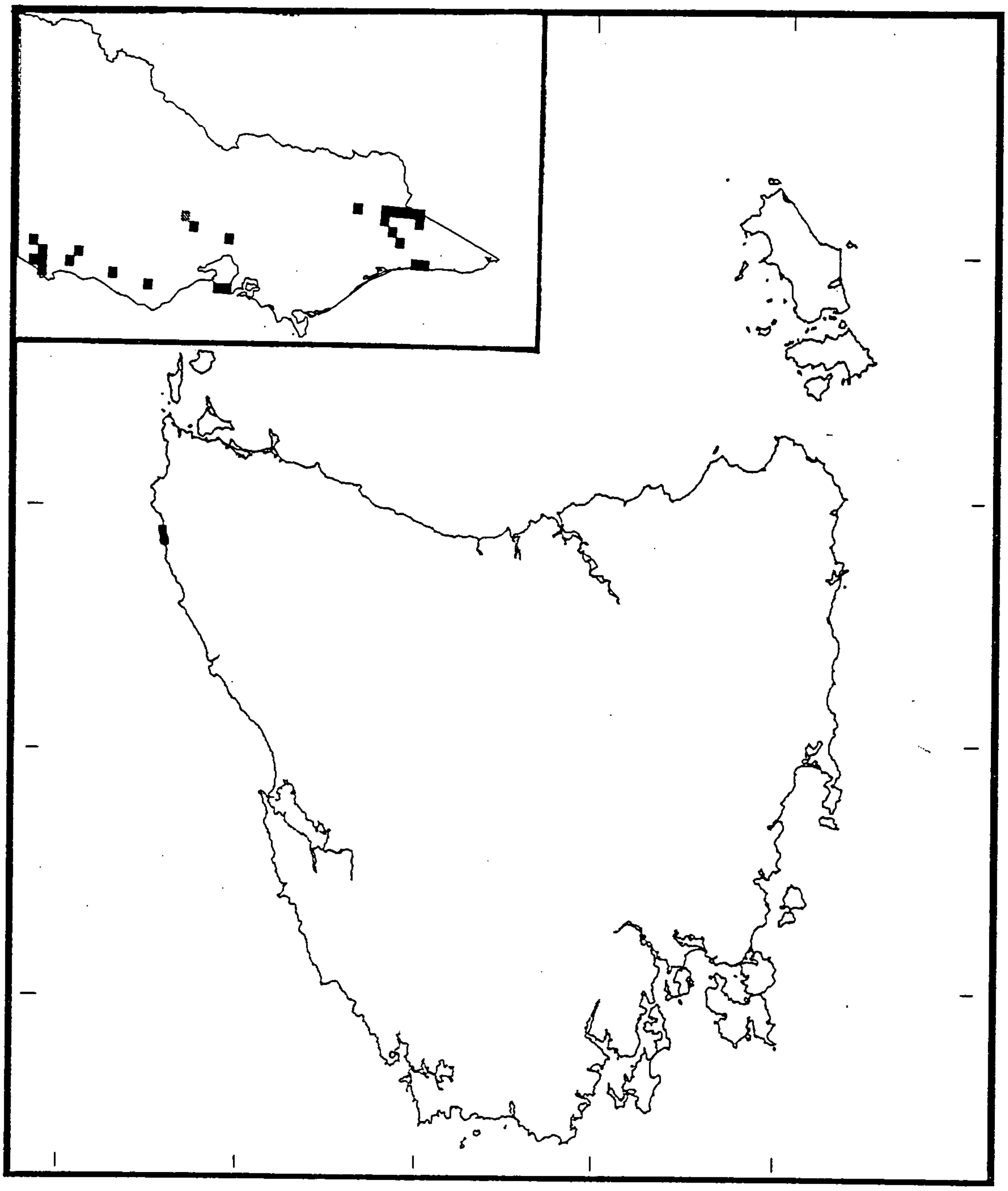


Figure 12.2: Distribution map of recently confirmed populations of *P. adscendens* in Tasmania and Victoria.

The site at Sarah Anne Rocks was very similar to Couta Rocks, being in coastal heath on a low, rocky headland of uplifted shale. It was steeper (30^{o}), had a south-westerly aspect, and had also a greater component of saggs and graminoids. *Cyathodes abietina* and *Correa alba* were locally common, however, the *Psoralea* was rare amongst *Lomandra longifolia, Dianella revoluta, Poa poiformis* and *Nablonium calyceroides.*

Figure 12.3: The herb-rich, heathy grassland at Couta Rocks, habitat of *P. adscendens.*

Couta Rocks, the most southern of the three known extant sites of *P. ascendens,* was again a well-drained low, rocky headland of weakly metamorphosed sediments approximately ten metres from high tide (Figure 12.3). *Psoralea* was most common in the heathy herbfield in the sandy soil of a drainage line, positioned in a saddle between rock outcrops; the slope here was 5^{o}, the aspect north-westerly. It was a more protected site, being to the lee of the onshore wind. There was a low cover of rock on the site, and similar covers of shrubs, herbs and grasses. *Cyathodes abietina* dominated the vegetation, along with *Leucopogon parviflorus* and *Monotoca submutica.* The ground layer was dominated by *Psoralea adscendens, Poa poiformis, Helichrysum acuminatum, Hypochoeris radicata* and *Calocephalus brownii.* Occasional *Pultenaea tenuifolia, Viola hederacea, Correa alba, Juncus planifolius, Poa rodwayi, Distichlis distichophylla* and *Danthonia penicillata* were also present. The site was subject to grazing and trampling by cows, but recent fire was not evident.

Table 12.1: Summary of habitat records and conservation information for *P. adscendens*.

Recent Records:	4 Sites recorded, 3 extant	
Habit:	Straggling to prostrate perennial herb	
Population Size:	100 - 1 000 (lower end of category)	
Regeneration:	Type:	Presumed seed germination
	Observed?:	Not observed
Habitat:	Landform:	Low, rocky headlands within coastal spray zone
	Altitude:	Less than 3 m above sea-level
	Aspect:	South-west through to North-west
	Slope:	5 - 30°
	Community:	Low, open coastal heath or heathy herbfield
Fire response:	Not observed	
Conservation Status:	Proposed:	**r1**
	Current:	**r1** (Kirkpatrick *et al.* 1991b)
Reserve:	Sundown Point Aboriginal Site (population of less than 100 individuals)	
Comment:	Confined to headlands of sedimentary or weakly metamorphosed sediments; sandy soils. Usually buffered from direct coastal exposure by being sited amongst rocks or leeward of the knoll or outcrop peak	

12.4 Phenology

The flowering time of this species has been recorded as mid spring to summer (Table 12.2). Later flowering (January) occurs at high elevations in Victoria (Conabere & Garnet 1987). Collections lodged at the Tasmanian Herbarium of flowering specimens have been made on 15th of January, 1941, and 8th and 11th of January, 1989. Plants were also in flower on 10th of December, 1990, and also in late January, 1992. Fruiting material has not been collected, nor was it seen during this study.

Table 12.2: Phenology of *P. adscendens*, as determined from literature and Tasmanian Herbarium records.

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Woolcock (1991), Norris & Harden (1991)	F	F										F
Conabere & Garnet (1987)	F										F	F
Jessop & Toelken (1986)	F											F
Rodway (1903)										F	F	
Lynch (pers. obs.)	F											F
Herbarium records	F											

F Flowering
P Fruit present

12.5 Discussion

Psoralea adscendens is a small, straggling to prostrate, perennial herb. In Victoria, *P. ascendens* tends to occupy high altitude woodland and forest, the sites often cool, moist and sheltered along water-courses. This distribution is exemplified by its common name of Mountain Psoralea. Even in South Australia, it is noted as preferring shaded sites in higher altitude forest. However, in Tasmania, this common name is quite incongruous. In Tasmania, the species is confined to small, coastal headlands at sea-level, and on sites of much greater exposure. The Tasmanian populations also vary from the more typical, and more common, Victorian populations in being located on sedimentary to metamorphic outcrops, rather than on volcanic or basalt outcrops.

The Tasmanian populations occur in low coastal heath or heathy herbfield within the coastal spray zone. The sites are all subject to wind pruning and grazing, and these maintain the openness of the sites. Evidence of recent firing was not observed, and the species' response to firing or intense or regular disturbance is not known. At these sites, the communities are dominated by coastal heath species, *Cyathodes abietina* and *Correa alba,* and commonly contain the grasses and herbs *Poa poiformis, Trifolium dubium, Pentapogon quadrifidus* and *Acaena novae-zelandiae.*

The primary determinant of this species' distribution in Tasmania may be its requirement for a cool, moist environment of high precipitation. The Victorian and Tasmanian *Psoralea* sites may be climatically similar; coastal conditions in North-western Tasmania approximating those of the eastern Victorian highlands, or south-western Victorian wet forest margins. The main differences are their geology and exposure. The restriction of the Victorian populations to volcanics or basalt may be a geographic corelation of these lithologies with mountain summits rather than a requirement of the species for high nutrient soils. However, substrate is a limitation on the species' extent in Tasmania; the sites are all localised to these small low, rocky headlands. The Tasmanian distribution may be a question of compromising relatively high fertility with a high rainfall regime. Fertile substrates are not common in coastal, western Tasmania. The exposed nature of the Tasmanian sites may be of competitive advantage to *P. adscendens.*

13. *PULTENAEA HIBBERTIOIDES* Hook.f./ *MOLLIS* Lindl.

(Guinea-flower Bush-pea/ Soft Bush-pea)

Pultenaea hibbertioides is a species originally described from the type locality near Georgetown, northern Tasmania, by J.D. Hooker (1856). It is closely related to *P. mollis* Lindl. (Soft Bush-pea, Narrow-leaf Bush-pea) and *P. viscosa* R.Br. ex Benth. However, Hooker (1856), Bentham (1864), Williamson (1922, 1928), Willis (1967), and most recently, Corrick (1988) all referred to problems of variation between the three species (Corrick 1988). Being unable to find consistent and well correlated features on which to delimit the many forms of *P. mollis*, Corrick has denoted this species to be a complex of forms. *P. hibbertioides* she now considers to be part of this complex. Galbraith (1977) lists two other forms of *P. mollis:* a dwarf form with clustered leaves and solitary or paired flowers; and, a form with much shorter, moss-like leaves.

It is expected that Corrick's redefinition of *P. mollis* incorporating *P. hibbertioides* (Corrick 1988) will be published in the Fabaceae (Papilionoideae) entry of the Flora of Australia within the next few years. As such, the wider distribution of *P. mollis* than *P. hibbertioides* increases the extent and abundance of the "species", although since *P. mollis* has not been recorded from Tasmania, its distribution and rarity in Tasmania under either nomenclature remains the same. Because the revision of *P. mollis* has not yet been published, this report will maintain the use of *P. hibbertioides* within a Tasmanian context, and distinguish both "species" when referring to Victorian populations.

13.1 Morphology (from Corrick 1988, Curtis & Morris 1975 and pers. obs.)

Pultenaea mollis is variable in habit, from semi-prostrate to an erect or spreading shrub 1-3 m tall. In Tasmania, it is an usually erect, sparingly branched shrub up to two metres in height, with villous or tomentose branches. The leaves are alternate, crowded, up to 12 mm in length, narrow-elliptic or linear and involute, or terete with an acute tip. They are usually scabrous and pilose, and have short petioles and narrow stipules, 4-5 mm long. The inflorescence comprises avery condensed raceme of 4-10 flowers at the tip of numerous short lateral branches. They are often clustered towards the ends of main branches, creating an arched or pendulous appearance when in flower. Numerous, overlapping bracts tend to obscure the pedicels. The pea-flowers are 8-12 mm long, with orange-yellow petals and a darker keel. The two upper lobes are united. The pod is obliquely ovate, pilose, plump and usually almost enclosed by the calyx. It contains one to two dark brown, ovoid seeds of 1.5-2.5 mm by 1-1.5 mm.

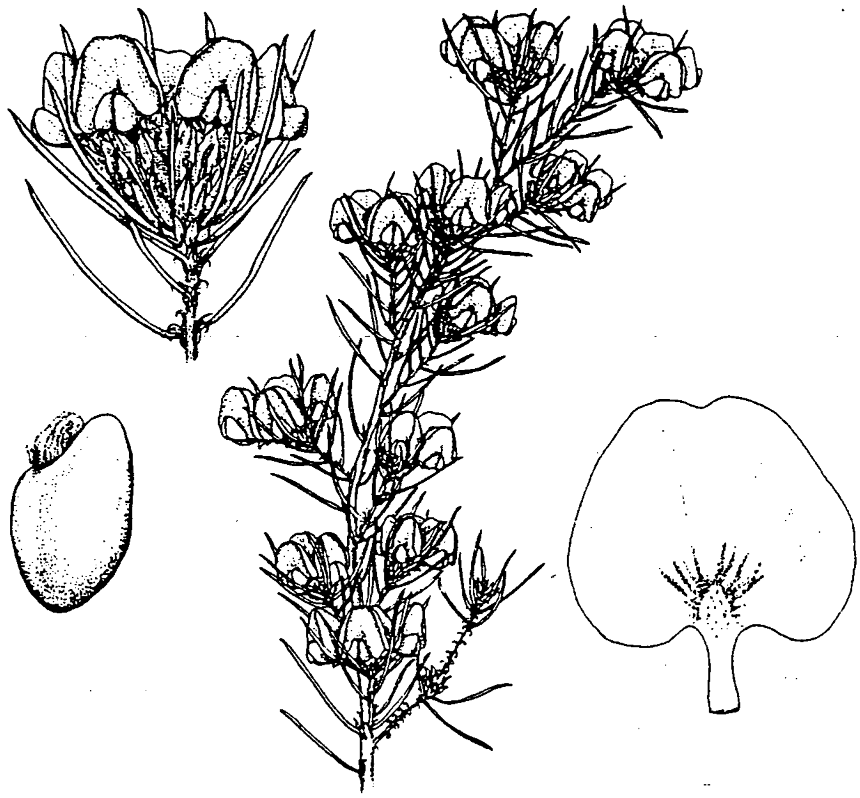


Figure 13.1: Morphology of *P. mollis* (from Corrick 1988).

13.2 Distribution and Rarity

Rodway (1903) reported *P. hibbertioides* to be present in New South Wales as well as Victoria, however, neither it nor *P. mollis* is included in the Flora of N.S.W. (Harden 1991). In Victoria, *P. hibbertioides* was previously considered to be restricted to South Gippsland, while *P. mollis* was considered to be widespread in coastal and moist hilly areas across southern Victoria, mainly south of the Great Dividing Range; from East Gippsland through the Melbourne district to the South-west but excluding South Gippsland. *P. mollis (sensu lato)* is spread across southern Victoria, and in Tasmania occurs in the vicinity of Georgetown and Lefroy (Figure 13.2).

The Tasmanian extent of this species is small. It was described by Rodway (1903) as near Launceston, Lefroy, and Georgetown. Its current distribution is very similar (Figure 13.2). Corrick (1988) was aware of only one isolated population in northern Tasmania, and the species was considered to be very localised (Curtis & Morris 1975). Old collections from this vicinity have come from Georgetown (1841 - 1842), Lefroy (1892), Beaconsfield, west of the Tamar River (C 19th), Point Effingham (1842), and from Georges Bay (C 19th). More recent records have come from two sites near Weymouth (1974, 1989), the Bridport Road near Lefroy (1979), and Badger Hill, south of Bridport (1991). Of these sites, I was only able to

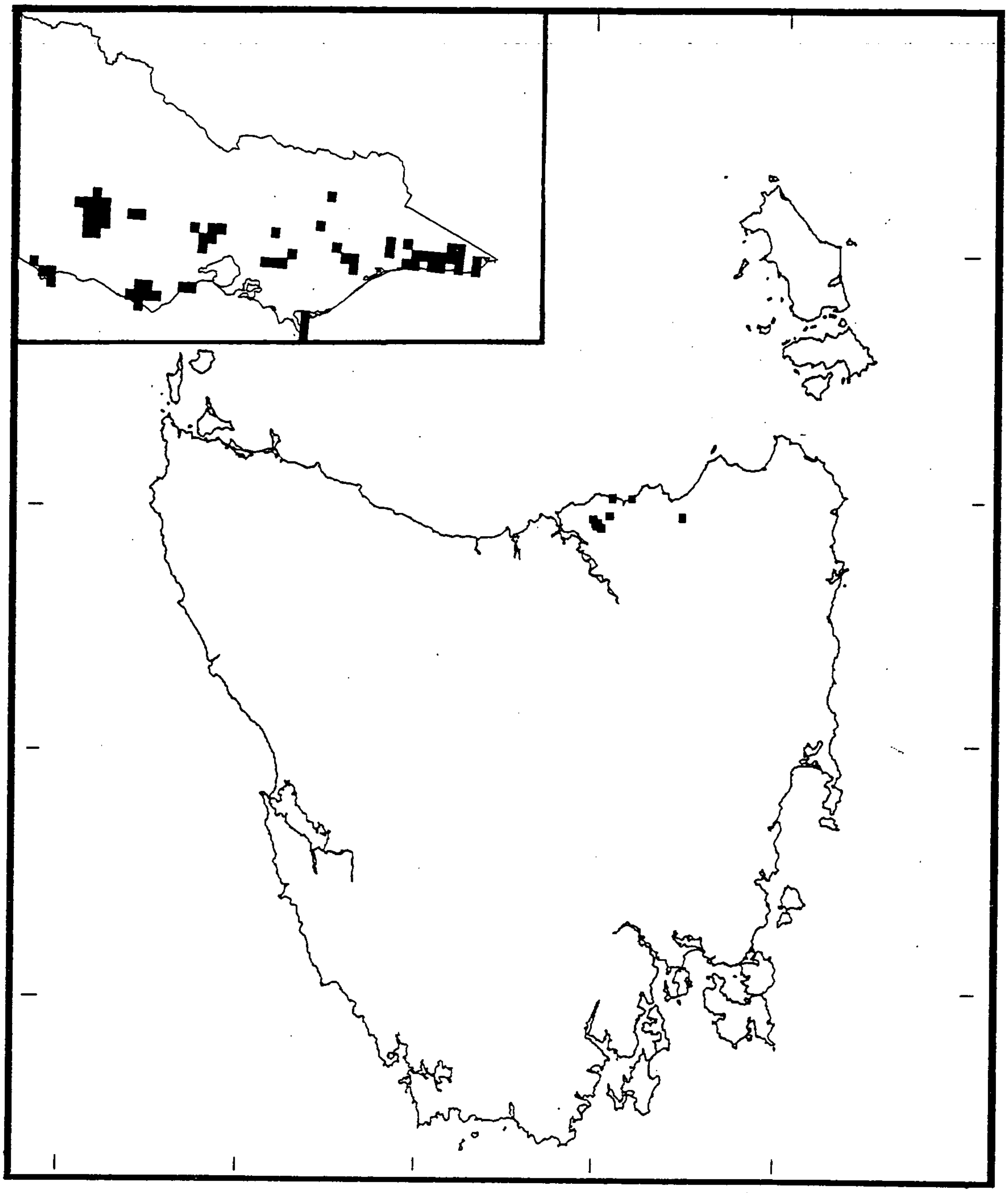


Figure 13.2: Distribution map of recently confirmed populations of *P. hibbertioides* (Tasmania) and *P. mollis* (Victoria).

relocate the two near Lefroy. It is, however, quite possible that extant populations are present in the vicinity of the other areas. No populations have recently been located close to Launceston or Georgetown, although other populations have been located in the course of this study. These have been found on Back Creek Road, near Pipers River, and in the northern end of the Den Ranges.

P. hibbertioides is ranked as unreserved and vulnerable (**uv**) in Kirkpatrick *et al.* (1991b). None of the populations have security of tenure, and some of the populations in the Lefroy area are threatened by local gold-mining operations. One population currently occurs on several grave sites at the Lefroy Cemetery (Figure 13.3), and is threatened by "weeding". The species is localised but abundant at most of its locations. The three populations within the Den Ranges number several thousand individuals.

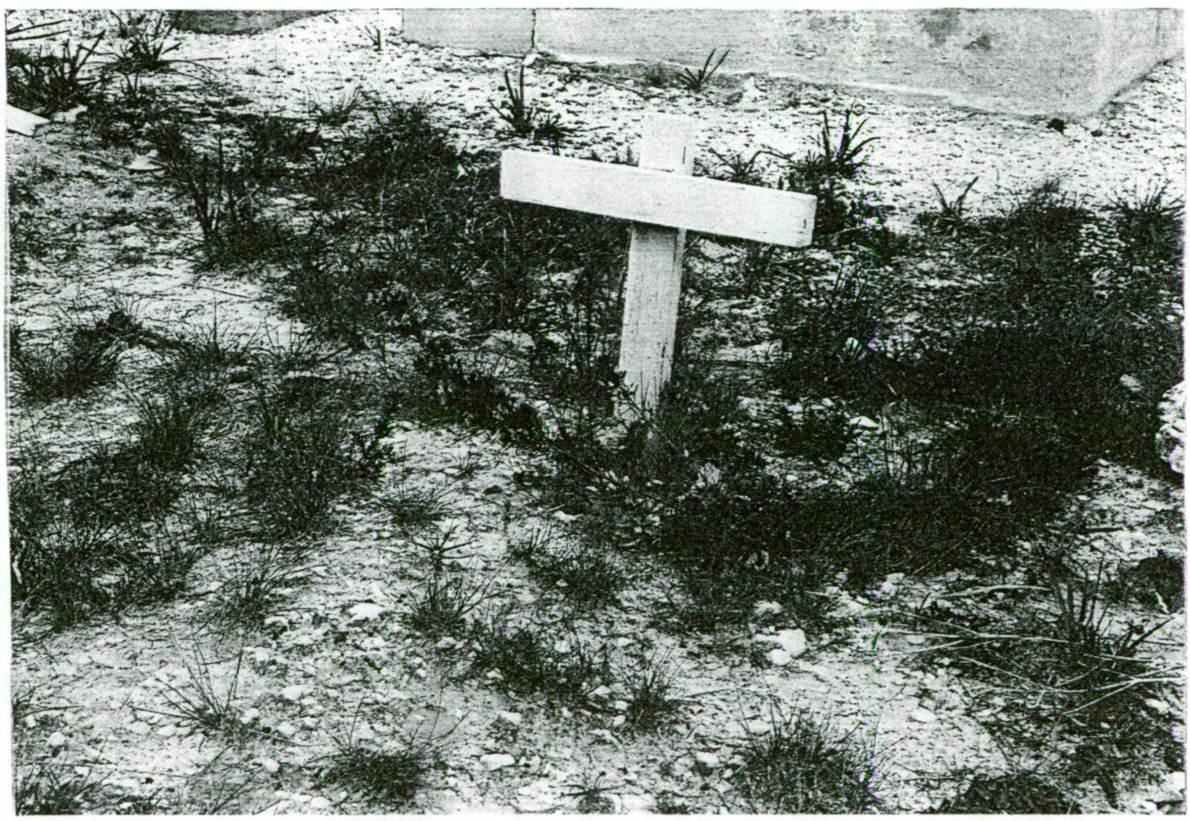


Figure 13.3: A grave and serious coloniser; *P. hibbertioides* at Lefroy Cemetery.

13.3 Habitat

In Victoria, *P. mollis* was regarded generally as widespread and prominent in coastal and moist, open, foothill forests across southern Victoria, while *P. hibbertioides* occurred on lower wooded slopes of the south-eastern ranges

(Woolcock 1991) and in rocky places (Costermans 1983). Cultivation notes from Elliot (1982) give the preferred conditions for *P. mollis* as semi-shaded and well-drained, while Galbraith (1977) states that it prefers sandy soils.

In Tasmania, *P. hibbertioides* occurs in heathy woodland and open forest on substrates of leached, skeletal soils on Mathinna sediments (most sites) or Tertiary sandstone and conglomerate (Badger Hill). It is usually in drought stressed sites such as along ridgelines, often subject to freqent firing or disturbance. Mathinna sediments comprise folded pre-Parmeener Super-Group sedimentary rocks, and the sites in the Lefroy Land System are formed on mudstone-slate (argillaceous) deposits with yellow-brown gradational soils of gravelly to sandy clay loams (Pinkard 1980). The Lefroy area was one of the three principal gold-mining centres of Tasmania, along with Beaconsfield and Mathinna (Pinkard 1980).

P. hibbertioides was most abundant in State forest to the south-west of Pipers River, in the far north of Tasmania. There were several populations in this vicinity, concentrated in an area of almost four kilometres by 1.5 km. The area has a long history of disturbance, through selective logging, via pits and trails being created in the search for gold, as well as by Telecom installation of telephone cables and by Council created drainage ditches alongside the Bridport Road. The Badger Hill site, to the south-east of Bridport, was the furthest removed from the other sites. It was not, however, relocated during this study.

The most south-eastern site of the Pipers River agglomeration occurred on south-west to north facing aspects on a ridge-slope in the Den Ranges. It was under *Eucalyptus amygdalina - E. obliqua* open forest over an open scrub understorey of *Leptospermum scoparium, Acacia terminalis, Banksia marginata* and *P. hibbertioides.* The ground cover was very open, and was dominated by *Pteridium esculentum* and *Gleichenia dicarpa.* The *Pultenaea* was regenerating in canopy gaps with soil free of litter and with scattered *Gahnia grandis* and *Gleichenia dicarpa.* Quartz pebbles were abundant in the heavy clay soil.

Plants of this species were also common on both sides of the road and close to nearby trenches. Seedlings were present on the roadside, where it had been scraped, and on gravel which had been bulldozed from the road surface. Larger shrubs were present in the woodland and next to the mining trenches. Scattered plants were present through the bush to the west on drier sites where disturbance, particularly the creation of old tracks, had occurred. Abundant plants could be found for just over one kilometre along a low ridgeline in State forest at the north-western extremity of the Den Ranges, on quartz-rich Mathinna sediments. The local community consisted of *Eucalyptus amygdalina* - *E. obliqua* open forest with an open heath understorey. A two metre shrub layer was dominated by *Leptospermum scoparium* and *Pultenaea hibbertioides*, while a one metre layer was dominated by these two species and *Allocasuarina littoralis, Pteridium esculentum, Lomatia tinctoria* and *Pultenaea gunnii.* Other species present included *Exocarpos cupressiformis, Banksia marginata, Acacia myrtifolia, Epacris impressa, Lepidosperma laterale, Gonocarpus tetragynus* and *Goodenia lanata.* The litter cover was moderately dense. Seedlings were observed in one area which had been burnt recently.

Farther west of the previous site, and in a degraded, more frequently burnt area of the same community, *P. hibbertioides* was also abundant for ten metres each side of a bush track. This area, of northern aspect and approximately 5^{o} slope, had been irregularly burnt; some *Banksia* surviving of at least 17 years of age. Abundant regeneration of *Pultenaea* was evident, varying in size from three centimetres tall through to mature plants. The soil comprised an indurated pale, grey clayey silt, rich in quartz clasts. At this site, *E. obliqua* and *E. amygdalina* dominated a woodland with scattered *Allocasuarina littoralis,* over a *P. hibbertioides* - *Leptospermum scoparium* heath. Other common understorey species were *Pomaderris apetala, Banksia marginata, Gahnia grandis, Lepidosperma laterale* and occasional *Exocarpos cupressiformis, Acacia terminalis, Lomatia tinctoria, A. myrtifolia* and *Leptomeria drupacea.*

The above community extended along tracks through the State forest for several kilometres, the floristic composition varying little on these drier sites. Some sites had higher, but still sparse, components of the sedges *Gahnia* and *Lepidosperma.* Other species present included *Epacris impressa, Daviesia ulicifolia, Pultenaea juniperina, P. gunnii, Pteridium esculentum, Lomandra longifolia, Gleichenia dicarpa, Pimelea humilis, Gonocarpus tetragynus, Helichrysum* sp., *Lindsaea linearis* and *Poa* sp. Past firing patterns have been complex and patchy; occasional *Allocasuarina* reached 15 cm diameter. Regeneration of *P. hibbertioides* was abundant in some shallow hollows and gullies. There was also an abundance of seedlings of less than three centimetres height where a patch had burnt the previous summer. The heath was more open in this locality, and consisted of woodland over low shrubland. There was often a high litter cover, up to 90% in some areas.

P. hibbertioides (less than 50 plants) grew out of the sides of drainage ditches (Figure 13.4) alongside the Bridport and Lefroy Roads, and above the ditches where the vegetation had been cleared and scraped. The soil was again quartz-rich Mathinna sediments. *Allocasuarina littoralis, E. amygdalina, L. scoparium* and *Gahnia grandis* were local to this site.

Figure 13.4: ***P. hibbertioides*** **colonising a disturbed roadside near Lefroy, northern Tasmania.**

Approximately 16 small *P. hibbertioides* plants were found inside the Lefroy Cemetery, with several more beside the entrance drive. While five of the plants were just inside the grounds, 11 of them actually occurred on very old (undated) grave sites. Between the graves was a mixture of native and weed species mown very short. The orchid *Caladenia patersonii* was locally common within the Cemetery. The vegetation surrounding the Cemetery was a very old low closed forest of *Allocasuarina littoralis* with scattered pits and trenches from gold digging. *Diplarrena moraea* was abundant amidst the complete cover of *Allocasuarina* "leaf" litter, while *Pteridium esculentum* and standing dead *Leptospermum scoparium* were present. The Cemetery sat atop a hill-top, and sloped gently to the south and east.

The site to the east of Weymouth was a near-coastal site, and occurred on a dry ridgeline at an altitude of 60 m. *P. hibbertioides* was common in the heath community on the edge of a *Eucalyptus amygdalina* woodland and low heath. This area had recently been subdivided, and access to the location of the site record could not be gained. The species was located to the west of Weymouth, near some gold diggings (probably in the vicinity of Back Creek) in 1974. Shrubs at this site reached just over two metres in height.

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One small population of *P. hibbertioides* was found during this study to the north of Pipers River. This site occurred in the scraped woodland verge beside Back Creek Road, on the roadside of a Crown Land block. Five small plants were present, amidst *Epacris impressa, Leptospermum scoparium, Pultenaea gunnii, Lomandra longifolia, Gahnia grandis, Melaleuca squarrosa, Gleichenia dicarpa,* and near *Eucalyptus obliqua* and *Allocasuarina littoralis.* Other populations or scattered plants of *P. hibbertioides* may also occur in this locality, and quite possibly within the Lefroy Recommended Area for Protection.

Table 13.1: Summary of habitat records and conservation information for *P. hibbertioides.*

Recent Records:	5 Sites recorded, 5 extant	
Habit:	Erect, sparingly branched shrub up to 2 m height, with villous or tomentose branches and alternate, crowded leaves, usually scabrous and pilose	
Population Size:	> 1 000	
Regeneration:	Type:	Germinates after soil disturbance or fire
	Observed?:	Observed at most sites
Habitat:	Landform:	Lower slopes and ridgelines of low hills trending N.N.W.
	Altitude:	(55-80 m -) 135-200 m
	Aspect:	North-west to North (-South-east)
	Slope:	$(0\text{-}3^o\text{-})$ $5\text{-}8^o$
	Community:	*Eucalyptus amygdalina - E. obliqua* open forest/ woodland over open scrub/ open heath of *Allocasuarina littoralis, Leptospermum scoparium, Banksia marginata, Pultenaea hibbertioides, Gahnia grandis, Pteridium esculentum, Gleichenia dicarpa,Lepidosperma laterale*
Fire response:	Germination from seed	
Conservation Status:	Proposed:	uv
	Current:	uv (Kirkpatrick *et al.* 1991b)
Reserve:	-	
Comment:	Closely related to *P. mollis* Lindl. and *P. viscosa* R.Br. ex Benth. Corrick (1988) redefined *P. hibbertioides* as part of a *P. mollis* complex; to be published in the Fabaceae (Papilionoideae) entry of the Flora of Australia Confined to argillaceous Mathinna beds of indurated quartz-rich, clay-silt soils	

13.4 Phenology

Flowering times for this species have been variously recorded as spring to mid summer (Table 13.2) . Fruiting has been recorded as November to January (Blombery 1967). Collections of flowering specimens lodged at the Tasmanian Herbarium have been made on 18th of November, 1841, 21st of October, 1842, November 1892, November 1975, and 24th of October, 1979. Specimens holding both flowers and pods were collected on 6th of December, 1841, 21st of October, 1842, and 3rd of November, 1974.

Plants at a site south of the Bridport Road and west of the Den Ranges were monitored during the spring and summer of 1991 - 1992. Buds did not develop until after the first week of September. Flowering began about the 24th of September and continued until mid November. The peak was during the first three weeks of October. Fruit developed through October to early January, and began to dehisce about the 15th of January. Fruit were present until the end of January.

Table 13.2: **Phenology of *P. hibbertioides/ mollis*, as determined from literature and Tasmanian Herbarium records.**

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Blombery (1967)	P								F	F	FP	FP
Cameron (1981), Rodway (1903)										F	F	
Corrick (1988)									F	F	F	F
Costermans (1983)									F	F	F	
Elliot (1982)										F	F	F
Woolcock (1991)	F											F
Lynch (pers. obs.)	P								bF	FP	FP	P
Herbarium records										FP	FP	FP

b Buds present
F Flowering
P Fruit present

13.5 Propagation

Propagation using vegetative cuttings of this species was attempted using pretreatment with 2 000 ppm I.B.A. The treatment was quite effective, with a resultant strike rate of 75%. The cuttings were made in March, maintained through winter in a glasshouse, and flowered the following spring.

13.6 Age of First Flowering

Several seedlings of *P. hibbertioides* were grown on in pots maintained initially inside a glasshouse and then outdoors at sea level in Hobart. After 2 years 4 months since treatment of the seed, or in their third spring season, one of the plants flowered. However, no fruit subsequently developed.

13.7 Disturbance

The trial for this species was run for approximately one year, until 23rd January, 1992. Problems were again encountered with the marker pickets for one of the transects being stolen. This site could not be relocated. Consequently, the results were limited, especially as there was minimal response at the remaining trial site. Of the eight disturbed plots, no germinants were located within, while of the eight undisturbed (control) plots, one germinant was located in one of the central plots. These data were obviously inconclusive. The local community was not even-aged and germinants could be observed in both field seasons, and at most sites, where the species was located.

13.8 Discussion

Pultenaea hibbertioides and *P. mollis* are closely related and variable species, and Corrick (1988) denoted the latter species to be a complex of forms incorporating the former. The long indecision (since 1856) about the distinctiveness of *P. hibbertioides* suggests there may be some variation, although it is not substantial. Additionally, "*P. hibbertioides*" is restricted to northern Tasmania and the Victorian district of South Gippsland, the south-eastern extent of *P. mollis*. The Tasmanian extent of this species is restricted, being from near Launceston, Beaconsfield, Lefroy and Georgetown. More recent records have not extended the distribution very far, and the sites near Georgetown and west of the Tamar have not recently been relocated. Extant populations may, however, be present in the vicinity of any of these areas. The lack of other forms of *P. mollis* in Tasmania maintains the need for conservation of the Tasmanian populations, an importance strengthened if these populations are genotypically distinct.

In Victoria, *P. mollis* is widespread and prominent in coastal and moist open forests on lower wooded slopes. Sites tend to be semi-shaded, well-drained, and on sandy or rocky soils. The Tasmanian sites are similar. They tend to be in heathy woodland and open forest on substrates of leached, skeletal soils on argillaceous (Mathinna) sediments. None of the sites are more than 16 km from the north coast.

The *P. hibbertioides* sites are usually seasonally drought stressed ridgelines and slopes, in State forest, and subject to freqent firing and disturbance of the soil and canopy. The sediments are weathered and of low nutrient status. Consequently, they support sclerophyllous and fire-adapted species. Typically, *P. hibbertioides* occurs in a community of *Eucalyptus amygdalina - E. obliqua* open forest/ woodland over open scrub/ open heath of *Allocasuarina littoralis, Leptospermum scoparium, Banksia marginata, Pultenaea hibbertioides, Pteridium esculentum, Gleichenia dicarpa, Gahnia grandis* and *Lepidosperma laterale.*

These sites have had a long and continuing history of mining, particularly for gold. Disturbance has been manifested in upheaval of surface soil in the form of trench and track creation associated with the gold-mining, and also through installation of telephone cables, grave-digging, dumping of soil and Council road-side drains, and via selective logging and road-side scraping and bulldozing. Animal digging is a minor component of the local soil disturbance. The creation of roads for access to drill-core sites and other dirt bush tracks appear to have been beneficial to the abundance of *P. hibbertioides.* Alongside the Bridport road and several of the major and minor dirt roads of this locality can be found stands of heathy forest with an understorey largely dominated by this species. It tends to occur on flat sites, on ridgelines and plains, and is often limited to within ten metres of the road. The disturbance generated by the creation of the road appears to have been the factor encouraging the species-roadworks proximity, and this is supported by the occurrence of the species on gravesites at Lefroy.

Soil disturbance near existing plants, such as has occurred with dumping of soil (various types including basaltic) and rubbish (including a horse carcass), and primarily by creation of tracks and ditches, does encourage germination. The species successfully regenerates post-fire, and regeneration is evident at most sites post-disturbance and post-fire. The *P. hibbertioides* opulations are not even-aged, and the proportions of species and their vigour and age appear to be dependent on disturbance or fire frequency. The area is patch burnt, and therefore, quite close areas of plants have quite different densities and heights of the *Pultenaea.* Opening of the canopy may also aid proliferation of this species, and greater levels of insolation may be the correlation of distribution with ridgelines, slopes and hilltops. The disturbance trial did not have positive results; possibly because it was instigated at the wrong time of year, because of limiting soil moisture conditions, or because canopy disturbance is also necessary in conjunction with ground disturbance.

14. *PULTENAEA HUMILIS* Benth. ex Hook.f. (Dwarf Bush-pea)

14.1 Morphology (from Woolcock 1991, Corrick 1980a, Curtis & Morris 1975 and pers. obs.)

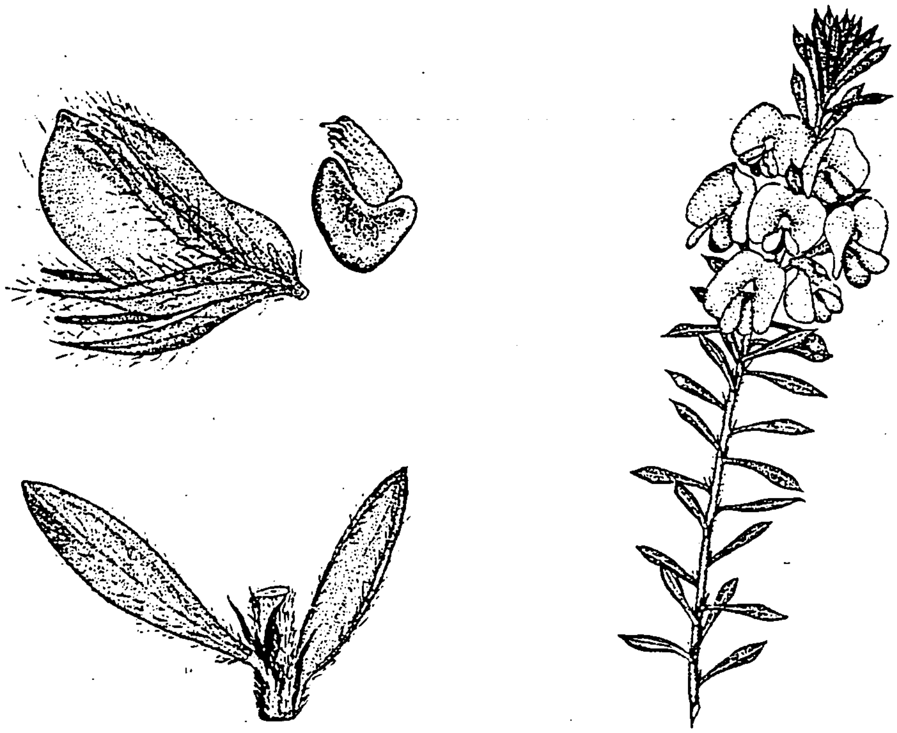


Figure 14.1: Morphology of *P. humilis* (from Corrick 1980a).

In Tasmania, *Pultenaea humilis* is a small, erect but spreading shrub with pubescent, thick and woody branches 15-30 cm in length. Its habit is, however, variable, and decumbent forms up to 50 cm are present in Victoria, as well as erect forms up to one metre high. Not only the size of the plants and their growth habit may vary greatly, but also the size of the leaves and the degree of hairiness. The stems are rounded and hairy. The leaves are alternate, crowded, and 8-12 (-14) mm long by 1-2 (-4) mm wide. They are linear-lanceolate to narrow-elliptic and incurved with the convex surface silky-hairy and the apex acute but blunt. Short, narrow, dark brown stipules are present, sometimes joined together near the base. The flowers are axillary and usually solitary, although crowded and occurring in leafy clusters at or near the ends of the branches. They are usually about 10 mm long by 10 mm wide and have short petioles 2-4 mm long. The flowers consist of orange-yellow petals with dark red lines on the standard and wings, and with a dark red or purple tip to the keel. The leafy tip of the branches continues to grow as the flowers develop. The pod is inflated, and almost enclosed by the hairy calyx. Each pod may hold two seeds. The seeds are reniform, light to dark brown and 2-2.5 mm by 1.25-1.75 mm.

14.2 Distribution and Rarity

P. humilis is widespread across Victoria, but excluded from the Alpine, Murray Valley, Mallee and Wimmera regions (Woolcock 1991). The stronghold of the species is in central and western Victoria, with isolated occurrences in Gippsland and on Pine Mountain (Figure 14.2). While some authors have extended the distribution of *P. humilis* to N.S.W. (Rodway 1903, Curtis & Morris 1975, Willis *et al.* 1975), there has been some confusion about the correctness of this. There is a possible record of this species by Williamson who recorded his variety *P. humilis* var. *glabrescens* from the Southern Tablelands (Jacobs & Pickard 1981). Corrick (1980a) places Williamson's collections as from Creswick, Sale and the Grampians. The National Herbarium of N.S.W. has a record from the Snowy River, but this could either have been the Southern Tablelands or Victoria. The species has recently, however, been excluded from the updated N.S.W. listing of species (Harden 1991). Rodway (1903) also incorrectly listed the species as present in S.A.

In Tasmania, *P. humilis* has long been known from Epping Forest (Rodway 1903). Only two extant sites have been located in Tasmania, both situated in the northern part of the Midlands, in the remnants of the Epping Forest (Figure 14.2). The two sites are within ten and a half kilometres of each other. Both exist in sandy soils laden with lateritic gravels. The larger of the two populations occurs on private land on either side of Powranna Road. The other location of *P. humilis*, at Epping Forest, was declared a conservation area in 1991. Here, *P. humilis* is locally common in a slight depression amidst the *Eucalyptus amygdalina* woodland dominating the locality. The low total number of plants present at only two sites presents the risk of stochastic destruction and consequent loss of half the population. *Pultenaea humilis* was, therefore, listed as endangered (**e**) in Kirkpatrick *et al.* (1991b).

14.3 Habitat

P. humilis has a preference in Victoria for damp wooded slopes, such as at Mt. Clay, to the north-east of Portland, and also occurs in valleys of the ranges (Woolcock 1991). Curtis and Morris (1975), however, state that its distribution is localised to sandy banks in the midlands and north of Tasmania. A preference for sandy sites is supported by Galbraith (1977). Cultivation notes given in Elliot (1982) suggest a preferred site for this species would be a sunny to semi-shaded well-drained position that is not too dry. Corrick (1980a) notes that, in Victoria, *P. humilis* appears to be tolerant of a range of soil types and situations. The sites vary

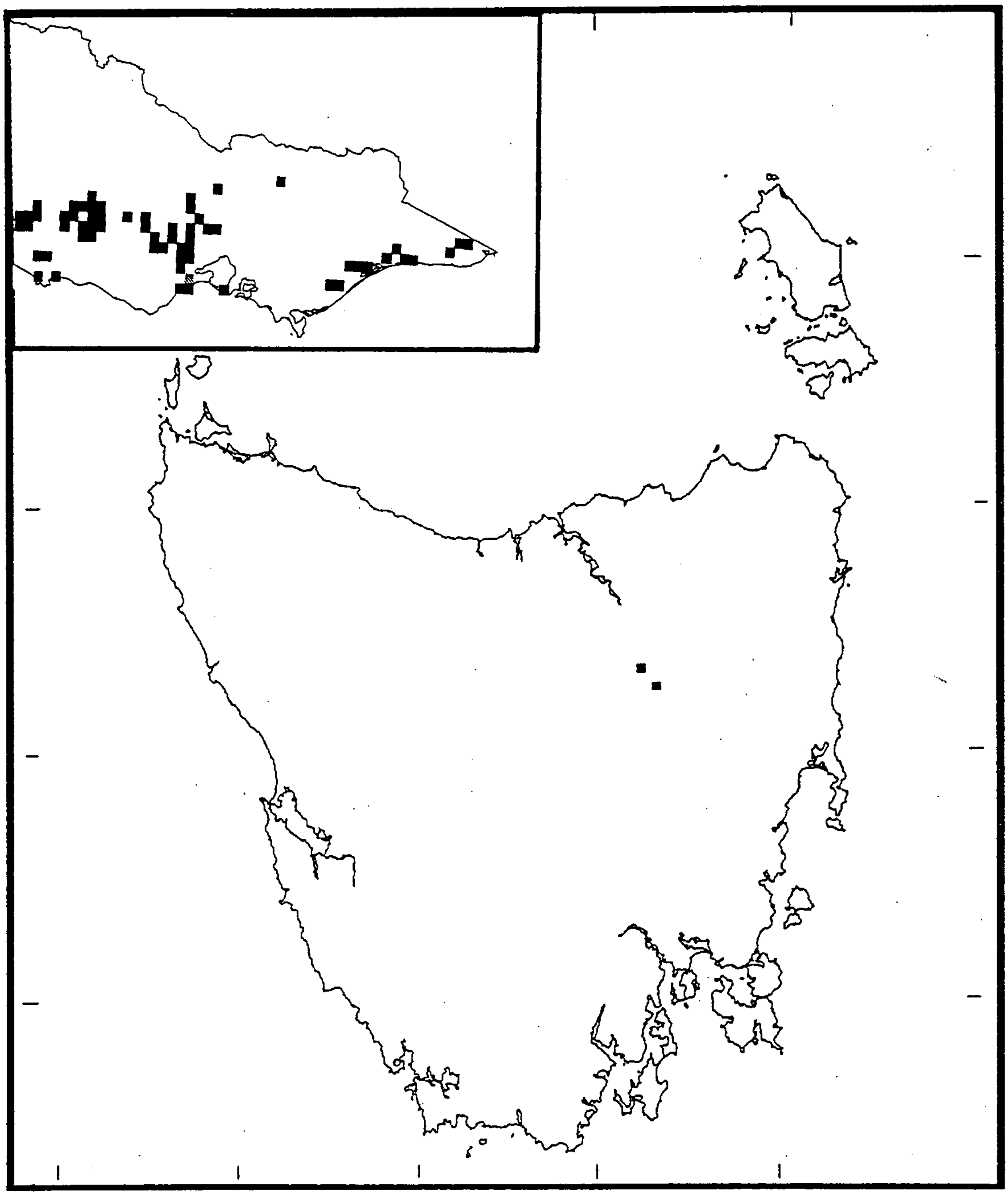


Figure 14.2: Distribution map of recently confirmed populations of *P. humilis* in Tasmania and Victoria.

from heathlands that are quite wet for much of the year (Figure 14.3), to sites in central and eastern Victoria, and the Grampians, of greater elevation with rocky and usually dry soil. Although the Tasmanian sites were well-drained, they were not drought-stressed sites. They also appeared to have had a reasonable amount of time without firing.

Figure 14.3: Heathy dry sclerophyll woodland with a ground cover dominated by *P. humilis* in East Gippsland, Victoria.

The Powranna Road site contained more than 1 100 plants of *P. humilis* scattered along a 1.63 km stretch beside the road, and extending into the woodland approximately 50 m on both sides. The private land was heavily grazed and used for wood-cutting, but supported *Eucalyptus amygdalina (- E. viminalis)* woodland with a sub-canopy of *Allocasuarina littoralis* open scrub with occasional *Banksia marginata* and *Acacia dealbata.* The understorey consisted of a low open heath predominantly of *Hibbertia hirsuta, H. riparia, H. serpyllifolia, P. humilis, P. pedunculata* and *Astroloma humifusum.* Other contributing species included *Bossiaea prostrata, Leucopogon virgatus, Platylobium obtusangulum, Themeda triandra, Stylidium graminifolium, Hovea heterophylla, Thelymitra* sp., *Wurmbea dioica, Comesperma volubile,* and the herbs *Hypericum gramineum, Viola hederacea, Centaurium erythraea, Pimelea humilis, Hypochoeris radicata* and *Goodenia lanata.* There was a sparse litter cover over the laterite gravel-laden, sandy soil. The site was almost flat, but sloped very gently to the east. Part of the community, containing *Pultenaea humilis,* had been burnt in the last five years. *P. humilis* was regenerating and appeared healthy. The site was not grazed all year round. *P. humilis* was quite abundant along the roadside where it flowers and fruits, despite at least annual mowing. Plants were quite abundant along a Council created drainage channel near the road-side fence-line. Much of the seed is not dispersed any great distance, and the plants have developed as matted clusters of many individuals.

The Epping Forest site was centred around a shallow depression, above which the local woodland canopy was much more open. More than 500 plants of *Pultenaea humilis* occurred, extending over an area of approximately 150 m by 200 m. The site had been grazed by sheep, while the occasional six metre high *Banksia* suggested that the site had not burnt in a hot fire for more than 20 years. The community consisted of *Eucalyptus amygdalina* woodland with occasional *Acacia dealbata,* and local *Allocasuarina littoralis* and *B. marginata.* The open heath understorey was dominated by *Spyridium vexilliferum, Hibbertia riparia, Lissanthe strigosa, Platylobium obtusangulum, Astroloma humifusum, Pultenaea humilis, P. pedunculata* and *Lissanthe strigosa.* Other species present included *Lepidosperma longitudinale, L. inops, Leucopogon virgatus, Dianella revoluta, Thelymitra* sp., *Bossiaea prostrata, Hovea heterophylla* and *Centaurium erythraea.* There was a moderate litter cover over the laterite gravel enriched sandy soil. The site sloped very gently to the north-west.

Table 14.1: Summary of habitat records and conservation information for *P. humilis.*

Recent Records:	2 sites recorded, 2 extant	
Habit:	Small, erect but spreading shrub with pubescent, thick and woody branches and linear-lanceolate to narrow-elliptic leaves with a silky-hairy convex surface	
Population Size:	> 1 000	
Regeneration:	Type:	Presumed seed germination after disturbance and fire
	Observed?:	Observed in unburnt, but grazed areas also with common soil disturbance from digging by bettongs
Habitat:	Landform:	Flat to gently sloping lateritic sandy plains
	Altitude:	190 - 205 m
	Aspect:	East, North-west
	Slope:	2 - 3°
	Community:	*Eucalyptus amygdalina* woodland with *Allocasuarina littoralis* +/- *Banksia marginata,* over low open heath of *(Spyridium vexilliferum), Hibbertia riparia, Pultenaea humilis, Astroloma humifusum*
Fire response:	Presumed seed germination	
Conservation Status:	Proposed:	v
	Current:	e (Kirkpatrick *et al.* 1991b)
Reserve:	Epping Forest Conservation Area	
Comment:	Restricted to laterite gravel-enriched, sandy soils of Epping Forest, Midlands	

14.4 Phenology

The flowering time for *Pultenaea* is recorded non-specifically by Blombery (1967). Other references (Table 14.2) list the flowering time of *P. humilis* as mid-spring to early summer. Corrick (1980a) notes that the main flowering time is late November extending to mid-December in higher, cooler areas. One specimen with pods is held at the Tasmanian Herbarium, and was collected in Epping Forest on the 17th of March, 1986. Personal observations of the species during this project (spring 1991 to summer 1992) indicated that buds did not develop until October, although they were difficult to discern amidst the leafy clusters at the tips of the stems. Flowering occurred from the last week of October until the first week of December. The peak of flowering was from about the 5th of November until about the 15th. Pods developed during December and began to open and release on about the 7th of January. Some fruit remained throughout January.

Table 14.2: Phenology of *P. humilis*, as determined from literature and Tasmanian Herbarium records.

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Blombery (1967)	P								F	F	FP	FP
Corrick (1980a)											F	F
Woolcock (1991), Rodway (1903)										F	F	F
Elliot (1982)	F?	F?							F?	F	F	F
Lynch (pers. obs.)	P									bF	F	FP
Herbarium records			P									

b Buds present
F Flowering
P Fruit present

14.5 Propagation

Germination trials for this species included the dry heat trials of two minutes exposure to 100°C and 80°C, as well as a scarification trial and control. However, there were too few seeds for any trials to be replicated except the scarification trial. An initial scarification test on fresh seed conducted prior to the germination trials resulted in 80% germination, indicating a moderate degree of non-viability within the seed batch (25.5% in later tests). Seeds were not tested prior to the trial, however, and the high level of non-viable seeds meant that the samples varied in size (N) after rotten seeds were discarded. Most of the non-viable seeds float, if tested before pretreatment. Of the species trialled, *P. humilis* was the most susceptible to persistent mould. Affected seeds tended to decompose quite quickly.

The trial results indicated that pretreatment was required for germination of this species. All treatments effected moderate germination response: 80°C dry heat (treatment 3) effected 66.7%, scarification (treatment 1) effected a mean of 60.9% and pretreatment of 100°C dry heat (treatment 2) effected 45.8%. None of the untreated seeds germinated (0%, treatment 5). Scarification caused rapid germination (majority within 52 days), while the heat treatments had scattered germination occurring throughout the 120 day trial period (Figures 14.5 - 14.7).

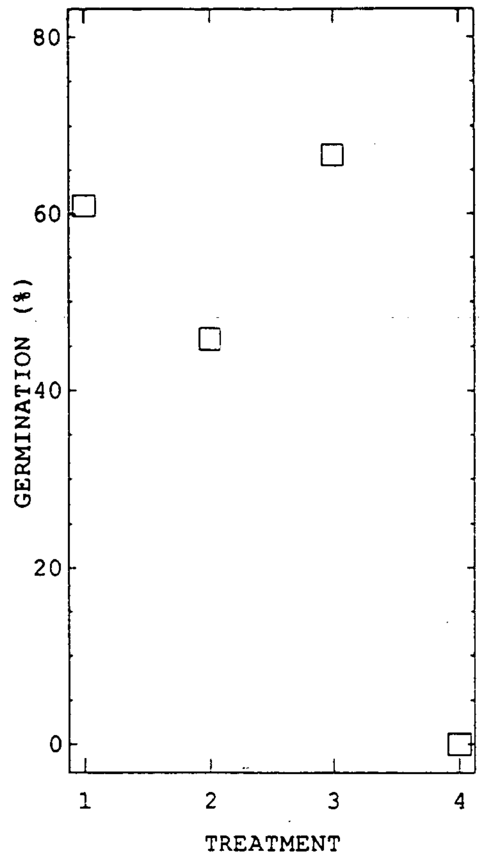


Figure 14.4: **Range of mean results for germination trials with standard errors.**

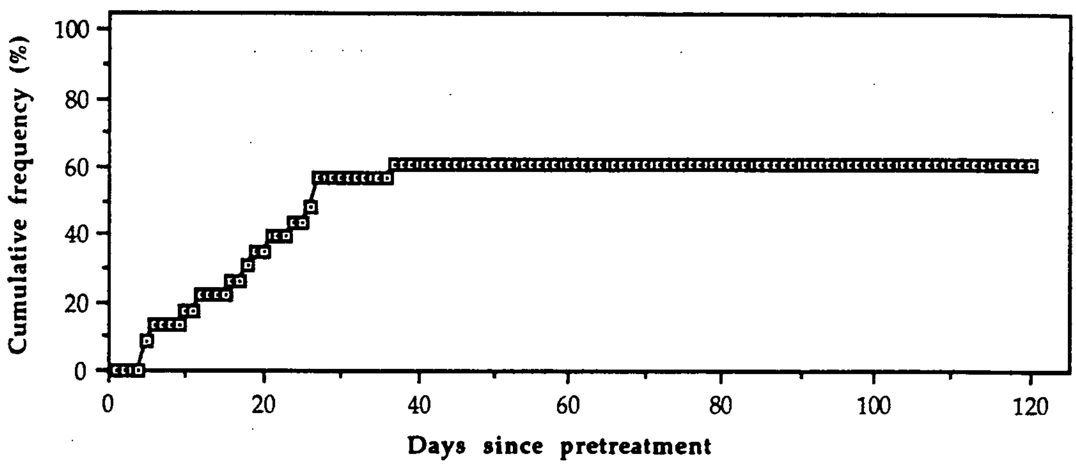


Figure 14.5: **Germination response for *P. humilis* to scarification.**

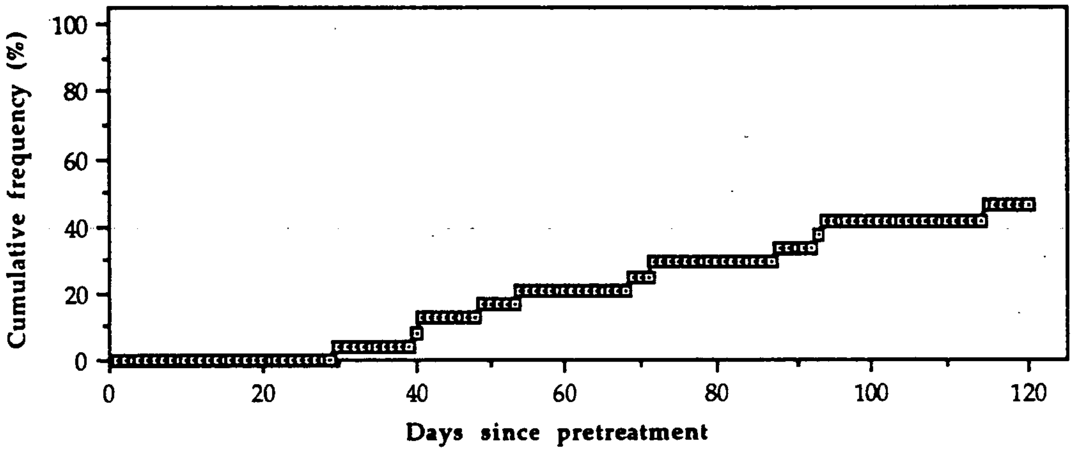


Figure 14.6: Germination response for *P. humilis* to pretreatment of 100°C.

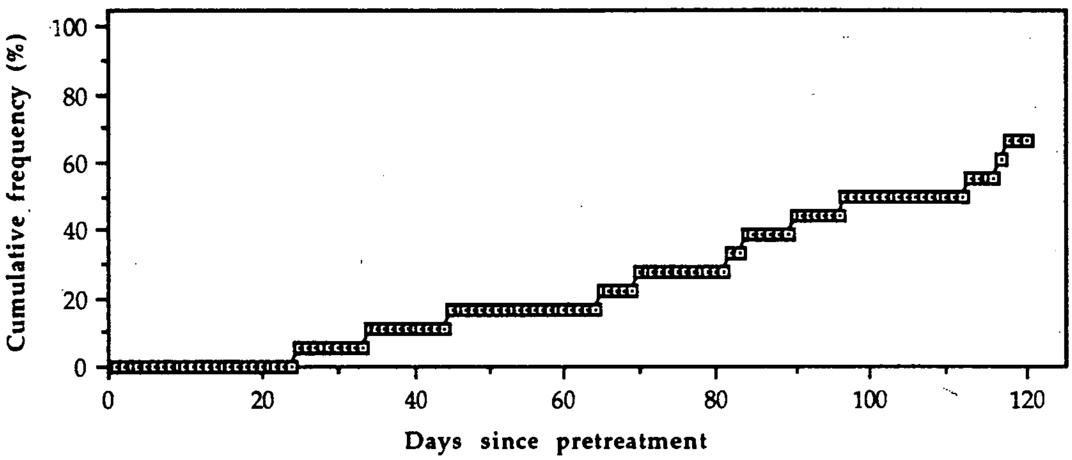


Figure 14.7: Germination response for *P. humilis* to pretreatment of 80°C.

14.6 Discussion

Pultenaea humilis is a low shrub with pubescent branches and lower sides of leaves. Its habit is variable across its range, in the characters of relative erectness, the size of the plants and leaves, and the degree of hairiness. The Tasmanian stock appears to be shorter than its Victorian relatives.

This species is very rare in Tasmania, with only two populations known, although it is locally common at these sites. There are about 1 600 plants present between the two sites; approximately 1 100 at one site of a 1.6 km road-side strip, and approximately 500 in a woodland area of 150 m by 200 m.

P. humilis is confined to the *Eucalyptus amygdalina* heathy woodland of Epping Forest, in the Tasmania Midlands. It occurs on sandy soils enriched with laterite gravels. These soils have been heavily leached, and therefore have a low inherent fertility (Fensham 1991). Two characteristics of the sites which may be the primary determinants of the species' presence are disturbance and water availability. Both sites have a long history of sheep grazing, with the more recent additional pressures of concentrated bettong diggings at one site, and mowing and possible overgrazing at the other site. Both sites are areas of localised water retention. One site is centred around a shallow, sedgy depression, and the other along a roadside with a Council constructed drain close to the boundary fenceline. It is possible that both factors contribute to encourage the presence of this species.

Both populations of *P. humilis* appear to be healthy, and some regeneration is evident. The experimental germination results indicated that pretreatment was required for germination. Temperature and scarification were both effective stimuli to seed germination, with heat of moderate intensity (80^{o}C) being the most effective pretreatment. These results support the ecological analogues of fire and disturbance being effective regeneration stimuli for *P. humilis.* The communities where *P. humilis* occurs are subject to mechanical soil disturbance from animal digging, and less naturally from wood-cutting, sheep grazing, roadside scraping and mowing, and construction of drainage ditches. Such disturbance may change site conditions, particularly the temperature regime, sufficiently to release seeds from enforced dormancy. Digging may bring seeds to the surface which, along with opening of the existing vegetation through grazing, may "shock" the seeds into germination by the shift in temperature or increase in amplitude of the diurnal temperature range. The sites do not appear to have had a high frequency of firing. The populations may be maintained by occasional firing with limited continuous regeneration from non-dormant seeds or in patches of mechanically disturbed soil. The non-dormant component of the annual seed produced may also be enough to supply new plants for a site that is not subject to fire. None of the untreated seeds germinated in the germination trial of this study, however, trials on a larger experimental sample may better indicate whether this species has a non-dormant proportion of seeds. The non-dormant component varied between 1.1 and 58.9% for the seed of various *Pultenaea* species tested by Auld and O'Connell (1991). Regeneration from a non-dormant proportion may be sufficient to maintain populations in the absence of both fire and disturbance.

15. *PULTENAEA PALEACEA* Willd. VAR. *SERICEA* Benth.

Pultenaea paleacea is a variable species with several named varieties. These varieties have distinct characteristics and non-overlapping ranges. It is probable that they all will be redescribed as separate species (M. Crisp, pers. comm.).

15.1 Morphology (from Curtis & Morris 1975, Corrick 1980b, Woolcock 1991, and pers. obs.)

Pultenaea paleacea var. *sericea* is a slender, low shrub with ascending, silky-pubescent stems, 20-80 cm long. It has slender, wiry branches which spread from the base, sometimes horizontally for 30 cm or more before ascending (Curtis 1955). The variety *sericea* is a dimunitive form of the species *paleacea* with slender, flaccid branches trailing amongst the surrounding vegetation. It has longer, paler foliage (Corrick 1980b) and conspicuously long, white-silky, scarious stipules and bracts (Willis 1972).

Figure 15.1: Morphology of *P. paleacea* var. *sericea* (from Woolcock 1991).

The leaves of *P. paleacea* var. *sericea* are alternate, linear or narrow-elliptical to oblanceolate, flat with recurved margins and an acute or acuminate apex. They are 7-20 mm long and 1-3 mm wide. The upper surface is glabrous, the lower silky-pubescent with pale, closely appressed hairs, and with a very short petiole. The stipules are scarious and light brown, 5-6 mm long. They may be more than half the length of young leaves but wither and also fade in the adult leaves. The flowers are axillary but clustered in very short, dense terminal heads, surrounded by overlapping, light brown floral bracts. Each flower consists of a hairy calyx, encircling an orange-yellow standard, 11-12 mm high of two united lobes, with yellow wings slightly tinged with purple and a darker yellow to purplish keel. The pedicel is short and subtended by a scarious bract 8-10 mm in length. The bracts grade from leaves with enlarged stipules to a trifid bract on the innermost flowers. The pods are flattened, silky-hairy with pale appressed hairs, and slatey-grey in colour. They contain one to two ovoid, black seeds of 2.25-3 mm by 1.75-2 mm.

15.2 Distribution and Rarity

At the species level, *P. paleacea* is widespread throughout Eastern Victoria, the Central Tablelands and Coastal N.S.W., as well as Queensland. The variety *sericea* is the common variety in Victoria, but is confined to far East Gippsland, South Gippsland and the Melbourne district, as well as northern Tasmania. It was once apparently quite plentiful in suburban areas of Melbourne, such as Mt. Waverley, Oakleigh and Brighton (Corrick 1980b).

This species is another of the legumes with a northern Tasmania distribution, an extension of a predominantly southern Victorian range (Figure 15.2). It has been collected from three sites in Tasmania: Bridport (Figure 15.3); Croppies Point, in the Waterhouse Protected Area; and Big Waterhouse Lake (M. Cameron, pers. comm.), also in the Waterhouse reserve. All of the sites are quite localised and although the plant may appear to be relatively common, the sites are not extensive. Accordingly, total numbers of the plant at each site are not high; for example, less than 100 plants occur at Bridport in an area of approximately 30 m by 10 m, and similarly less than 100 plants occur at Big Waterhouse Lake in an area of 15 m by 15 m. The Croppies Point site was not relocated during this study, but a note with the specimen states that plants of this species were very rare, and no fertile material was found despite the date of collection being during the "normal" period of flowering (Section 15.4). It is quite likely that *P. paleacea* var. *sericea* is more widespread, and that other extant populations have been overlooked. Surveys of suitable similar habitat were not conducted during this study.

Pultenaea paleacea var. *sericea* is listed as unreserved and vulnerable (**uv**) in Kirkpatrick *et al.* (1991b). The Waterhouse Protected Area is not sufficient reservation due to the insecurity of its tenure. The vulnerability status of the species follows from the low numbers of individuals present in Tasmania, and its inadequate reservation.

15.3 Habitat

P. paleacea, at species level, occurs on sandy to clayey soils (Weston 1991), although Woolcock (1991) cites its habitat as damp, lowland heaths. Corrick (1980b) notes the likely habitat of var. *sericea* as damp, sandy heathland, sometimes along streams or in depressions among rocks. One of the old records (by F. Mueller, November 1852) from near Brighton, Victoria, noted the species to be in shady, inundated places. *P. paleacea* var. *sericea* was reported from near Bridport, northern

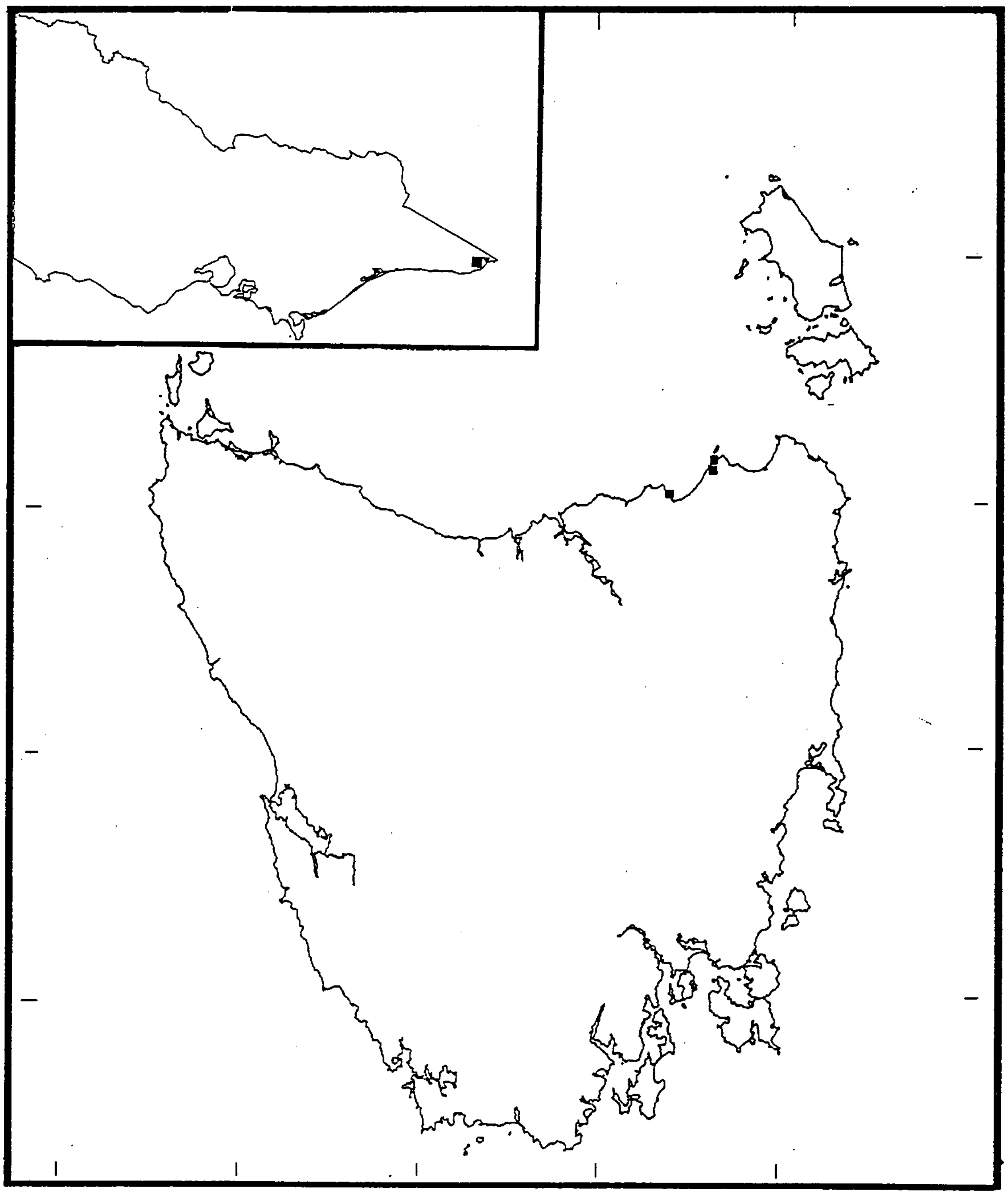


Figure 15.2: Distribution map of recently confirmed populations of *P. paleacea* var. *sericea* in Tasmania and Victoria.

Tasmania, to be common in wet, sandy heaths (Curtis 1955). All of the Tasmanian sites consist of coastal grassy heaths, marginal to shallow, sedgy, sandy depressions.

Figure 15.3: Sedgy heathland with *P. paleacea* var. *sericea* near Bridport.

The site at Bridport (Figure 15.3) contained less than 100 plants of *P. paleacea,* in a predominantly saggy sedgeland at an altitude of approximately 18 m. The site was in the ecotone between a poorly drained sedgeland with emergent *Eucalyptus ovata,* occupying a slightly depressed elongated bowl, and the sedgy heathland on the outskirts of the depression. The site was on a slight slope (3 - 4^{o}), with a south-westerly aspect (232^{o}), and on a fine sandy soil. The site appeared to have been in the past an open woodland, which has converted to heath through frequent burning and woodcutting. *Banksia marginata* was local, but not within the

P. paleacea site, and two shrubs were aged as 18 and 15 years old. *Acacia sophorae* was also local to the site. *Lomandra longifolia, Lepidosperma filiforme, Restio* sp. and *Themeda australis* dominated the ground cover, while other contributing species included *Epacris lanuginosa, Sprengelia incarnata, Leptospermum scoparium, Melaleuca gibbosa, P. dentata, Ricinocarpus pinifolius, Baeckea ramosissima, Gahnia grandis* and *Senecio jacobea.*

At Big Waterhouse Lake, *P. paleacea* was scattered amidst saggy, open heathland with low (eight metres tall) emergent *Eucalyptus ovata* and occasional *Banksia marginata.* Less than 100 *P. paleacea* plants occurred through the site, an area of 15 m by 15 m. The one metre tall heath was dominated by *Epacris lanuginosa,* along with *Leptospermum scoparium, Leucopogon virgatus* and *Dillwynia glaberrima. Pimelea linifolia, Hibbertia acicularis, H. sericea* and *H. virgata* also contributed. The ground layer was dominated by *Lomandra longifolia,* while grasses and herbs were of low cover, and consisted primarily of *Themeda australis, Stipa* sp., *Poa* sp., *Anthoxanthum odoratum, Hypochoeris radicata* and *Trifolium repens. Pultenaea paleacea* was also of low cover, but sometimes in moderately dense clusters. It tended to occur amidst other, denser shrubs or dead branches littering the ground. The site was located in a depression amidst undulating sands. The altitude was approximately 15 m, and the slope 2 - 3^{o} to the south-west. The *Banksia* were approximately 9 - 12 years old.

Table 15.1: Summary of habitat records and conservation information for *P. paleacea* var. *sericea*.

Recent Records:	3 Sites recorded, 3 extant	
Habit:	Slender, low shrub with ascending, silky-pubescent wiry branches	
Population Size:	100 - 1 000 (lower end of category)	
Regeneration:	Type:	Presumed seed germination
	Present: Not observed	
Habitat:	Landform:	Edge of, or within, shallow depressions in undulating sands
	Altitude:	15 - 18 m
	Aspect:	South-west
	Slope:	2 - 4^{o}
	Community:	Saggy sedgeland or saggy, open heathland; emergent *Eucalyptus*
Fire response:	Not observed	
Conservation	Proposed:	**uv**
Status:	Current:	**uv** (Kirkpatrick *et al.* 1991b)
Reserve:	-	
Comment:		

15.4 Phenology

There are few specific references to the flowering period of *P. paleacea* var. *sericea.* Blombery (1967) lists September to December for *Pultenaea* in general, with fruit produced between November to January. Corrick (1980b) lists the flowering period for *P. paleacea* var. *sericea* as late October to early November. Flowering specimens lodged at the Tasmanian Herbarium were collected on 15th of October, both in 1949 and 1952, 15th of November, 1952, (these all from the Bridport site), and a vegetative one was collected from Croppies Point on 23rd of November, 1983. The site at Bridport was relocated on 17th of October, 1991, and at Big Waterhouse Lake on 21st of November, 1991. Plants at these times were post flowering. Ripe pods were collected from the plants at Bridport on 19th of January, 1992 (Table 15.2).

Table 15.2: Phenology of *P. paleacea* var. *sericea*, as determined from literature and Tasmanian Herbarium records.

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Corrick (1980b)										F	F	
Lynch (pers. obs.)	P								F?	P	P	P
Herbarium records			F							F	F	

F Flowering
P Fruit present

15.5 Discussion

P. paleacea var. *sericea* has a distribution restricted, in Victoria, to far East Gippsland, South Gippsland and the Melbourne district, and in Tasmania, to the near-coastal, northern part of the State. As with several other legumes rare in Tasmania, this species has a range concentrated in southern Victoria and extending south across Bass Strait.

At species level, *P. paleacea* tends to prefer sandy to clayey soils, in damp, lowland heaths, and this follows for var. *sericea* also. The three recent collections in Tasmania have all come from sandy sites which are marginal to or within shallow, sedgy depressions. Such sites are poorly drained and may become waterlogged in winter. They are dominated by heath, sagg and sedge species adapted to poorly aerated, low nutrient soils. Typically, these species include *Banksia marginata, Epacris lanuginosa, Leptospermum scoparium, Melaleuca gibbosa, Pultenaea dentata, Gahnia grandis, Lomandra longifolia, Lepidosperma filiforme* and *Restio* spp. *P. paleacea* var. *sericea* is usually amongst dense vegetation. It may also be found amongst rocks (Corrick 1980b). Both these situations afford the plants some protection from grazing. Such coastal communities support a variety of herbivores which may eat *P. paleacea*.

The limited number of sites limits the strength of conclusions on the habitat preferences of the species, however, the sites accord with each other in consideration of aspect, gradient, soil type, landform and plant community. They also accord with the very general descriptions of sites in Victoria.

16. *PULTENAEA PROSTRATA* Benth. ex Hook.f. (Silky Bush-pea)

16.1 Morphology (from Curtis & Morris 1975, Corrick 1977 and pers. obs.)

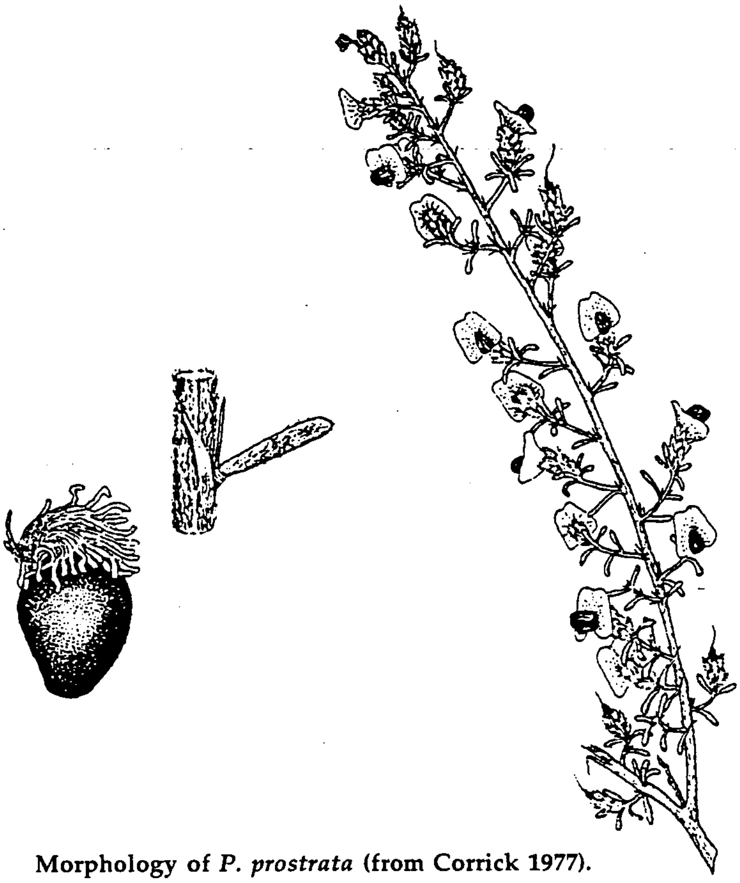


Figure 16.1: Morphology of *P. prostrata* (from Corrick 1977).

Pultenaea prostrata is a small, stiff shrub with prostrate, or decumbent, pubescent branches to about 20 cm long. Victorian populations may contain more erect plants up to 50 cm high. Young, new growth tends to be thickly clothed with white hairs, giving the plant a silvery appearance. This hairiness may also be present on scabrous older leaves, or they may be glabrous. The leaves are alternate, linear and inrolled to form a channelled upper surface, 4-6 (-8) mm long. The leaves have a distinct petiole and an obtuse apex. The stipules are two millimetes long, pale and lanceolate. The flowers are solitary, and terminal on very short lateral branches. The pea-flowers comprise a yellow standard of two united lobes with dark streaks at the base. The keel and the wings may be deep purplish-brown. The calyx is also clothed with silky hairs, and is surrounded by numerous, persistent, broad bracts with ciliate margins. These bracts can be used to distinguish *P. prostrata* from *P. tenuifolia*, with which it has been confused. The pod is ovoid-acute, dark-brown-villous, and as long as the calyx (Jessop & Toelken 1986). Each pod contains two seeds. The seeds are reniform, very dark brown and 1.5-2.25 mm by 1.25-1.5 mm.

16.2 Distribution and Rarity

P. prostrata has been recorded from South Australia, Victoria, New South Wales, and Tasmania. In S.A., it is found in the Murray, Southern Lofty, and South-eastern districts (Jessop & Toelken 1986). In Victoria, it occurs mainly in the western districts, but also extends to the centre. It does not reach the coast, which might be expected since the sandy, calcareous soils and dunes of north-western Victoria are derived from an old coastal formation (Corrick 1977).

The type specimen of this species was collected by R. Gunn in Tasmania, and the description by Bentham was published by Hooker in 1856. Rodway (1903) records the species as present at Ross, Avoca and near Brighton. Other old records come from the Mowbray Railway Reserve at Launceston (1921), near Evandale, from Georges Bay and from the South Esk River (the last three records from the C. 19th). The extent of *P. prostrata* in Tasmania (Figure 16.2) has probably declined with the decline of its habitat, grassy woodlands. One population was recently (1983 - 1984) found at Tunbridge Nature Reserve, in a privately owned paddock north of the reserve, and continuing into the adjacent Recreation Oval, several hundred metres north of the reserve. Other populations have been located at the Campbell Town Golf Course (1985), at Marsh Creek, north-west of Avoca (1992), and a site north of Bothwell (1991).

Two Herbarium specimens labelled as *P. prostrata* do not hold fertile material, and cannot be easily distinguished from *P. tenuifolia.* One specimen was collected in a grassland community at Bothwell, while the other specimen was collected at St. Helens (Georges Bay). If the non-overlapping ranges and habitats of these two species in Tasmania may be used as an auxiliary to identification, the former is most likely to be *P. prostrata.* The latter is more likely to be *P. tenuifolia,* according with the north- and north-eastern coastal distribution of this species.

Pultenaea prostrata is listed as endangered (e) in Kirkpatrick *et al.* (1991b). The recent declaration of Tunbridge Nature Reserve has given this site security of tenure. However, only two plants of *P. prostrata* are known within the reserve.

16.3 Habitat

P. prostrata occurs on the sandy inland soils (Corrick 1977) of inland and mallee Victoria (Woolcock 1991). In Tasmania, however, it is found in grassy woodlands, grasslands and artificially induced (cleared) grasslands. It was recorded by Curtis and Morris (1975) as occurring in grasslands in the Midlands,

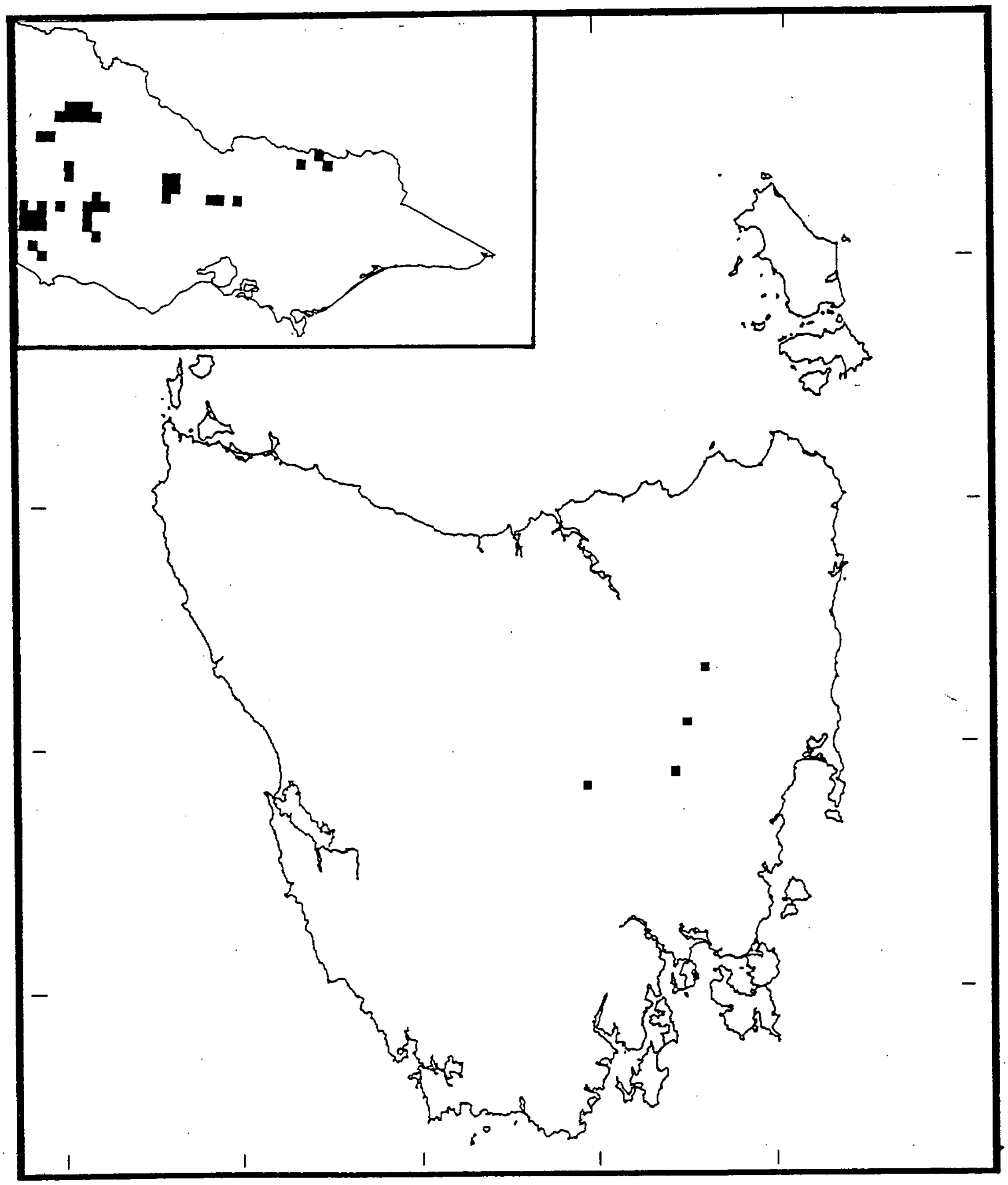


Figure 16.2: Distribution map of recently confirmed populations of *P. prostrata* in Tasmania and Victoria.

the species being known from collections from the South Esk River, Launceston, Evandale, Ross, Avoca and Brighton. The more recent collections from Tunbridge, Campbell Town, north-west of Avoca and north of Bothwell have widened the known distribution of the species. Unfortunately, the former collections have not recently been relocated, and the species is only known from the latter populations, all discovered in the last ten years.

Only two plants of *P. prostrata* were present in the Tunbridge Nature Reserve, however, there were more in a privately owned paddock north of the reserve (less than 100 plants), which continued into the adjacent Recreation Oval (15 plants), several hundred metres north of the reserve. These areas were all in various stages of degraded *Eucalyptus pauciflora* grassy woodland on brown loam underlain by dolerite (altitude about 205 m). Clearing and grazing have elimated the *Eucalyptus* species, however the reserve maintained a number of species of grasses and herbs, rare in Tasmania.

The two *Pultenaea* plants within the Tunbridge Nature Reserve grassland (Figure 16.3) were separated by about 100 m. They both had stems interfingering with the dense grass cover to almost one metre across. The ground cover was dominated by a dense cover of *Themeda triandra, Poa labillardieri* and *P. rodwayi*, with scattered *Helichrysum apiculatum, Centaurium erythraea, Scleranthus diander, Vittadinia* spp., *Acaena echinata* and *Leptorhynchos squamatus.* One site sloped gently to the south-east, the other more steeply, being just over the side of the broad hill sloping down to the salt lake. This site had *Acacia dealbata* nearby. All plants within the nearby paddock site were grazed back to very short stems, however, *Pultenaea prostrata, Convolvulus erubescens, Vittadinia* sp., *Ptilotus spathulatus* and *Hypochoeris radicata* were evident.

The site near the Recreation Oval site was a small area fenced off from the rest of the oval. The site was located on a fairly flat plain which sloped gently to the north, and comprised a remnant grassland with planted *Pinus radiata.* The dominant natives were *Themeda triandra, Helichrysum apiculatum, Acaena echinata, Pultenaea prostrata, Stipa* sp., *Convolvulus erubescens, Oxalis perennans* and *Brachyscome rigidula.*

The first site located at Campbell Town was in the north-eastern part of the Golf Course; a small area of low open *Acacia dealbata* forest over open grassy prostrate heath. The heath species were predominantly *Astroloma humifusum, Hibbertia fasciculata, Pultenaea prostrata* (less than 30 plants) and *Scleranthus biflorus.* The grasses included *Poa infirma, P. sieberiana, P. hookeri, Danthonia setacea* and *Aira*

Figure 16.3: The open grassland habitat of *P. prostrata* at Tunbridge.

caryophyllaea, while other species present included *Convolvulus erubescens*, *Lepidosperma inops*, *Dianella revoluta*, *Helichrysum apiculatum*, *Pimelea humilis* and *Ulex europaeus*. The gorse appeared to be increasing, and needs treatment. There was a sparse litter cover. The site had been protected by being close to a storage shed, and had not burnt for at least 20 years. The course was on a flat plain at an altitude of about 205 m, and occurred on sandy soil underlain by basalt.

The south-eastern edge of the Campbell Town Golf Course, however, was discovered in 1992 to contain a remnant grassland with more than 400 individuals of *P. prostrata*. This is an area where trees have been planted in the last few years, and which is regularly mown. The area had been regularly burnt in the past, and Gorse is intruding. This block of land has an interesting history. For the last 65 years, it had been managed as a Golf Course. One small area, however, was a gravel pit more than 30 years ago, and now contained scattered *Pultenaea*. Prior to golf, the block was used as a horse-track and cow common. The area of most abundant *Pultenaea* occurred in a mown mixture of *Themeda triandra*, *Hypochoeris radicata*, *Lepidosperma inops*, *Astroloma humifusum* and *Bossiaea cinerea*. The mowing does not prevent the prostrate *Pultenaea* from flowering or producing an abundance of fruit.

A new site for this species was discovered in early 1992 at Marsh Creek, north-west of Avoca. The grassland community contained up to 1 000 individuals of *P. prostrata* (L. Gilfedder, pers. comm.). It was situated in an open swampy plain at an altitude of about 290 m, and was underlain by dolerite.

A small population of the species occurred on a slope above a tributary of Hunterston Rivulet, north of Bothwell. This site was a grassy, low open shrubland on shallow soils on dolerite, at an altitude of 610 m, and was on gully slopes grading gently to the south. The site was heavily grazed by sheep in the winter, as well as by deer and wallabies. Although the adjacent *Eucalyptus rubida* - *E. pauciflora* woodland had been burnt, there was no evidence of recent fire in the shrubland community. The community had a very sparse cover of low shrubs, dominated by *Olearia algida.* The ground cover was dominated by *Poa gunnii,* as well as *Danthonia* sp., *Agrostis* sp., *Deyeuxia* sp. and *Pentapogon quadrifidus.* Other species included *Aira caryophyllaea, Bossiaea prostrata, Helichrysum apiculatum, Schoenus apogon, Leptorhynchos squamatus, Vulpia bromoides* and *Wahlenbergia* sp. *Leucopogon virgatus, Astroloma humifusum* and *Lepidosperma inops* occurred locally. About 36 plants of *Pultenaea prostrata* were present in an area of 30 m by five metres, and other individuals were scattered locally.

Table 16.1: Summary of habitat records and conservation information for *P. prostrata.*

Recent Records:	4 sites recorded, 4 extant	
Habit:	Prostrate shrub with pubescent branches to about 20 cm length, and linear, inrolled leaves which are thickly clothed with white hairs when young	
Population Size:	> 1 000	
Regeneration:	Type:	Presumed seed germination
	Observed?:	Not directly observed
Habitat:	Landform:	Approximately flat plains to gentle slopes of gully- and hill-sides
	Altitude:	205 - 290 (-610 m)
	Aspect:	Variable (South, East, North)
	Slope:	2 - 6°
	Community:	*Themeda triandra - Poa* spp. grasslands, grassy *Olearia algida* shrubland, or heathy *Acacia dealbata* forest, with *Astroloma humifusum, Helichrysum apiculatum, Lepidosperma inops*
Fire response:	Resprouts after cool burns; presumed germination of seed after moderate to high intensity fires	
Conservation Status:	Proposed:	**u*v**
	Current:	**e** (Kirkpatrick *et al.* 1991b)
Reserve:	Tunbridge Nature Reserve (*not considered adequate, only two plants inside reserve)	
Comment:	Sites occur predominantly on dolerite, also on basalt	

16.4 Phenology

The flowering time for *Pultenaea prostrata* has been recorded as September to December, with fruiting from November to January (Table 16.2). Collections of fertile material held at the Tasmanian Herbarium were collected, for flowering material: November 1892, November 1921, 9th of November, 1983 and 29th of October, 1984; and for fruiting material: 10th of January, 1985. One late flowering specimen that also held pods was collected in November 1891.

Personal observations of the populations at Tunbridge Oval and the Campbell Town Golf Course during spring and summer 1991 - 1992 indicated that buds developed from mid-September through October, and flowering began in the first week of November. The peak of flowering occurred between about the 7th until the 15th of November, and flowering had finished by the 21st of November. The plants under an *Acacia* canopy at Campbell Town continued flowering until early December. Fruit developed through December and early January, and began to be released about the 11th of January. Development was later, again, at Campbell Town, and seed was present until late January. Most of the pods appeared to drop from the plant to the ground prior to dehiscence, rather than dehiscing while still attached to the branch. Most of the seed was removed by ants.

Table 16.2: Phenology of *P. prostrata*, as determined from literature and Tasmanian Herbarium records.

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Jessop & Toelken (1986)									F	F	F	
Rodway (1903)											F	
Woolcock (1991)									F	F		
Lynch (pers. obs.)	P								b	b	FP	FP
Herbarium records	P									F	FP	
	b Buds present F Flowering P Fruit present											

16.5 Propagation

Germination trials for this species included the dry heat trials of two minutes exposure to 100°, 80°, 60° and $40^{\circ}C$, as well as a scarification trial and untreated control. An initial test scarification conducted prior to the germination trials resulted in germination of 94% of seed. The germination trials conducted on *Pultenaea prostrata* displayed significant variation between germination response ($p < 0.00001$, d.f. = 5, F = 139.156). The trials were split into three groups of homogeneity based on the treatment means (Table 16.3, Figure 16.4).

The first group comprised the scarification trial (treatment 1) in which 98.4% of seeds germinated, the 80° trial (treatment 3) which effected 90.0% germination and the $100^{\circ}C$ trial (treatment 2) which effected 89.7% response. The $40^{\circ}C$ trial (treatment 5) effected 50.0% germination, which was not a significantly

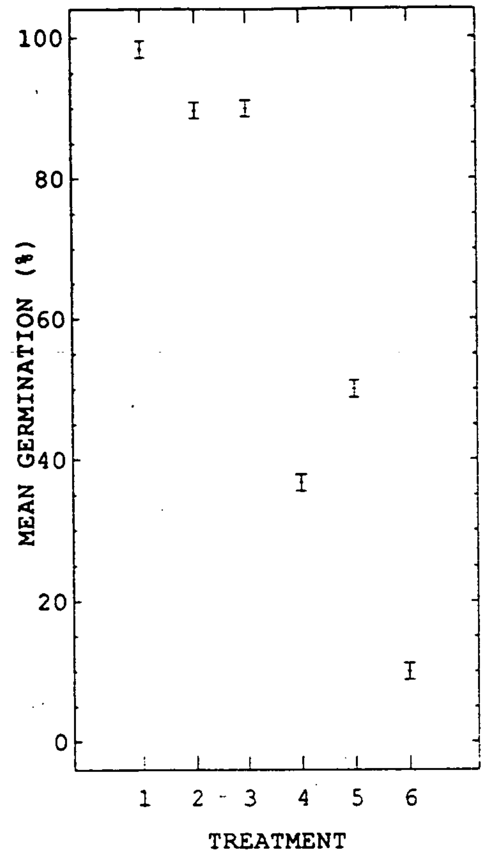


Figure 16.4: **Range of mean results for germination trials with standard errors.**

Table 16.3: Scheffe multiple range analysis of variation between treatment means.

Treatment	Trial	N	Homogeneous Groups		
6	Control	30	X		
4	60°C	30		X	
5	40°C	30		X	
2	100°C	30			X
3	80°C	30			X
1	Scarified	60			X

different result from the 60°C trial (treatment 4) with 36.7% germination. 10.0% of the control seeds germinated (treatment 6), showing that a small proportion of seeds do not require pretreatment. The rate of germination in all trials was rapid, with the majority of seeds germinating within 30 days (Figures 16.5 - 16.10). Seeds treated by scarification, however, germinated within nine days, while seeds subjected to the 80°C trial took 49 days to germinate.

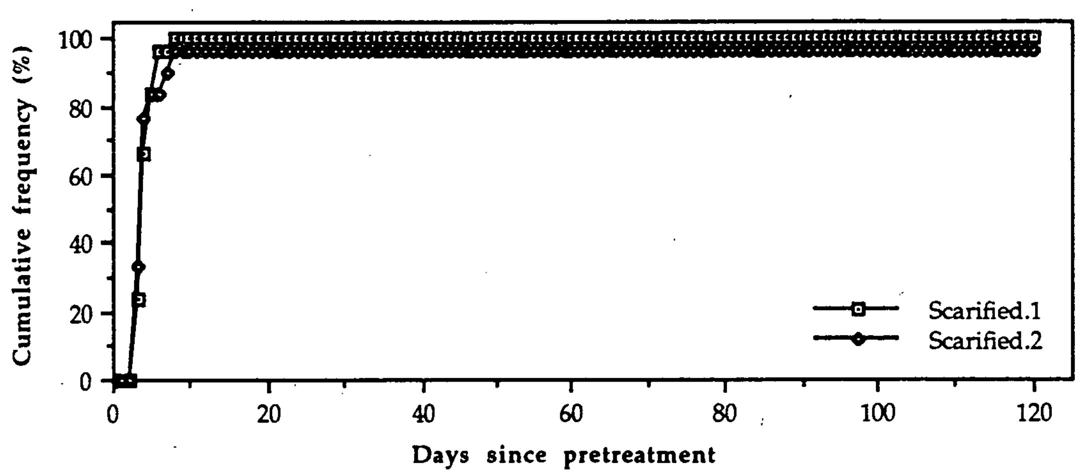


Figure 16.5: **Germination response of *P. prostrata* to scarification pretreatment (groups 1 and 2 represent replicate treatments).**

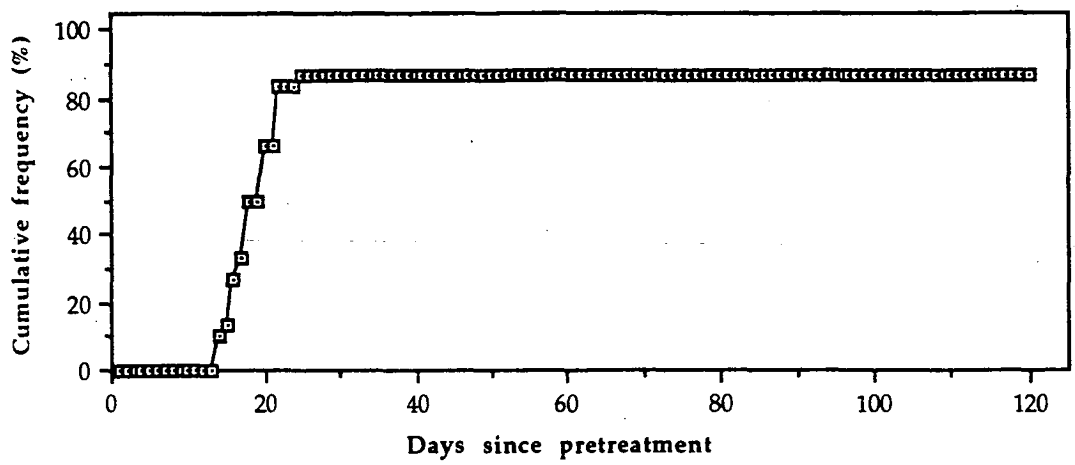


Figure 16.6: Germination response of *P. prostrata* to pretreatment of 100°C.

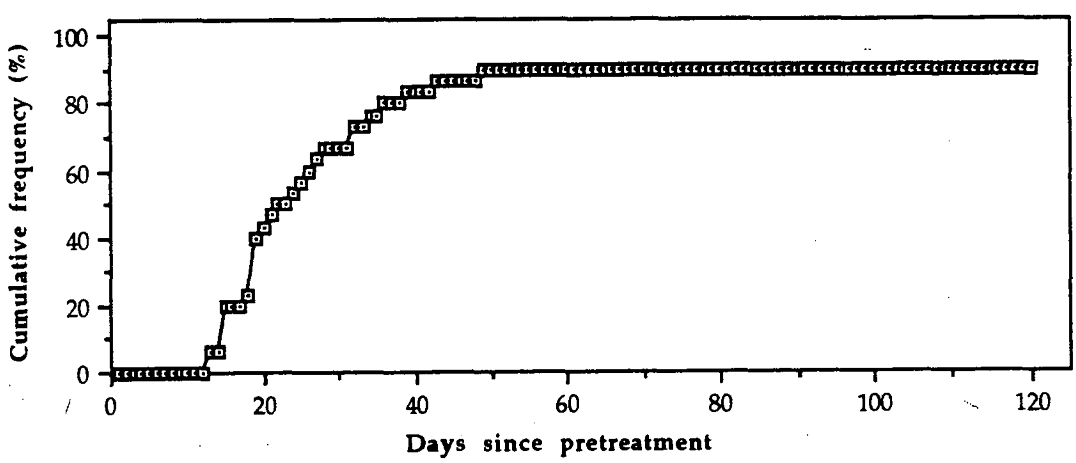


Figure 16.7: Germination response of *P. prostrata* to pretreatment of 80°C.

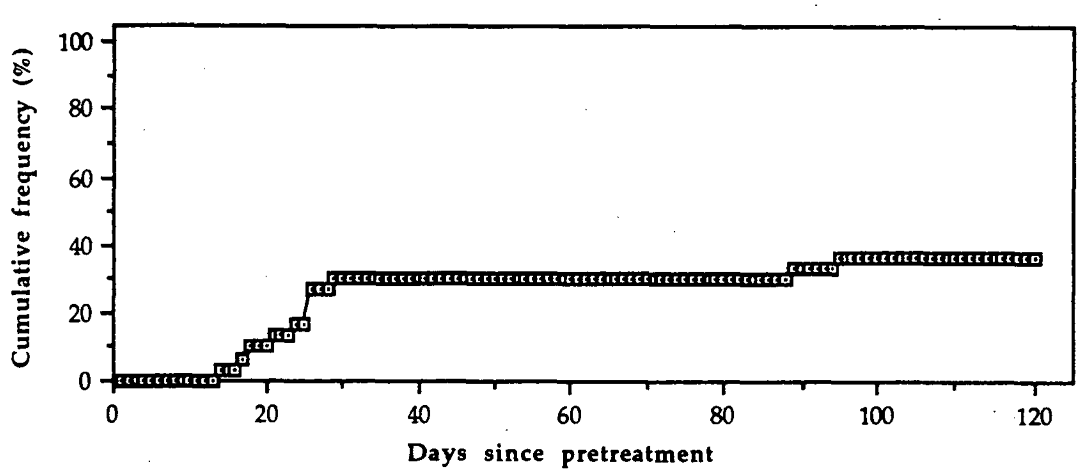


Figure 16.8: Germination response of *P. prostrata* to pretreatment of 60°C.

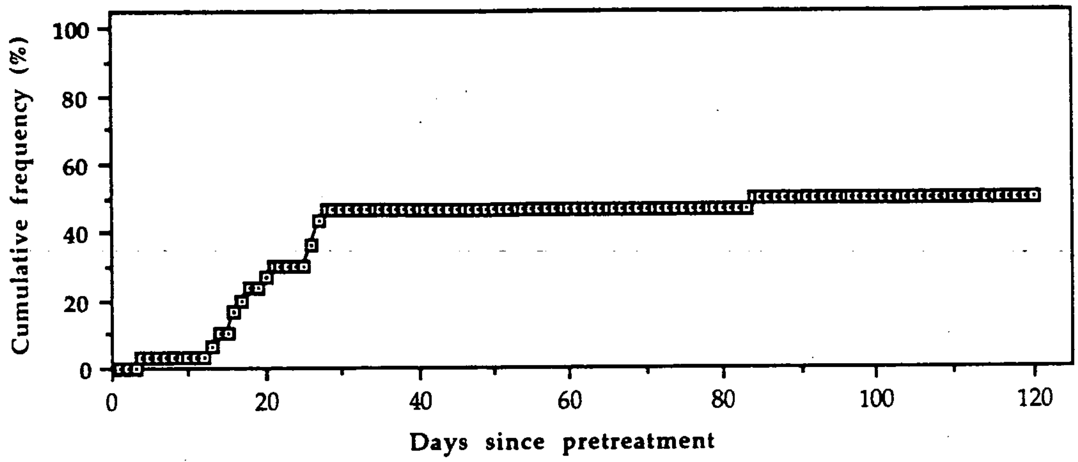


Figure 16.9: Germination response of *P. prostrata* to pretreatment of 40°C.

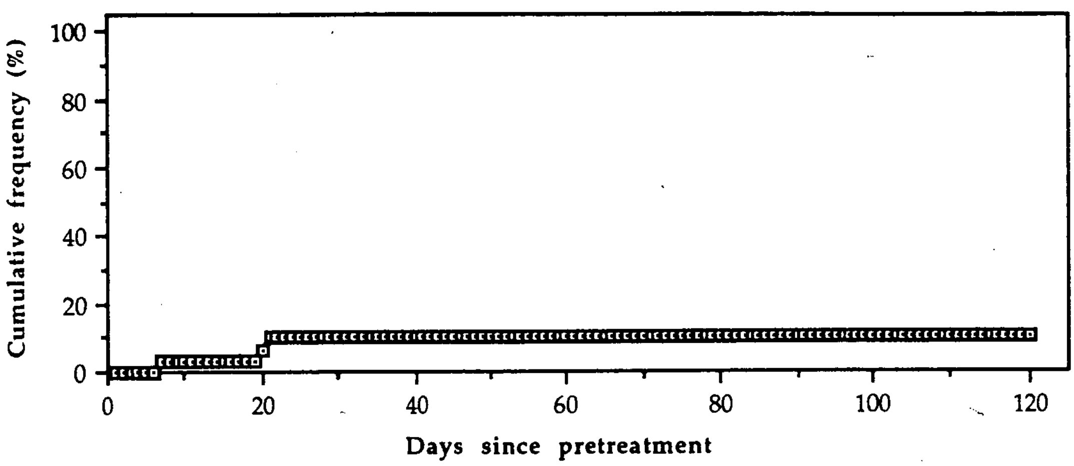


Figure 16.10: Germination response of *P. prostrata* with no pretreatment.

16.6 Age of First Flowering

Several seedlings of *P. prostrata* were grown on in pots maintained initially inside a glasshouse and then outdoors at sea level in Hobart. After 2 years 4 months since treatment of the seed, or in their third spring season, one of the plants flowered. However, no fruit subsequently developed.

16.7 Discussion

In Victoria, *Pultenaea prostrata* is a species of sandy soils of the inland and mallee. Unlike most of the rare Tasmanian species which share a distribution with Victoria, it occurs mainly in the western districts of Victoria, extending to the centre and north-east. In Tasmania, it is a plant of the Midlands grassy woodlands and grasslands, on sites of doleritic and basaltic soils. Both areas are some of the drier parts of their respective States. In the Big Desert and Wyperfeld areas of western Victoria, *P. prostrata* sites receive 300 - 400 mm rainfall annually, while in the Midlands grasslands of Tasmania, sites receive less than 600 mm annually.

None of the old Midlands records of the distribution of *P. prostrata* have been relocated in recent years, and the species is now only known from sites "discovered" in the past ten years. It is debatable as to whether these are new sites or whether they have merely been overlooked in the past. Legumes are not generally known for dispersing great distances. Local colonising ability has been demonstrated at Campbell Town, however, where scattered plants now exist on a 30 year old gravel pit and abundant regeneration has occurred in an area ripped and planted with young trees.

Knowledge about specific management practices appropriate to grassland species is still in its infancy, and populations should be monitored to assess the suitability of existing practices (Fensham 1991). Discussion about methods and their relative advantages has been discussed in Kirkpatrick (1991), Fensham (1991) and Gilfedder (1991). The following discussion relates to *P. prostrata,* and locations such as Tunbridge need to be considered in the context of the requirements of all the other rare species present.

The experimental germination results indicated that a small proportion of seeds are non-dormant, but that pretreatment with temperature or scarification significantly increases germination response. Scarification and the higher temperatures (100^{o}, 80^{o}C) were the most effective method of pretreatment, although temperatures of 40^{o} and 60^{o}C also effected moderate amounts of germination. The ecological equivalence of these trials is presumed to be disturbance and firing.

Pultenaea prostrata appears able to withstand considerable disturbance, exemplified by the mass regeneration of one population on private land at Tunbridge in the Midlands, Tasmania. This site has been cleared of tree and shrub cover and also burnt periodically. The site was heavily grazed back to bare earth in winter and the exposed soil on this north-facing slope may have gained sufficient insolation to reach temperatures which could induce germination of seed in the soil. Some temperate zone species of *Pultenaea*, including *P. prostrata*, have been recorded to germinate in temperatures as low as 40°C in trials. Sites such as that occupied by this Midlands population of *P. prostrata*, which have high levels of insolation, may experience temperatures of 60°C in summer (Pyrke 1994). Alternatively, the germination of *P. prostrata* at this site may have been related to soil disturbance associated with the grazing and the low level of competition. Another possibility is an increased amplitude of diurnal temperature fluctuations due to the removal of vegetation cover and exposure of the soil. *P. prostrata* exists at this site as very small plants, being grazed back to their basal stem and may survive by resprouting. Whether these plants are new germinants or resprouts needs to be determined by monitoring of the plants through winter and spring. Vegetative growth over spring - summer was not sufficient to induce flowering of the plants.

Pultenaea prostrata also occurs on an ungrazed site at Tunbridge with the overstorey and most non-prostrate shrubs removed, and is able to reproduce successfully and vigorously. The site at Hunterston Rivulet is also heavily grazed by sheep in winter. Clearing of overstorey and thinning of understorey species does appear to encourage this species. Grazing or mowing enough to reduce competition from the vigorous native grasses in co-existence also appears to be beneficial. However, prevention of seed production via overgrazing limits expansion of the population. The shrubs must also reach reproductive maturity periodically to replenish the soil-stored seed bank.

The plants can also withstand low intensity fires, and readily resprout. The Tunbridge reserve had not been fired for eight years until a low intensity experimental burn in mid October, 1986, and in winter 1990, after both of which the *Pultenaea* resprouted (L. Gilfedder, pers. comm.). There were no new germinants. The paddock population has not been burnt in recent memory, although it gets heavily grazed back to earth in winter (L. Gilfedder, pers. comm.). Mass regeneration of *Pultenaea prostrata* was observed at this unburnt site.

The population may survive with many of the small (less than two centimetre length stems) plants continually resprouting once the winter grazing pressure declines or after occasional low intensity fires, and some germination introducing new plants to the population. The very low level of competition would aid such processes. Such additions may be sufficient to maintain the viability of the population in the absence of fire, or occasional moderate to hot fires may be required to induce larger scale germination.

17. *PULTENAEA SELAGINOIDES* Hook.f. (Clubmoss Bush-pea)

Figure 17.1: Habit of *P. selaginoides*.

This species has been confused with *Almaleea subumbellata* (previously in the genus *Pultenaea;* Crisp & Weston 1991). These plants may appear similar in habit and foliage, however, there are important distinctions enabling field identification. *P. selaginoides* has axillary and shortly pedicellate flowers, in leafy heads or scattered along the ends of the branches (Figure 17.1), whereas those of *A. subumbellata* are almost sessile and in dense, terminal heads. *P. selaginoides* has narrowly obovate to oblong-cuneate leaves often slightly infolded and with an acute apex, whereas *A. subumbellata* has oblong-lanceolate to oblong-elliptic, flat leaves with either a blunt or acute apex. New growth of the branches of *P. selaginoides* may continue through the axis of the flowers as well as in pseudo-whorls below the flower-heads, unlike growth in *A. subumbellata,* which does not continue through the centre of the axis, only in pseudowhorls. *P. selaginoides* reaches to 2.5 m height while *A. subumbellata* tends to only reach 0.9 m.

17.1 Morphology (from Curtis & Morris 1975 and pers. obs.)

P. selaginoides is a slender, erect shrub up to 2.5 m in height, with brittle, ascending branches. The branches are marked by tuberculate scars from past season's fallen leaves. The leaves are 5-10 mm long, thick, and narrowly obovate to oblong-cuneate leaves with an acute apex. They may be flat or are often slightly infolded, and may have a raised ridge on the abaxial surface. The species flowers prolifically with many small bright yellow pea-flowers, shortly pedicellate and axillary in leafy heads or scattered along the ends of the branches. The standard has reddish markings radiating from above the claw. Each pod contains two seeds, which are reniform, black, and 2-2.25 mm by 1.1-1.25 mm. Reference diagrams for the morphology of this species can be found in Stones and Curtis (1978b) and in Woolcock and Woolcock (1984).

17.2 Distribution and Rarity

P. selaginoides is the third of the species endemic to Tasmania considered in this report, and is similarly restricted to central eastern Tasmania (Figure 17.2). Its conservation status is listed as vulnerable nationally (**Vv** Kirkpatrick *et al.* 1991b; **2V** Briggs & Leigh 1988), and it is reserved within the Douglas-Apsley National Park. Although being one of the two best populations known of this species in condition and abundance, this population is restricted to an area of approximately 600 by 800 m in the south-east corner of the park. Another population occurs on the Swan River, in a proposed extension to the Hardings Falls Forest Reserve. Other extant populations are known from the Apsley River (six plants), to the south of Bicheno, and from State forest near Horseshoe Marsh on the St. Pauls River. The type specimen of *P. selaginoides* was collected in November, 1848, from the St. Pauls River. It has been reported from the St. Pauls River at Avoca (Rodway 1903), however, it is no longer evident there. Collection was made of this species in the 19th Century from Nowhere Else, St. Pauls Plains, about eight kilometres downstream from Horseshoe Marsh and to the west of the Douglas-Apsley.

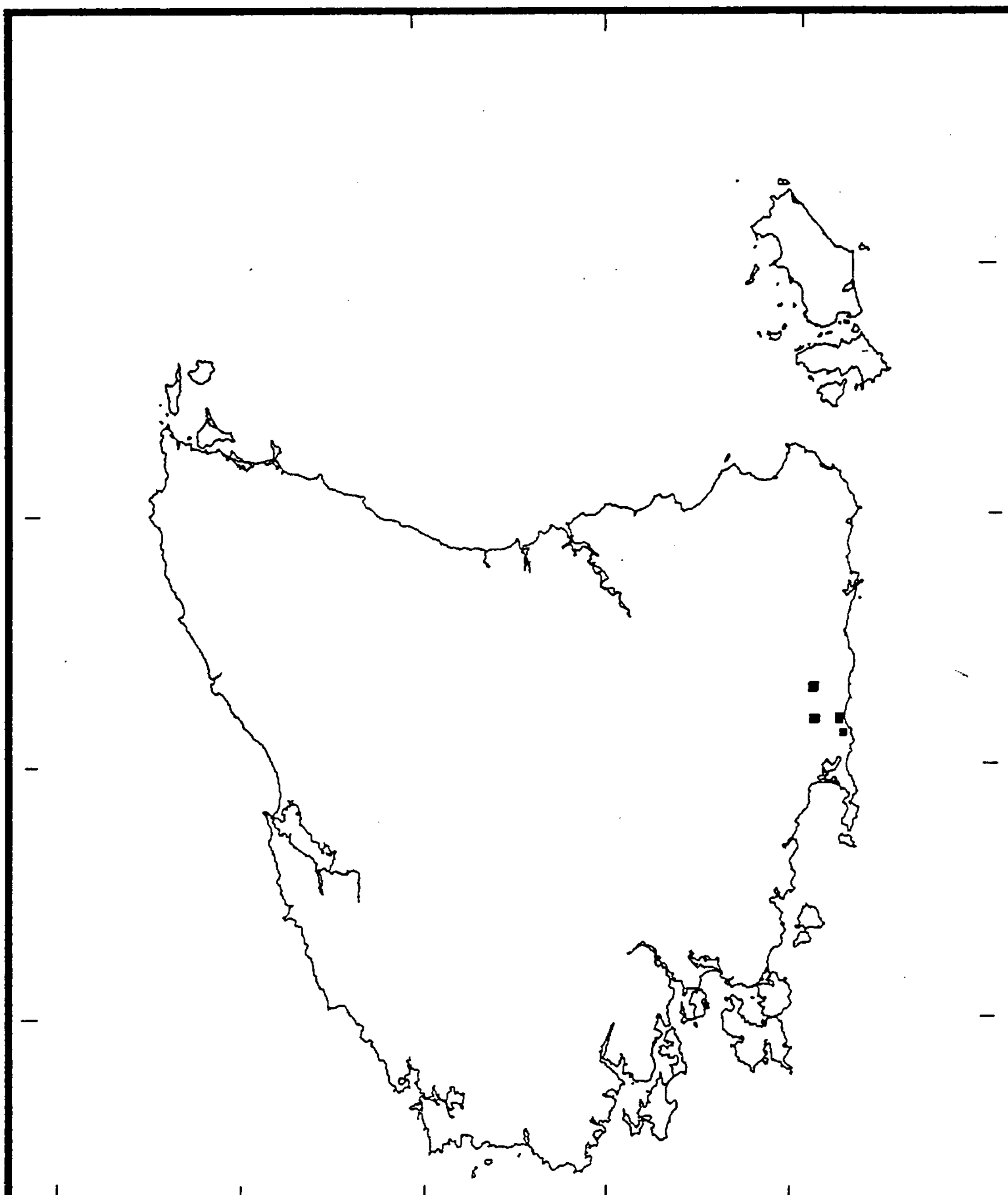


Figure 17.2: Distribution map of recently confirmed populations of *P. selaginoides*.

However, a recent survey of this area failed to locate extant *Pultenaea selaginoides* (M. Askey-Doran, pers. comm.).

17.3 Habitat

Three of the *P. selaginoides* sites occur in the one land system (Mt. Allen land system; Davies 1988), with the Apsley River site in the Apsley River Flats land system. The Mt. Allen sites all have high rainfall (750 - 1 000 mm p.a.) and are in mountainous areas of Jurassic dolerite. Two of the Mt. Allen group are in seasonally swampy areas, while an apparently "drier" site, on a ridgeline east of Blindburn Creek, loses soil-water through gravity flow but gains precipitation by cloud-lie. The Apsley River site has a more moderate rainfall (625 - 750 mm p.a.), but the site is riparian and amidst a flat plain on Jurassic dolerite, and would not be moisture stressed.

Approximately fifty plants of *P. selaginoides* were located on the Swan River, north of Hardings Falls. There were scattered individuals through the community, and probably also other pockets of the *Pultenaea*. This community was quite old with many of the *Leptospermum* senescing. Emergent *Eucalyptus ovata* were present on higher ground. The heathy scrub appeared to be even-aged, having regenerated after massive disturbance, probably a hot fire. It was located within a wide alluvial flood zone, which floods periodically. The ground cover was minimal close to the river channel and also beneath the closed scrub. Old basal coppicing and new shoots from shallow roots of the *Pultenaea* was observed, as well as occasional seedlings in early summer. The scrub was dominated by *Leptospermum scoparium* and *P. selaginoides*, with *L. lanigerum*, *Acacia mucronata* and *Pomaderris apetala*. *Hibbertia riparia* and *Gonocarpus tetragynus* dominated the sparse ground cover, with *Gahnia grandis*, *Lomandra longifolia*, *Micrantheum hexandrum*, *Diplarrhena moraea*, *Hierochloe rariflora* and *Centaurium erythraea* also present. Other local species were *Grevillea australis*, *Epacris lanuginosa*, *E. gunnii*, *Bauera rubioides*, *Pultenaea stricta*, *Almaleea subumbellata* and *Clematis aristata*. *Epacris tasmanica* was present but rare. Low shrubs, and probably seedlings, were grazed by wallabies and wombats, while the ripe pods were eaten by yellow-tailed black cockatoos.

Several sites have been located along the ridgeline east of Blindburn Creek and north-west of Bicheno. The sites occurred in the heads of drainage lines or on flatter shelves on the western slope of an apparently dry dolerite ridge. Like *Hovea corrickiae*, these populations exist on an easternmost range with increased levels of effective precipitation from cloud-lie and from easterly showers. The local vegetation comprised a mosaic of various aged heaths to dense *Leptospermum* scrub, regenerating after firing. *Eucalyptus amygdalina* and *Callitris rhomboidea* dominated the vegetation at the top of the drainage lines, and on the ridge crest extending down the eastern slope of the ridge.

One site at the north-eastern end of the ridgeline was burnt within the last twenty years. This site contained *Eucalyptus barberi, P. selaginoides* and *Spyridium microphyllum* coppicing from basal resprouts. The areas of most abundant *Pultenaea* were in open heath with low *Eucalyptus barberi* emergents on flat to moderately sloping sites with reasonable soil accumulation and where they are not overtopped by *Leptospermum grandiflorum* (Figure 17.3). Dense thickets of closed *Leptospermum* scrub were interspersed with younger heaths across the slope. The *Pultenaea* occurred amidst a mid dense cover of *Spyridium microphyllum* with *S. obovatum, Hakea epiglottis, Leptospermum grandiflorum, Lepidosperma laterale, L. inops, Xanthorrhoea australis, Dillwynia sericea, Epacris tasmanica* and *Leucopogon virgatus.* Many juvenile *Pultenaea* (0.2 m tall) were present in the area. The site was on a rocky knoll at the head of a drainage line just west of the ridge crest and extending west onto the fire-scarred slope.

Figure 17.3: Typical habitat of *P. selaginoides;* the ridgeline east of Blindburn Creek, Douglas-Apsley National Park.

The site farther south occurred on a dolerite shelf one-third of the way down the western side of the ridge. It sloped at 5^{o} to an aspect of 245^{o}, and the deeper soils on the shelf gain moisture from the rocky slope above, with retention aided by a dense, if not deep, litter cover. The vegetation at this site consisted of an *Eucalyptus amygdalina* woodland with a three to four metre tall, moderately dense layer of *Leptospermum grandiflorum* and *Pultenaea selaginoides.* A 0.5-1.5 m tall shrub layer consisted primarily of *P. selaginoides, Xanthorrhoea australis, L. grandiflorum, Melaleuca gibbosa, Acacia verticillata, Hibbertia riparia,* with also *P. gunnii, A. genistifolia, Spyridium obovatum, Cyathodes juniperina, Leucopogon collinus* and *Leptomeria drupacea.* The ground cover included *Lepidosperma laterale, L. inops, Callitris rhomboidea* seedlings, low *Spyridium microphyllum* and *Astroloma humifusum.* Other sites, similar to this localised cluster of *Pultenaea,* probably occur along the ridgeline (one other site located by T. Moscal) and quite possibly on nearby ridges and hills.

Six plants occurred on the Apsley River, south-west of Bicheno, on private land. The plants were relatively old, the community having not burnt for at least thirty years (flowering material was collected from this species in 1967). There was some physical damage to the *Pultenaea* resulting from the movement of cattle through the scrub. No regeneration was observed, despite ample light and small areas of disturbed ground suitable for seedling establishment. The *Pultenaea* were on the margins of a dense riparian scrub verging into scrubby low woodland. The community comprised a sparse overstorey of *Eucalyptus amygdalina,* with *E. ovata* and *Allocasuarina littoralis,* over a mid dense three metre tall layer of shrubs, a lower sparse shrub layer at 1.5 m, and a predominantly saggy ground layer, with very sparse grasses and herbs. The most common shrubs were *Leptospermum scoparium, Melaleuca gibbosa* and *Bursaria spinosa,* while other contributing species included *Callitris rhomboidea, Pomaderris apetala, Acacia verticillata, A. genistifolia, A. dealbata, Pultenaea stricta, Micrantheum hexandrum* and gorse, *Ulex europaeus.* Saggs present included *Lomandra longifolia, Lepidosperma laterale* and *L. concavum,* while grasses present included *Themeda triandra, Poa labillardieri, Ehrharta stipoides* and *Danthonia caespitosa.* The site had a slight gradient to the north-west, and a Jurassic dolerite substrate.

One site was located early in 1992 on the upper St. Pauls River, downstream of Horseshoe Marsh. This site, at 520 m altitude, was on the river-flat and in the adjacent heath. Beside the river channel, *Hakea epiglottis* dominated a tall (five metre) shrubland, with a secondary shrub layer at four metres dominated by *Leptospermum lanigerum* and *Allocasuarina littoralis,* and a two metre tall, sparse layer of *L. lanigerum* and *P. selaginoides.* Other species present included *L. scoparium* and *Bauera rubioides*. Currently dry flood channels and debris indicate that periodic flooding occurs. Farther from the river's edge, *Eucalyptus gunnii* dominated a low open woodland, with a five metre tall, sparse shrub layer of *H. epiglottis*, *Allocasuarina littoralis* and *L. scoparium*, and a two metre shrub layer dominated by *P. selaginoides*, *B. rubioides*, *Micrantheum hexandrum* and *L. scoparium*. *Gahnia grandis* dominates a sparse ground layer. *Melaleuca squarrosa* and *Callistemon viridiflorus* were also present. The site had not been recently burnt.

Table 17.1: Summary of habitat records and conservation information for *P. selaginoides*.

Recent Records:	4 sites recorded, 4 extant	
Habit:	Slender, erect shrub, 2.5 m tall. Brittle, ascending branches with tuberculate scars, growing in sparse pseudowhorls and extending through its centre. Shortly pedicellate and axillary flowers in leafy heads or scattered along the branch ends	
Population Size:	Very approximately 1 000	
Regeneration:	Type:	Basal coppicing, germination from seed
	Observed?:	Observed at Hardings Falls, Blindburn Creek
Habitat:	Landform:	alluvial flats or flood zone, (or ridgeline shelf, knoll, or soak)
	Altitude:	(20 -) 215 - 290 m (- 520 m)
	Aspect:	South-west to north-west (to north-east)
	Slope:	< 3° (- 6°)
	Community:	Heathy scrub of *Leptospermum, Pultenaea, Melaleuca, Hakea* spp. with *E. ovata, E. amygdalina* or *E. barberi* emergents, or *E. amygdalina* woodland over scrub
Fire response:	Coppicing after cool fires, germination after moderate to hot fires (see Section 17.5)	
Conservation	Proposed:	**Vv**
Status:	Current:	**Vv** (Kirkpatrick *et al.* 1991b); **2V** (Briggs & Leigh 1988)
Reserve:	Douglas-Apsley National Park	
Comment:	Sites on Jurassic dolerite in areas of moderate to high effective precipitation (> 750 mm p.a.) and/ or periodic flooding All populations currently producing fruit, but appear to be up to 30 years old	

17.4 Phenology

Pultenaea generally flower between September to December, with seeding from November to January (Blombery 1967). Only one source refers specifically to the flowering of *P. selaginoides:* Stones and Curtis (1978b) state that flowers were collected on 2nd of November, 1967 and fruit on 28th of December, 1969, from the Apsley River (Table 17.2). Most specimens of *P. selaginoides* held by the Tasmanian Herbarium were in Sydney during this project for taxonomic redetermination. Only one fertile specimen was still held, one in flower, collected November 1971. Vegetative specimens were collected in 1848 and on 10th of May, 1980.

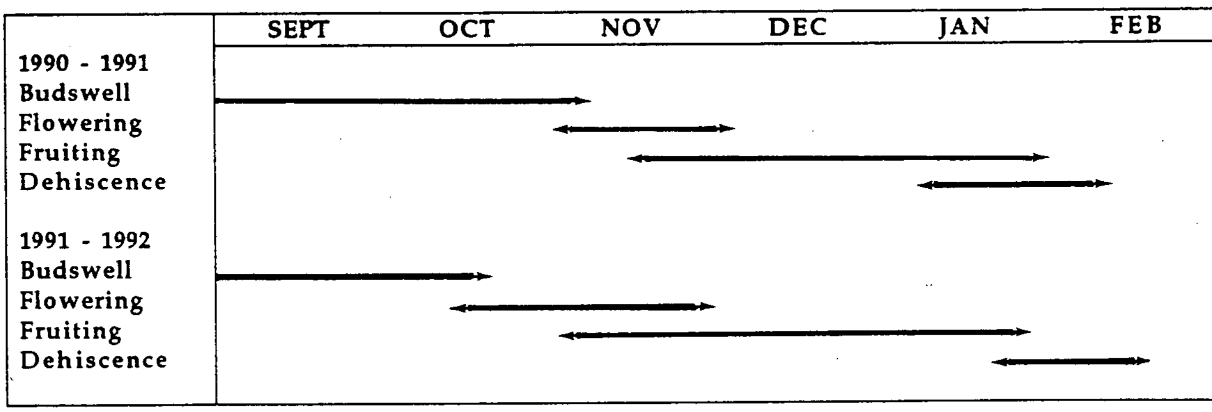
Table 17.2: Phenology of *P. selaginoides*, as determined from literature and Tasmanian Herbarium records.

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Blombery (1967)	P								F	F	FP	FP
Stones & Curtis (1978b)											F	P
Herbarium records											F	

F Flowering
P Fruit present

In spring, 1990, buds developed through September to early November (Table 17.3). Budburst, followed by earliest flowering, began at the start of November. Flowering continued until early December. Fruit began to develop after successful fertilisation, and continued to develop until seeds were fully formed in mid to late January. The pods dehisced and seeds were released over several weeks in mid January to early February. The population at Blindburn Ridge flowered earlier than the Hardings Falls population. This population had finished flowering by 18th of November except for one late plant.

Table 17.3: **Field observations of phenological activity, spring to summer, 1990 - 1991 and 1991 - 1992, at Hardings Falls site, Swan River.**



The pattern in spring of 1991-1992 was similar, although flowering and fruiting commenced about two weeks earlier than the previous year. Development of the seeds and pods took longer, and dehiscence did not commence until late January. The population on the Apsley River flowered earlier than the Hardings Falls population, and had finished flowering by 7th of November except for a few late plants. Fruit production in both seasons was substantial, with great variation between individual shrubs. The plants in more open microsites appeared to be healthier and produced a greater abundance of fruit. This appeared to be due to competition for light, with more successful plants unshaded by taller shrubs such as *Leptospermum*.

17.5 Propagation

Germination trials for this species included the dry heat trials of two minutes exposure to 100°C, 80°C, 60°C, and 40°C, as well as a scarification trial and control. An initial test scarification of fresh seed conducted prior to the germination trials resulted in germination of 92.3% of the seeds.

The trials conducted on *P. selaginoides* varied significantly between treatments ($p < 0.00001$, d.f. = 5, F = 199.427). There was also significant variation between most treatments (Figure 17.4, Table 17.4). The scarification trial (treatment 1) effected a mean response of 93.3%, and the 100°C trial (treatment 2) effected a mean of 86.7%. These two treatments were the most effective but were not significantly different in result to each other. The 80°C trial (treatment 3) effected a mean of 41.2% response, while the 60°C trial (treatment 4) effected a mean of only 13.1%. No germination was apparent in either the 40°C trial (treatment 5) nor the control (treatment 6).

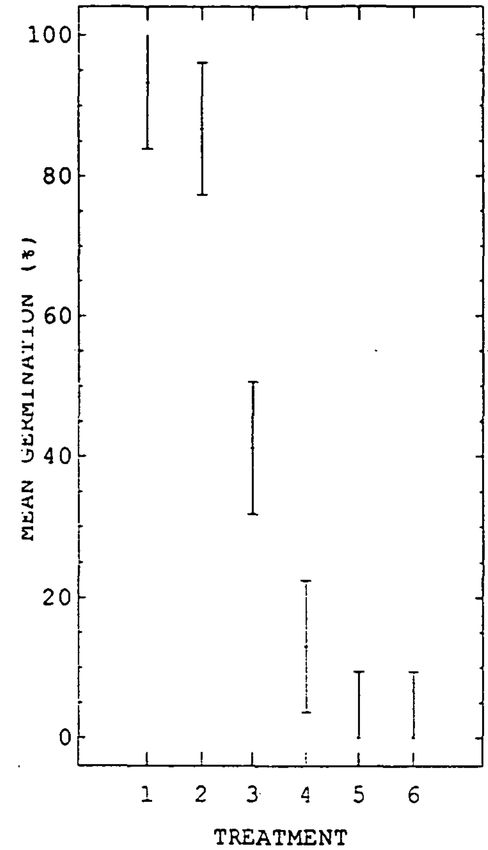


Figure 17.4: **Range of mean results for germination trials with standard errors.**

Table 17.4: **Scheffe multiple range analysis of variation between treatment means.**

Treatment	Trial	N	Homogeneous Groups			
6	Control	30	X			
5	40°C	60	X			
4	60°C	60		X		
3	80°C	60			X	
2	100°C	60				X
1	Scarified	60				X

The scarification treatment effected rapid germination, all response occurring within 25 days (Figure 17.5). The other successful treatments displayed germination throughout the 120 days of the trial (Figures 17.6 - 17.8).

Propagation using vegetative cuttings of this species was attempted, firstly, by sterilising the cutting material in a 0.5% chlorine dip for 3 - 5 minutes, and then application of Clonex rooting hormone; both softwood and hardwood hormones. The cuttings were made in May, and maintained in a glasshouse until potting up in November. Three combinations were trialled: (i) chlorine dip only (18 cuttings); (ii) chlorine dip, followed by softwood hormone dip (20 cuttings); and (iii) chlorine dip, followed by hardwood dip (20 cuttings). The treatments had variable effectiveness, with resultant strike rates of (i) 11%; (ii) 20%; and (iii) 50%.

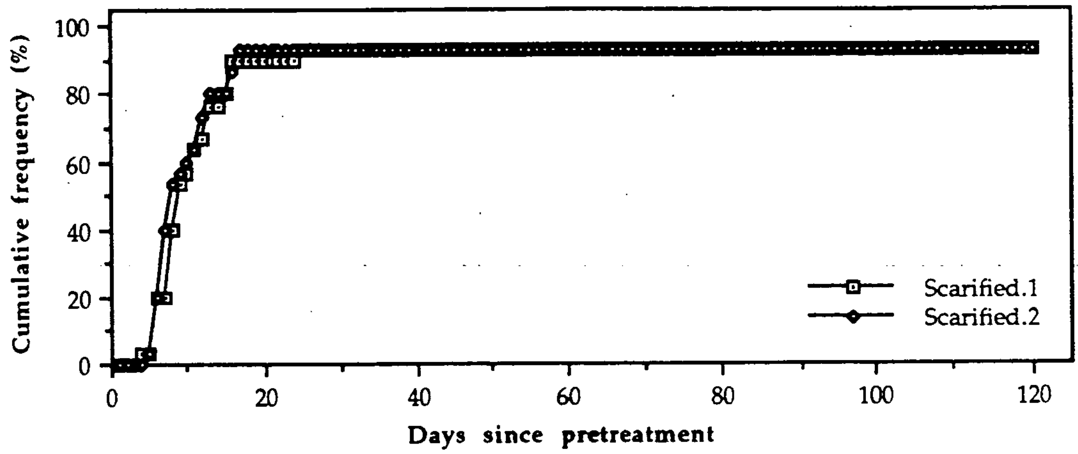


Figure 17.5: Germination response of *P. selaginoides* to scarification pretreatment (groups 1 and 2 represent replicate treatments).

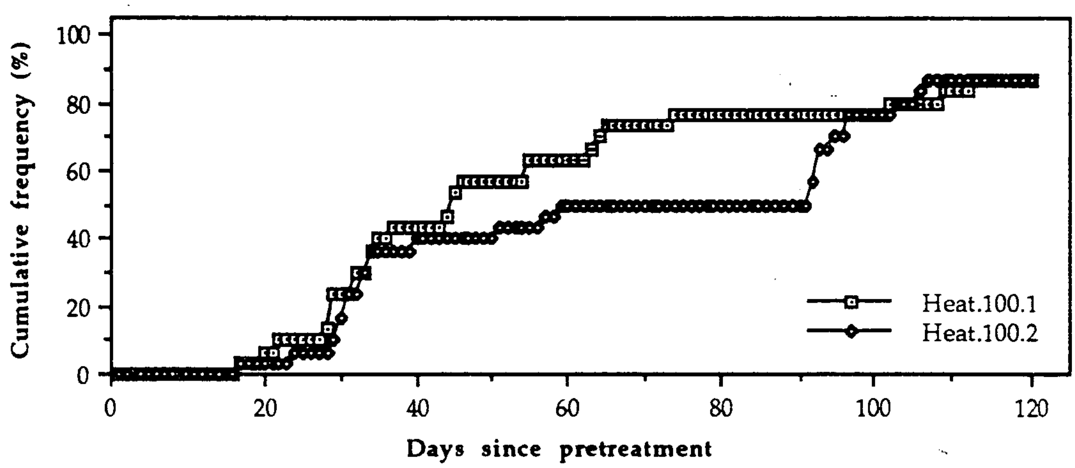


Figure 17.6: Germination response of *P. selaginoides* to pretreatment of 100^{o}C (groups 1 and 2 represent replicate treatments).

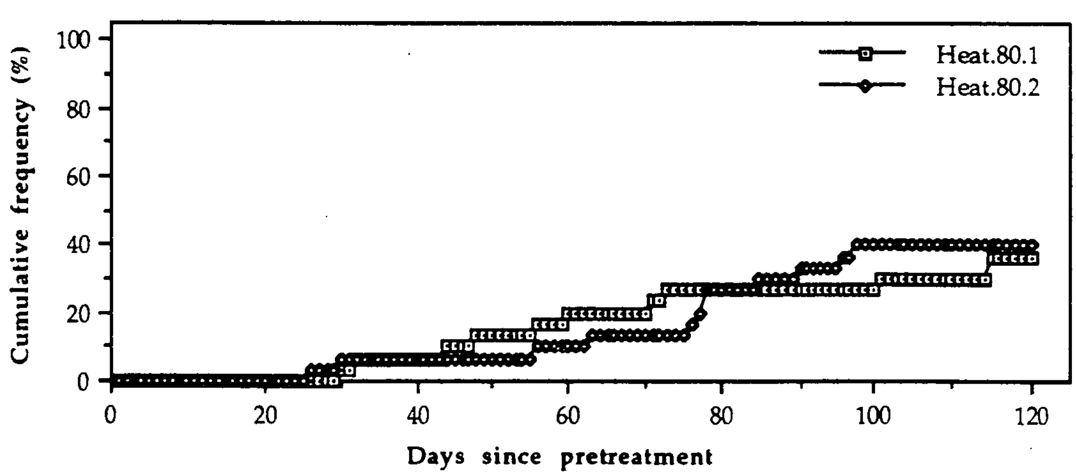


Figure 17.7: Germination response of *P. selaginoides* to pretreatment of 80^{o}C (groups 1 and 2 represent replicate treatments).

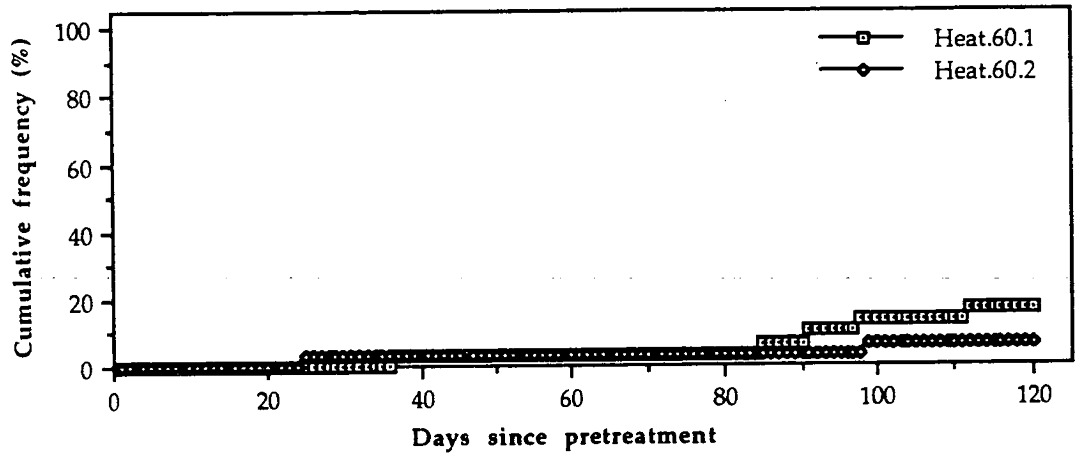


Figure 17.8: Germination response of *P. selaginoides* to pretreatment of 60°C (groups 1 and 2 represent replicate treatments).

17.6 Age of First Flowering

Approximately twenty seedlings of *P. selaginoides* were grown on in pots maintained initially inside a glasshouse and then outdoors at sea level in Hobart. After 2 years $3^1/_2$ months since treatment of the seed, or in their third spring season, two plants flowered. However, no fruit subsequently developed.

17.7 Soil-Stored Seed Bank

Seed of *Pultenaea selaginoides* was found to be quite common in the soil seed bank with a high proportion of soil profile cores containing seed (93.75%). A total of 136 seeds were found from 30 cores with a total volume of 0.013 m^3 or 1 311 cm^3 and with a surface soil area of 0.1122 m^2. Some of the cores (53.3%) had seeds only within the top two centimetres of soil, while 86.67% of cores with seeds held seeds only in the top four centimetres of soil. The second section of cores, from 2 - 4 cm depth in the soil profile, also contained reasonable quantities of seed, 37.5%. All but one of these cores with seed at 2 - 4 cm depth also had seeds in the top two centimetres of the core. Seeds were sparse below four centimetres depth. The sections between 4 - 6 cm and from six centimetres to the bottom of the core (usually to ten or 12.5 cm) had much lower quantities of seeds; only 12.5% of both series of sections contained seeds, and only one seed was found in each. These cores did, however, tend to contain seeds in all or nearly all of the sections, possibly displaying the influence of animal digging or some other disturbance in bioturbation of the soil. One of these cores with seeds throughout the soil profile also contained small pieces of white and blue plastic throughout the profile. Plastic was found in the top two centimetres of three other cores.

Occasional concentrations of seeds were found in some cores, with 31.25% of the cores containing greater than ten seeds in the top two centimetres (one of these had 29 seeds), and one core at 2 - 4 cm depth also containing more than 10 seeds. At least five other types of seed were also common in, and recovered from, the cores. Large quantities of charcoal were evident throughout the profile in most cores (75%). Charcoal was not present in 12.5% of cores, while the other 12.5% contained charcoal only in the upper four or six centimetres.

17.8 Disturbance

The four plots for this species were checked finally for germination after one year on 24th January, 1992. The results for each plot were, as follows:

Plot 1 - 3 germinants;	Control 1 - 0 germinants;
Plot 2 - 5 germinants;	Control 2 - 0 germinants;
Plot 3 - 2 germinants;	Control 3 - 0 germinants;
Plot 4 - 3 germinants;	Control 4 - 3 germinants.

These results indicate that disturbance does increase the likelihood of germination at a site. Germination did, however, occur in undisturbed areas and occasional germinants were noted outside these plots. This species was also observed to vegetatively sprout from rhizomes and basal shoots.

17.9 Pollination

Two specimens of the following species were collected on 15th November 1990, at the Hardings Falls population of *P. selaginoides.* The adults are pollen feeders (J. Lawrence, pers. comm.), but may also transfer pollen between flowers (R. Coy, pers. comm.). One to two of these beetles were observed to be present inside the keel of all flowers of *P. selaginoides*, while the flowers were in early to peak flowering.

Order	Coleoptera
Sub-Order	Polyphaga
Series	Cucujiformia
Super Family	Cucujoidea
Family	Nitidulidae
	Notobrachypterus species

One specimen of the following species was collected on 15th November, 1990. This large scarab beetle is primarily carnivorous as larvae, but the adults may feed on pollen (J. Lawrence, pers. comm.). The beetles may also transfer pollen between flowers (R. Coy, pers. comm.). It was observed to be vigorously pushing into the keel of the pea-flowers.

Order	Coleoptera
Sub-Order	Polyphaga
Series	Cucujiformia
Super Family	Cleroidea
Family	Cleridae
	Eleale species

Specimens of a native bee and a flower spider were also collected from the flowers of *P. selaginoides*. Unfortunately, identification by the relevant entymological authorities has not been completed.

17.10 Discussion

Pultenaea selaginoides is currently under taxonomic revision. It is closely related to the recently described genus *Almaleea* (Crisp & Weston 1991). However, the authors' recent cladistic analysis separated *P. selaginoides* from both *Pultenaea* and *Almaleea*. *P. selaginoides* may require a new monotypic genus (P. Weston, pers. comm.). This possibility underlines the importance of this species to the biodiversity of Tasmania's east coast flora.

This species is restricted to four extant populations in central eastern Tasmania, totalling approximately 1 000 plants. The populations occur in riparian sites and on the upper slopes of ridgelines on the seaward slopes of the east coast. The largest and healthiest population is reserved in the Douglas-Apsley National Park. However, this population is localised to several sites in an area of approximately 600 by 800 m. The other sizeable population occurs on the Swan River, in a proposed extension to the Hardings Falls Forest Reserve. This is a mature population, and successfully reproducing at present. The species is a host to the pathogen *Phytophthora cinnamomi*, which is widespread in the region (T. Wardlaw, pers. comm.), but is resistant to its effects (Barker 1994). Other extant populations of *P. selaginoides* are known from the Apsley River, south of Bicheno, a non-viable population of six plants, and from State forest near Horseshoe Marsh on the St. Pauls River. Earlier collections of *P. selaginoides* also came from this region. It was collected in the 19th Century from Nowhere Else, St. Pauls Plains, about 8 km downstream from Horseshoe Marsh and to the west of the Douglas-Apsley. Further investigations in this area are warranted.

The sites at which this species occurs have notable similarities; being on Jurassic dolerite in areas of moderate to high effective precipitation (> 750 mm p.a.) and/ or periodic flooding. Three of the sites were included in the one land system (Mt. Allen land system: Blindburn Ridge, Swan River and St. Pauls River) by Davies (1988), with the Apsley River site excluded (Apsley River Flats). The Mt. Allen sites all have high rainfall (750 - 1 000 mm p.a.) and are in mountainous areas (215 - 520 m altitude). Two of the Mt. Allen group are in seasonally swampy areas of alluvial flats or flood zones, while the apparently "drier" sites on Blindburn Ridge occur either on a shelf, knoll, or soak with locally greater soil accumulation to retain water and increased precipitation from cloud-lie. The Apsley River site has a more moderate rainfall (625 - 750 mm p.a.) and is at lower altitude (20 m), but the site is riparian and amidst a flat plain, and would not be moisture stressed. The clay soils present at most of the sites, except those at Blindburn Ridge, have low permeability which contributes to the waterlogging and flooding of these sites. Blindburn Ridge sites tend to be on clay loam soils with moderate permeability.

P. selaginoides occurs in heathy scrubs dominated by *Leptospermum, Pultenaea, Melaleuca* and *Hakea* with *Eucalyptus ovata, E. amygdalina* or *E. barberi* emergents, or in *E. amygdalina* woodland over scrub with similar understorey dominance. The populations personally observed (Blindburn Ridge, Apsley River, Swan River) are all older than twenty years, although one site at Blindburn Ridge has coppiced plants and 0.2 m tall seedlings evident after more recent fire. Fire is a part of the regeneration ecology of these communities. Large quantities of charcoal were evident throughout the profile in most of the soil cores from the Swan River. Although the plants are currently successfully resprouting, they may require a moderate to hot fire to induce seed germination rather than coppicing.

Dormancy in *P. selaginoides* is dependent on the seed coat barrier to imbibition. The experimental germination results indicated that both temperature and scarification promote germination, with seeds being sensitive to temperature intensity. Only minimal germination occurred at 60^{o}C, but the germination response increased with increasing temperature from 60^{o} to 100^{o}C. The natural analogue of the temperature trial is presumed to be firing, while for scarification it is presumed to be mechanical disturbance, such as occurs during flooding. The greater degree of germination at higher temperatures indicates that moderate to hot fires are required for abundant germination of *Pultenaea.* With most seeds concentrated in the top four centimetres of the soil profile, good predicted germination should result from temperatures of 80^{o} - $100^{o}C$ in the top two centimetres of the soil profile (Auld & O'Connell 1991). Low intensity fires effect predicted temperatures of only 40^{o} to two centimetres depth, although temperatures of 60 - 70^{o} occur for a few minutes at one centimetre depth (Auld & O'Connell 1991). Low intensity fires may induce adequate regeneration if timed shortly after fruit dehiscence, when quantities of seed are still present on the ground surface. Further work is needed to determine the precise extent and influence of scarification occurring in field situations.

The populations are all known to flower, and abundant fruit were produced at the monitored site on the Swan River. It is a spring flowering species, peaking in November, with fruit ripening in mid January to early February. Other populations varied slightly, however, flowering and possibly fruiting several weeks earlier. Fruit production in both seasons was substantial, with great variation between individual shrubs. The plants in more open microsites appeared to be healthier and produced a greater abundance of fruit. Firing may also benefit the *Pultenaea* in this regard by opening the community structure.

Many seeds, along with other material such as plastic and other flood debris, are incorporated into the soil profile, primarily in the top few centimetres. Other seeds also accumulate within the soil, usually from hard-seeded species. Quite large numbers of seeds may be concentrated in areas, probably due to close proximity to abundantly fruiting branches. Seeds also reach farther down the profile, probably through processes of bioturbation, such as localised animal digging or deposition after floods. Experimental trials determined that disturbance did encourage germination. Other germinants in undisturbed trial areas and outside the plots predominantly occurred in microsites free of competition. The ground cover is maintained fairly bare through shading by the dense scrub and by flood disturbance.

18. *VIMINARIA JUNCEA* (Schrad. & J.Wendl.) Hoffsgg.
(Golden Spray or Native Broom)

18.1 Morphology (from Curtis & Morris 1975, Woolcock 1991, Wiecek 1991 and pers. obs.)

Viminaria juncea is a tall, glabrous, willowy, single stemmed shrub or low tree to six metres in height. It has slender, smooth, erect stems and drooping branches, which are terete, glabrous, and of a light-green colour. The leaves have reduced to filiform petioles 3-25 cm long, although juvenile leaves of one to three leaflets may be present on younger plants or shoots. The flowers are small, yellow and solitary, in terminal racemes or the upper axils. The common name of Golden Spray derives from the racemes forming a golden-yellow spray of up to 20 cm length. The corolla is yellow to orange, and may have red blotches and a darker keel. The pedicels are slender, and five millimetres in length. There are five free and equal lobes and ten free stamens. The fruit is a small, inflated, obovoid legume, which is black and with an oblique beak. Each pod contains one seed, or occasionally (1.3%) two. The seeds are pale brown, reniform and 2-2.7 mm by 1.5-2 mm. They do not retain an elaiosome.

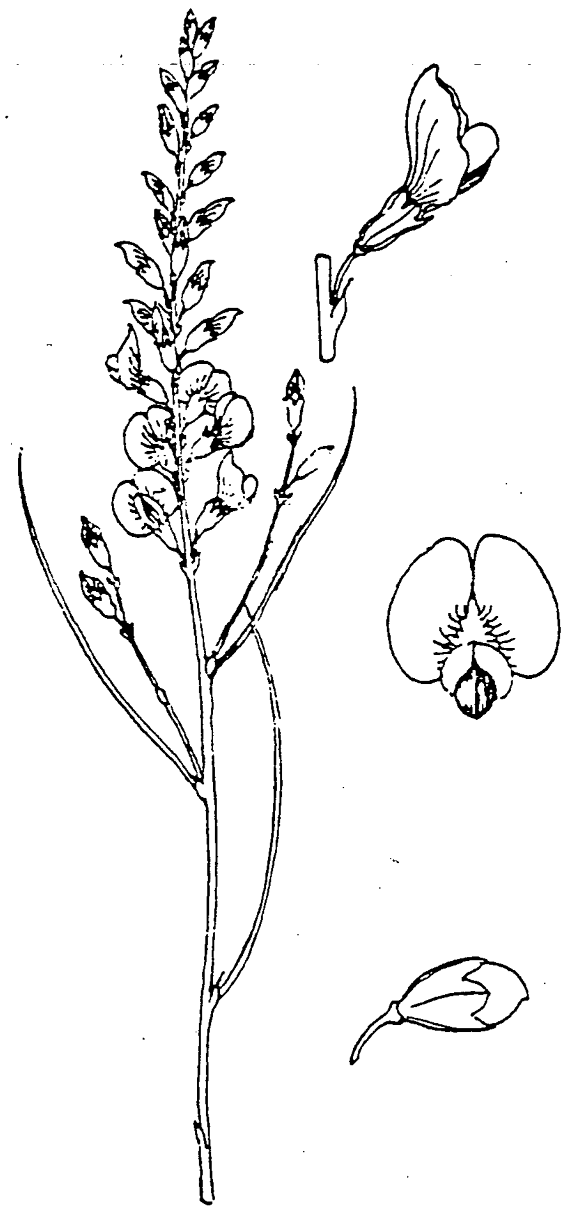


Figure 18.1: Morphology of *V. juncea* (from Woolcock 1991).

Experimental trials on the morphological variation in this species determined that geographically isolated populations vary widely and consistently from one another in heteroblastic development of their seedlings, even though they are virtually indistinguishable in the adult state (Walker & Pate 1986). The principal varying attributes were the number of trifoliate juvenile leaves formed before transition to the adult phyllodinous habit, and the habit varying from tall and sparingly branched to prostrate and multibranched. The two habits were suggested to correlate, respectively, with shaded, moist forest habitats and exposed seasonally arid habitats likely to dry out in early summer. The variation was determined to be of stabilised characters not subject to phenotypic plasticity, and displayed by all members of a seedling progeny under a wide range of nutrient and water regimes (Walker & Pate 1986). The implication is that other geographically isolated populations, such as the Tasmanian ones, may be of similar genotypic distinctiveness.

18.2 Distribution and Rarity

The genus *Viminaria* is endemic to Australia, and includes one species, *V. juncea,* which occurs in the non-tropical higher rainfall regions of all States except the Northern Territory (Woolcock 1991). It occurs in south-eastern Queensland (Galbraith 1977), and south-eastern South Australia (Southern Lofty, South-east and Kangaroo Island districts; Jessop & Toelken 1986).

In New South Wales, *V. juncea* occurs in the coastal regions, while in Victoria, the species has been recorded in all districts except the Mallee, North-east, Alpine and Gippsland Lakes, but is concentrated in the southern districts (Figure 18.2). It is, correspondingly, a species of widespread distribution, with a preference for swampy, coastal situations (Wiecek 1991; Figure 18.3).

This species is only known from one district in Tasmania (Figure 18.2), and within this area from only three clusters of plants totalling less than 100 individuals. The area where *Viminaria* occurs is at Pelican Bay, on the Freycinet Peninsula of eastern Tasmania, and the three sites are scattered over one and a quarter square kilometres. The earliest dated Herbarium specimen was collected in 1945 from "near Coles Bay", although there is a specimen also from Rodway's collection. This specimen must have been collected after 1903, however, as Rodway (1903) included the species in his Tasmanian Flora as present based on its inclusion in Mueller's Census. He himself considered its presence in Tasmania, at that time, as doubtful. It is possible that *V. juncea* is more widespread, and that other extant populations have been overlooked. Surveys of suitable similar habitat were not conducted during this study.

V. juncea is considered unreserved and endangered by extinction in Tasmania (**ue**; Kirkpatrick *et al.* 1991b). This classification follows from the low numbers of *V. juncea* present in the State, their geographic restriction, and the inadequate reservation of this species.

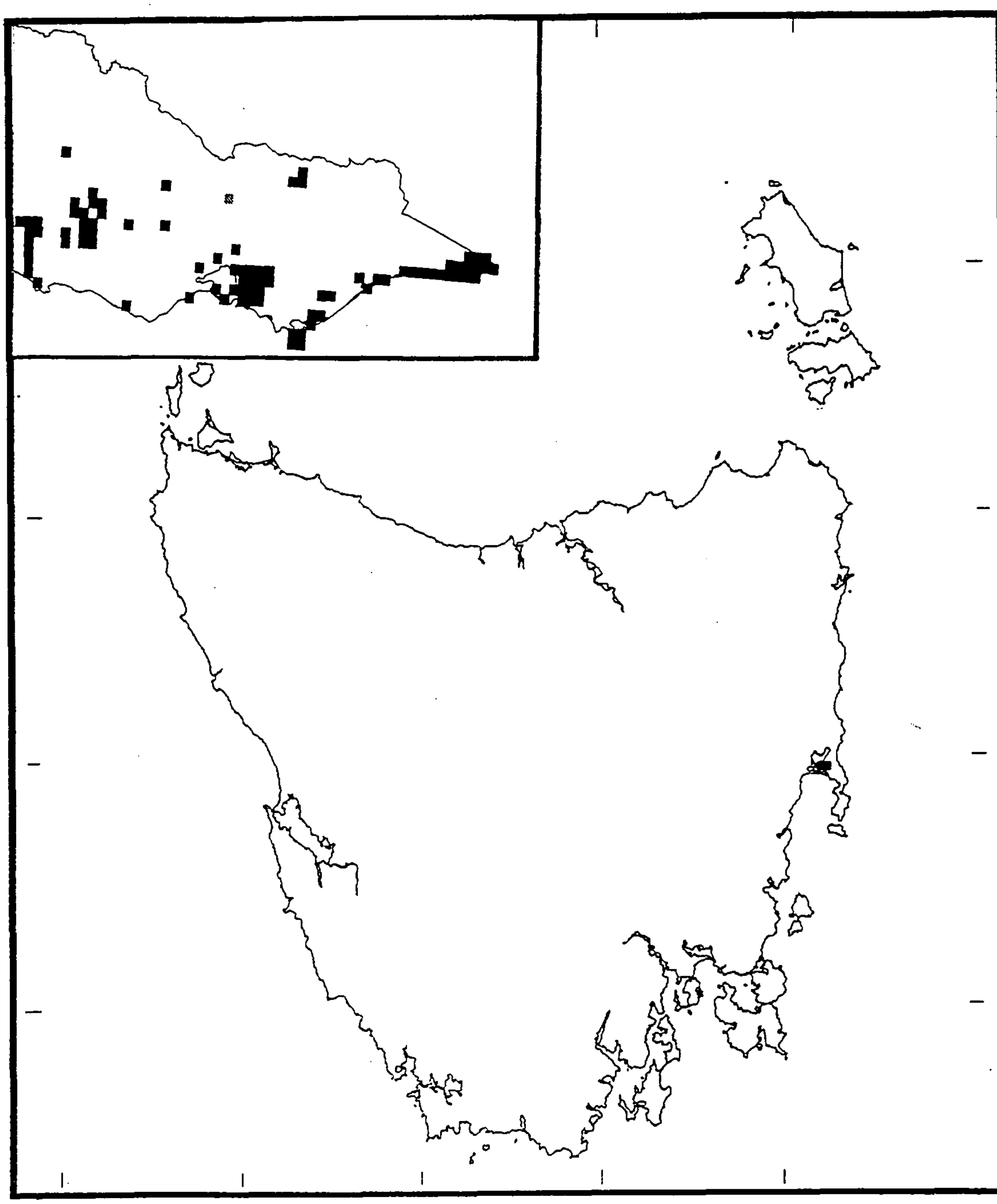


Figure 18.2: Distribution map of recently confirmed populations of *V. juncea* in Tasmania and Victoria.

Figure 18.3: Dense scrub dominated by *V. juncea* in East Gippsland, Victoria.

18.3 Habitat

Viminaria juncea is a fast-growing shrub legume, inhabiting a wide range of soil types in higher rainfall regions, and occurs in all major forest ecosystems, open woodlands and heathlands of south-western Austalia (Walker & Pate 1986). The sites tend to be either permanently flooded environments or on heavier soils waterlogged during winter (Walker & Pate 1986). Blombery (1967) states that the species will grow equally well in either wet or well-drained positions, but it is probable that both features are required. The species prefers sites which are moist and well drained (SGAP undated), but is capable of withstanding extended periods of wetness in seasonally inundated depressions or in sites with seasonally increased runoff (Walker & Pate 1986). The habitats are generally more or less open heath habitats with either full or partial sun exposure.

The three Tasmanian sites were all similar, comprising heath or fernland communities on sites with high water-tables. The *Viminaria* plants were most abundant near the Wallaroo property; extending from the scrub margin close to the water's edge about 30 m onto the slightly more elevated sand-rises farther north. The vegetation consisted of tall shrubland with emergent *Eucalyptus pauciflora.* The *Viminaria,* along with *Acacia verticillata, Leptospermum lanigerum, L. scoparium* and *Sprengelia incarnata,* dominated a mid-dense 2.5 - 4 m layer. A dense cover of *Gleichenia microphylla* dominated a 1.7 m layer with *Epacris lanuginosa, E. obtusifolia, Pultenaea dentata, Dillwynia glaberrima, Leptocarpus tenax, Lepyrodia tasmanica, Empodisma minus, Gompholobium huegelii* and *Xyris* sp.

The second Tasmanian *Viminaria* site was situated in tall open shrubland with high proportions of sedges and ferns. The site occurred in a slight depression of the open swampy plain adjoining Pelican Bay (seven *Viminaria* present). It was dominated by *Viminaria* and *Leptospermum scoparium* with moderately dense *Gleichenia microphylla, Lepidosperma concavum, Leptocarpus tenax* and *Juncus* sp. amidst open *Leptospermum scoparium* and *L. lanigerum* heath.

The third site occurred at the break of slope rising above the plain, but was more poorly drained than the local heath due to increased water runoff from the road and the drainage channel beside the road (39 *Viminaria* present). It comprised tall open shrubland with emergent *Eucalyptus amygdalina* and *E. pauciflora. Banksia marginata* and *Allocasuarina littoralis* sparsely overtopped a heath of *Leptospermum scoparium, Hakea tetragona, V. juncea, Epacris lanuginosa, E. obtusifolia* and *Dillwynia glaberrima.* A moderately dense cover of *Leptocarpus tenax* and *Restio complanatus* dominated the ground layer. Other species included *Selaginella uliginosa, Poa* sp. and *Gnaphalium* sp.

Table 18.1: Summary of habitat records and conservation information for *V. juncea.*

Recent Records:	3 Sites recorded, 3 extant	
Habit:	Tall, willowy, single stemmed shrub or low tree with drooping branches of terete phyllodinous stems	
Population Size:	10 - 100 (upper end)	
Regeneration:	Type:	Germination of seed
	Observed?:	Reported in Walker & Pate (1986) Damaged seedlings can form adventitious roots from the base of the stem
Habitat:	Landform:	Open heathy flats and slope verges, which are moist and well drained but permanently or seasonally waterlogged
	Altitude:	Approximately sea-level
	Aspect:	Nil (- South to South-west)
	Slope:	0° (- 4°)
	Community:	(Open) tall shrubland with ferny or sedgy understorey and emergent *Eucalyptus*
Fire response:	Regeneration by seed	
Conservation Status:	Proposed:	**u*e**
	Current:	**ue** (Kirkpatrick *et al.* 1991b)
Reserve:	* One site is just inside the Moulting Lagoon Game Reserve, however, the numbers of *Viminaria* are too few to constitute adequate reservation.	
Comment:	All three sites occur within one and a quarter square kilometres of each other.	

18.4 Phenology

The flowering period for this species has been recorded as August to December, with fruiting in December to January (Table 18.2). Specimens of flowering material lodged at the Tasmanian Herbarium were collected 12th of December, 1945, 30th of December, 1983, "about Christmas", 1945. One specimen with flowers and some young pods was collected 15th of January, 1977. Other material with fruit only was collected February 1946, 3rd of February, 1945. A vegetative specimen was collected 24th of August, 1974 .

Table 18.2: Phenology of *V. juncea*, as determined from literature and Tasmanian Herbarium records.

Source	Month of Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Blombery (1967)	P							F	F	F	F	FP
Jessop & Toelken (1986), Woolcock (1991)	F	F									F	F
SGAP (undated)	(F)								(F)	(F)	F	(F)
Wiecek (1991)									F	F	F	
Lynch (pers. obs.)	P										bF	FP
Herbarium records	FP	P										F

b Buds present
F Flowering
(F) Intermittent flowering
P Fruit present

Fruit was present on the trees on the 14th of December, 1990. The following season, in spring 1991, new shoots developed during early November, however, buds were not evident. The buds developed very quickly, and the plants had begun to flower by the 25th of November, 1991. Flowering occurred over an extended period, being still evident on the 28th of December. Fruit had formed by 29th of January, 1992, but had not yet dehisced or dropped from the branches.

Twenty trees at the first site (Section 18.3) were tagged on 14th of December, 1990, and one branch which had flowered that season on each tree was tagged. The branches were at varying distances from the trunk, and also from the main branch on which they had developed. The following spring, on 28th of November, 1991, the branches were rechecked. Seventeen of the tagged branches were relocated. Fourteen were completely dead, while the apical section of the other three had died and a new shoot had developed from farther down the branch. This explained the relative density of the foliage and abundance of dead branches present on the trees. The flowering stems die after the fruit is produced and released, after which the branch reshoots from below the dead stem either at its base or below the dead apical section.

18.5 Propagation

An initial germination trial was conducted on this species to test the method. One hundred percent of seeds responded to treatment by scarification of the seed coat within six days. Germination trials were not followed through for this species, despite ample quantities of seed, because of the recent work conducted by Auld and O'Connell (1991) which included *V. juncea* in a study of the germination requirements of 35 N.S.W. legumes.

The trials conducted by Auld and O'Connell (1991) considered the germination response of *V. juncea* to a range of heat treatments (40, 60, 80, 100, 120^{o}C) for a range of exposure periods (1, 5, 10, 30, 60, 120 minutes). Viability of the seed lot was determined to be very high (99.5%), with 2.3% of the seeds non-dormant. For short heat durations (< 30 minutes), maximum response was gained from the 100^{o} treatment. This was only approached by the 80^{o} treatment after a heating period of 30 minutes, when all seeds germinated. Treatment of 80^{o} for ten minutes only resulted in about 60% response, and for five minutes only effected about 20% response. Treatments of 60^{o} were ineffectual. The authors used these results to predict the response from simulated low and moderate intensity simulated burns at one centimetre intervals to a depth of eight centimetres. These results are reproduced below (Table 18.3). They indicate that significant germination is only achieved during moderate intensity fires, and only at depths of two centimetres or less. Temperatures of 80^{o}C are experienced at these depths during moderate intensity fires, but only 40^{o}C in low intensity fires. The assumption used for seed presence in the soil profile was that seed was distributed evenly within each depth range: 0 - 5 cm (64.5% of seed), 5 - 10 cm (20%) and > 10 cm (15.5%).

Table 18.3: Predicted percentage germination of *V. juncea* under two fire intensities (L Low, M Moderate) for a range of soil depths (after Auld & O'Connell 1991).

Depth/ Intensity	1 cm	2 cm	3 cm	4 cm	5 cm	Total seed bank
L	1.7	0	0	0	0	0.2
M	42.9	18.5	1.7	0.9	0.3	8.3

Seed dormancy may also be broken by immersion of seeds in 1M H_2SO_4 for two hours, followed by 24 hours in running tap water. Seedlings can then be raised in sand with a sample of the habitat soil added to provide indigenous strains of the nodule forming organism *Rhizobium* (Walker & Pate 1986).

18.6 Discussion

The genus *Viminaria* is monotypic, having only the one species, *V. juncea*. It occurs throughout near coastal regions of temperate Australia. It is possible that the Tasmanian populations, being geographically isolated from their Victorian relatives, have a level of genotypic distinctiveness. Such distinctiveness would make the conservation of these populations important not only for the conservation of the State's flora but also for preservation of genetic diversity within the species.

Viminaria juncea is extremely restricted in Tasmania, being confined to less than 100 individuals in an small area of less than 1.25 km^2. It has been suggested that the species was introduced to Tasmania, a possibility since it has in the past been a common nursery species in Victoria and Tasmania (D. Tonkinson, pers. comm.). However, there is no evidence to support this hypothesis. It is also possible that the species is restricted by lack of suitable habitat, by competition, or by historical factors such as clearing or increased fire frequency. The habitats in which *Viminaria* occurs, however, are common in eastern Tasmania, and the causal factors limiting the species' distribution are not known.

The species is recorded by Auld and O'Connell (1991) as fire sensitive, and plants are killed by fire with subsequent regeneration from soil-stored seed. Walker and Pate (1986) concur, stating that seedlings establish from seed largely, if not exclusively, following fire or other disturbance of the habitat. It is a prolific seed producer, with 5 000 to 12 000 seeds collected from single plants in Western Australia from a variety of contrasting habitats (Walker & Pate 1986).

Viminaria juncea generally occurs in coastal, open habitats dominated by tall shrublands with ferny or sedgy understoreys and emergent *Eucalyptus*. The dominant species tend to be the heath species *Leptospermum scoparium, L. lanigerum, Epacris lanuginosa, E. obtusifolia,* and *Dillwynia glaberrima,* the fern *Gleichenia microphylla,* and the monocots *Leptocarpus tenax, Juncus* sp. and *Restio* sp. The soils consist of pale, Holocene sands, and tend to be moist but well drained. They are, however, subject to either permanent or seasonal waterlogging. The sites comprise flats near the water-line, a shallow, swampy depression, and the poorly drained break of slope above the estuarine plain. The high water-table, and likely occasional and possibly extended periods of waterlogging at these sites, supports the hypothesis that *Viminaria* competes well on these sites through its ability to fix nitrogen under waterlogged conditions. This ability is enabled by the plant's capacity to develop pneumatophores and an integrated system of aerenchyma within its lower stem, roots and nodules (Walker *et al.* 1983).

This species is probably vulnerable to the soil-borne pathogen *Phytophthora cinnamomi*, due to the similarity of its root structure to those of the Proteaceae. The development of intense, local, lateral root production (proteoid roots) has been well documented for many genera of the Proteaceae (Lamont 1974 in Bowen 1981), and similar structures are also known in a few native Australian legumes including *Viminaria juncea* (Lamont 1984). Such roots enhance absorption of poorly mobile ions from soil and organic matter, as well as nutrients from leachates of decomposing organic matter (Bowen 1981).

19. GENERAL DISCUSSION

19.1 Conservation Biology and Ecology of the 16 Rare Tasmanian Fabaceae

The 16 rare Fabaceae considered in this study all occur in Tasmania primarily in the understorey of heathy or grassy eucalypt forests or woodlands, although some occur in coastal heaths, grasslands or sedgelands (Appendix 22.4). They have morphological features consistent with adaptations to nutrient deficient soils and aridity: leaves which are thickened and leathery, small and linear or inrolled; phyllodinous leaves; and/or hairy stems and leaves (Appendix 22.4). Such characteristics reduce the leaf surface available for transpiration, or in the case of pubescence, create a layer of still air around the leaf thereby reducing the transpiration rate. The phyllodes and spinous branches of some species act as a structural adaptation to aridity and as a deterrent to herbivores; an important factor due to the high nitrogen levels of their foliage.

Most of the species that were surveyed were found to produce seed in large quantities, with physical dormancy, high viability, and with an elaiosome (Appendix 22.4). All of the species tested have a physical seed dormancy, except for *A. axillaris,* which has both a physiological and physical barrier. Two of the species *(Glycine latrobeana, Viminaria juncea)* had 100% response to a scarification trial, indicating that removal of the physical barrier allows germination. Seed viability in the species varied between 74.5% to over 90%. Similarly, most of the 35 Fabaceae species tested by Auld and O'Connell (1991) also had very high (greater than 90%) viability. The seed of many of the species is likely to be ant-dispersed, since most have elaiosomes, the small, white appendages which are specialised food bodies. Only three of the species did not have elaiosomes *(Glycine latrobeana, Psoralea adscendens, Viminaria juncea),* while seed of *Desmodium gunnii* was not collected.

Physical seed dormancy enables opportunistic secondary species to maintain soil-stored seed banks and to regenerate *en masse* after appropriate stimulation, such as fire or soil disturbance. Seed of *Pultenaea selaginoides* was found to be quite common in the soil seed bank, particularly in the top four centimetres of the soil profile. The seed may be concentrated in localised areas, and the locations of seed within the soil seed bank may not be static. Bioturbation of the soil at the *P. selaginoides* site was evident since minute pieces of plastic were recovered from more than six centimetres depth. A similar concentration of seed in the top five centimetres of the soil profile was found with *Acacia suaveolens* (Auld 1986). However, the number of seeds recovered was low; 4/27 m^2 (Auld 1986).

Shea *et al.* (1979) similarly recovered low densities of 0.2 seeds/19 m^2 for *A. pulchella, Mirbelia dilatata* and *Bossiaea aquifolium.* Parker and Kelly (1989) suggest that representation of the dominant species of a community in the seed bank is usually low except for some genera such as *Acacia, Cassinia, Bedfordia, Pultenaea,* and usually excludes serotinous genera with aboveground seed banks, such as *Eucalyptus* and those of the Proteaceae.

All of the species tested in this study except for *Acacia axillaris* were found to respond to heat trials *(A. pataczekii, Hovea corrickiae, Pultenaea humilis, P. prostrata, P. selaginoides),* although the level of response varied considerably between species. Several other species were determined to also have a physical seed dormancy, although their specific response to heat was not tested *(Bossiaea obcordata, Glycine latrobeana, Viminaria juncea).*

The population structures of *Acacia axillaris* and *A. pataczekii* indicate that they have pulse regenerated. Fire is presumed to have been the stimulus for regeneration of *A. axillaris* at the Dukes Marsh site. However, fire is not required for the germination of either species. The continuous pattern of regeneration of *A. axillaris* at Mt. Barrow has occurred in the absence of fire, while seed of *A. pataczekii* germinated during trials without pretreatment. Minor disturbances may be responsible for continuous germination of these species. Alternatively, a proportion of seed may be able to establish each season from seed that is non-dormant or from seed that has had its dormancy broken through exposure to cold winter temperatures.

Leguminous species generally occupy sites which are drought-stressed and nutrient-poor environments with high frequencies of disturbance. Most of the rare Tasmanian legumes also occupy habitats which are rocky, or sandy and dry with low nutrient soils, or rocky and disturbed environments with limited competition (Appendix 23.4). Most of the species occupy sites with a long history of disturbance and grazing or frequent firing (Appendix 23.4).

Disturbance was seen to initiate regeneration of *Bossiaea obcordata, Pultenaea hibbertioides, P. humilis, P. prostrata* and *P. selaginoides.* Sufficient disturbance for regeneration may occur from animal digging, in drainage lines on slopes, or during flooding, through weathering and abrasion by wind and water, and from insect predation. Removal of existing vegetation, disturbance of the soil, and change in the temperature regime of the microsite, such as through a shift in temperature or increase in amplitude of the diurnal temperature range, may result in the release of seeds from enforced dormancy (Harper 1977). Anthropogenic disturbance near roads and from small-scale mining and Council/Telecom dug trenches induced regeneration in *P. hibbertioides, P. humilis* and *P. prostrata.* Overgrazing of sites so that the soil was exposed has also induced germination of *P. prostrata.* Similarly, the papilionaceous species *Ulex europaeus* and *Trifolium subterraneum* have also been shown to respond to such modifications (Ivens 1978, Taylor 1981; in Baskin & Baskin 1989).

The proportion of seeds of the rare Tasmanian species that are non-dormant varied considerably; between 0% and 27% (Appendix 22.4). Auld and O'Connell (1991) also found great variability in their study, the level of non-dormancy varying between 0% and 58.9%, independent of genus, study site and seed weight.

Non-dormancy has been previously recorded in species of *Acacia.* Occasional specimens of *A. dealbata* and *A. melanoxylon,* for example, may be observed in gaps in unburnt wet and dry sclerophyll communities in Tasmania. At a site in South Africa, 4% of freshly shed seeds of *A. longifolia* germinated immediately on release, with 1.2% surviving and adding to the population (Pieterse & Cairns 1988). It has also been recorded in *A. peuce, A. harpophylla, A. argyrodendron* and *A. cambagei* (Cavanagh 1987), four species predominantly of semi-arid to arid regions, or which reproduce primarily by root or stem suckers. Similarly, the rare Tasmanian endemic *A. pataczekii* appears to regenerate largely vegetatively from rhizomes and has a high level of non-dormancy in its seed. Non-dormancy facilitates regeneration in areas which are less fire- or disturbance-prone. Such areas provide fewer opportunities for obligate seed regenerators to germinate, and species which are primarily post-disturbance resprouters also do not need to rely on the longevity and viability of the soil seed bank. Species of less disturbed sites may therefore be advantaged by a lesser degree of innate physical dormancy.

Fire may encourage resprouting in some species. *Acacia pataczekii* regenerates continuously by resprouting from rhizomes protected by the surface layer of soil. *Bossiaea obcordata* was suggested by Auld and O'Connell (1991) to possibly resprout after fire, although it is fire sensitive and would be killed by high temperature fires. *Pultenaea prostrata* has resprouted after two controlled burns at a Midlands site (L. Gilfedder, pers. comm.). *Glycine latrobeana* is also likely to resprout after fires because of its large tap-root. *Pultenaea selaginoides* was observed to have developed basal coppicing, presumably after flood disturbance. *Acacia retinodes* was also observed to be sprouting from rhizomes in disturbed dune areas.

Clearly, most of the rare Fabaceae of this study have biological and ecological characteristics that fit the classical pattern of legume behaviour.

However, some were found to have atypical biological characteristics. It is these deviations which may be important indicators to the causes of rarity in the Tasmanian species.

This was most clearly apparent with the dormancy of *Acacia axillaris* being physiologically based as well as due to a physical barrier. Significant germination in this species was achieved only with cold stratification or with removal of the testa. This kind of innate dormancy has not previously been reported for a legume species in Australia, although fluctuating temperatures have been found to induce germination in the papilionaceaous species *Ornithopis compressus, Trifolium subterraneum, Lupinus cosentini, Medicago truncatula* (Quinlivan 1971) and *Swainsona canescens* (Quinlivan 1970 in Mott & Groves 1981).

The continuous regeneration of *A. axillaris, A. pataczekii* and *Hovea corrickiae* also differs from the typical reliance of legume species on fire or disturbance to initiate regeneration. Reproduction was shown to be quite variable between species, with one species *(Glycine latrobeana)* having the facility to self-fertilise flowers and another reproducing primarily vegetatively *(A. pataczekii)*. The level of sexual reproductive success was quite poor with some species *(A. pataczekii, G. latrobeana)*. Reproductive success may vary between sites, as shown with *A. axillaris* and *A. pataczekii,* and it may also vary considerably between years, shown with *H. corrickiae.*

Some of the rare Tasmanian legumes do not occupy the more typical drought-stressed, low nutrient environments that Fabaceae generally inhabit. Three of the species occur on sites of dolerite or basalt with relatively high fertility *(Acacia axillaris, A. pataczekii, Pultenaea prostrata)*. Eight of the species occur in habitats which are not drought stressed *(A. axillaris, A. pataczekii, Desmodium gunnii, Hovea corrickiae, Psoralea adscendens, Pultenaea humilis, P. selaginoides, Viminaria juncea)*. Several other species display quite wide environmental tolerances. *Acacia pataczekii* occurs at sites with a variety of geologies, and sometimes on the boundaries of differing lithologies. *Desmodium gunnii* occurs in environments with a wide range of climatic and edaphic conditions, but which are generally neither moisture stressed nor recently disturbed. Across its range, *V. juncea* also occupies sites varying widely in climate and soil type. This species is, however, concentrated in sites which are permanently flooded or which have heavier soils which become waterlogged in winter.

Several of the rare Fabaceae are restricted in Tasmania to specific, often localised lithologies. *Acacia retinodes* predominantly occurs in coastal Victoria and south-eastern South Australia on calcareous sands. In Tasmania, this species is only known from coastal sites with sands underlain by calcarenite on the north-west side of Flinders Island. Similarly, *Psoralea adscendens* is much more restricted in Tasmania than in Victoria, and there are distinct differences in its habitat between the two States. In Victoria, *P. adscendens* commonly occurs at moderately high altitudes on fertile soils along watercourses or on wet forested slopes. However, in Tasmania, it only occurs at a limited number of very localised coastal sites on weakly metamorphosed sediments. Both *A. retinodes* and *P. adscendens* appear to more habitat specific in Tasmania than in Victoria. Two other species, *Pultenaea hibbertioides* and *Bossiaea obcordata*, also are largely restricted, in this case to sites of infertile, skeletal sedimentary soils that are seasonally drought-stressed and highly disturbed. *B. obcordata* is, however, known from one higher altitude site with a rocky, dolerite substrate. These species are not edaphically restricted in Victoria, and their limited distribution in Tasmania may be more related to competition than edaphic conditions *per se*. The rare Fabaceae may be outcompeted by local species in Tasmanian sites with environments similar to the Victorian sites. However, the stressful nature of other sites may exclude local species adapted to more productive environments while still being within the tolerance limits of the rare species. The species may not even be more habitat specific in Tasmania but may appear to be so because of their limited number of populations. Their potential niche space may be much greater than their actual range.

With the conversion of much of the grassy woodlands in Tasmania to pasture, much of the habitat of *Pultenaea prostrata*, *P. humilis* and *Glycine latrobeana* and some of the habitat of *Desmodium gunnii* has been lost. These species occur in an ecosystem (grassy woodland) that is threatened by clearing and agriculture. Over 80% of the original area of grasslands and grassy woodlands in Tasmania has been substantially altered from its natural state (Kirkpatrick *et al.* 1988). In the Tasmanian Midlands, only fragmented remnants of the original vegetation remain (Fensham 1989). Species such as *P. humilis*, whose range in Tasmania is entirely restricted to this area, are threatened if the Midlands vegetation is further reduced. It is impossible to know how much more abundant such species were prior to European settlement. However, even now across their range, they have a highly localised and sparse distribution.

The habitats of two of the species are being encroached upon by development. *Acacia retinodes* is losing habitat to coastal development on Flinders Island. The area where *Viminaria juncea* occurs is also threatened by development and the problems associated with nearby human residences. However, there is no evidence to suggest that these species have been more widespread during the time of European occupation of Tasmania.

The distribution of sites of populations of the species can be tied to particular environmental factors, especially edaphic factors, as in the cases of *Acacia retinodes, Bossiaea obcordata, Psoralea adscendens, Pultenaea hibbertioides.* However, the potential niche of these species appears to be much larger than their realised niches since there is unoccupied habitat available. The realised niches of all the rare Fabaceae comprise discrete and fragmented patches within the environment with apparently suitable habitat unoccupied. This is especially so for species such as *A. retinodes, Eutaxia microphylla, Hardenbergia violacea, Pultenaea humilis, P. paleacea* var. *sericea, P. prostrata* and *Viminaria juncea* which are much more widespread in Victoria. By example, there are many areas with calcareous soils in north-west Tasmania and on King Island which should be suitable habitat for *A. retinodes* (J. Kirkpatrick, pers. comm.). Two of the species *(Desmodium gunnii, Glycine latrobeana)* are restricted in abundance across their range, this situation being more extreme in Tasmania. The endemic species, *A. axillaris, A. pataczekii, P. selaginoides,* and the highly disjunct species *Hovea corrickiae* also appear to have small realised niches.

Some of the species may have transient distributions. Several of the populations recorded for *Pultenaea prostrata* and *P. selaginoides* earlier this century were not able to be relocated during this study, while other populations were found. The timing, distribution, form and severity of vegetation disturbance may be important factors in determining the success of species regenerating from the soil seed bank (Thompson & Grime 1979). Such factors may lead to fluctuating presences and abundances of species at a site. The discovery of new sites may also be a result of more intensive survey of likely habitats.

There is the added complication for some of the species of their small size and inconspicuous appearance *(Bossiaea obcordata, Desmodium gunnii, E. microphylla, G. latrobeana, Psoralea adscendens, Pultenaea paleacea* var. *sericea, P. prostrata).* This may have led to their having been overlooked in the past and their extent being underestimated. Two of the species have also suffered from taxonomic misidentifications *(D. gunnii, G. latrobeana).*

19.2 Application of Rabinowitz' (1981) and Prober's (1989) Typologies of Rarity

The typology of rarity of Rabinowitz (1981; Table 1.2) considers the current geographic distribution of the species but not the differences responsible for habitat specificity. Fundamental processes in the species' origins, dispersal mechanisms, and environmental and competitive tolerances and stresses are not taken into account. Consequently, species of similar Rabinowitz types should not be confused as being rare due to the same processes.

In classifying the 16 Fabaceae of this study, the most common type of rarity was Type II (Table 19.1). This was also the most common type of rarity found by Rabinowitz *et al.* (1986). These species are typically restricted to specific habitats, occur over a wide geographic range, but are locally abundant. The Tasmanian species fitting this category (Table 19.1) tended to be abundant in Victoria, and sometimes also in S.A. and south-eastern N.S.W., but were rare and even threatened in Tasmania. The environmental limitations to their distributions are generally not known, but *A. retinodes, B. obcordata, Hardenbergia violacea, Psoralea adscendens* and *P. hibbertioides* are largely restricted to specific lithologies.

Table 19.1: Application of Rabinowitz' (1981) and Prober's (1989) typologies of rarity to rare Tasmanian Fabaceae.

Species	Type of Rarity (Rabinowitz 1981)	Type of Rarity (Prober 1989)
Acacia axillaris	Type VI	Group 1/1+2
Acacia pataczekii	Type VI	Group 1/1+2
Glycine latrobeana	Type IV	Group 5
Hovea corrickiae	Type VI	Group 2/1+2
Pultenaea selaginoides	Type VI	Group 1/1+2
Acacia retinodes	Type II	Group 1a/1b (+/-2)
Bossiaea obcordata	Type II	Group 1a/1b (+/-2)
Desmodium gunnii	Type IV	Group 5
Eutaxia microphylla	Type II	Group 1a/1b (+/-2)
Hardenbergia violacea	Type II	Group 1a/1b (+/-2)
Psoralea adscendens	Type II	Group 1a/1b (+/-2)
Pultenaea hibbertioides	Type II	Group 1a/1b (+/-2)
Pultenaea humilis	Type II	Group 1a/1b (+/-2)
Pultenaea paleacea var. *sericea*	Type II	Group 1a/1b (+/-2)
Pultenaea prostrata	Type II	Group 1a/1b (+/-2)
Viminaria juncea	Type II	Group 1a/1b (+/-2)

The second most numerous form of rarity in this study was the restricted, and often threatened, endemic species (Type VI); the classic case of rarity (Rabinowitz 1981). The species exist in large populations, but are predisposed to endangerment by their narrow range and distribution. *Hovea corrickiae* was also included in this category since it is very restricted to only a few sites in north-eastern Tasmania and western Victoria.

The other species of this study were of Type IV rarity. These species are widespread and habitat specific populations of low numbers of plants. Their low densities mean that such species tend not to fill the ecological niche. These species have a wide geographic distribution, but occur in low densities. Consequently, the populations may be subject to all the vagaries of small populations; little buffering ability in relation to chance environmental fluctuations or disturbances, and reduced fitness with respect to competition, predation, reproduction (locally or genetically) or inbreeding (Cody 1986). Adequate dispersal and regeneration is especially important for these species, which may not survive in isolated or fragmented populations.

Rabinowitz *et al.* (1986) suggests that species of Type II rarity have, in the past, dispersed into a wide variety of habitats but have only colonised certain patches, the especial suitability of which may be difficult to ascertain. She argues that "transplants" of plants into suitable areas where the species presently does not occur is not really an appropriate conservation measure for such species. The suitability and likely success of such transplants is difficult to predetermine, and therefore, protection of reserves against environmental perturbation not characteristic of the site is probably critical. This probably applies also to rarity Types VI and IV, where the localised nature of the species' distributions may camouflage their environmental tolerances and limitations. Rabinowitz stresses that both for endemics and species of wide geographic range, that most species occur in restricted habitats.

Application of Prober's model of rarity (Figure 1.1) requires information on the current and past distribution and phylogenetic relationships of the species as well as their physiological limitations. However, in the absence of some of this information, the initial divisions of the model can still be used to indicate possible causes of a species' rarity. Determination of the actual causes would require further investigation of the species' phylogenetics and physiology.

The groupings of the 16 rare Tasmanian Fabaceae under the Prober model are very similar to those gained from the Rabinowitz model (Table 19.1). None of the species appear to be restricted by geographic barriers. Two of the species, *Glycine latrobeana* and *Desmodium gunnii*, are sparsely distributed and separate from the other species at the second junction of the flow chart. Neither species appear to be restricted by a sparsely distributed microhabitat. There is also no reason to presume they are random relicts in unsuitable habitats. Instead, *G. latrobeana* and *D. gunnii* may be limited by predation (Prober group 5) and/or intraspecific competition (Prober group 4). These factors may be exacerbated if these two species are at their ecological limit in Tasmania.

The other 14 Fabaceae have moderate to large sized populations although *Hovea corrickiae* has a disjunct distribution and can be split off at the third junction of the model. This disjunction suggests that this species is relict, and since its habitat appears to be relatively common, *H. corrickiae* may be a random relict (Prober group 2). Prober suggests that such species now exist in unsuitable habitats and are likely to die out unless suitable conditions return. If *H. corrickiae* is restricted by a rare habitat, it may be a relict in refuge, and safely preserved until conditions similar to a past environment enable the species to disperse and become common (Prober group 1+2).

The remaining 13 species have a nuclear if widespread distribution. They may be separated into two groups: firstly, the three species which are nationally rare or vulnerable (Rabinowitz type VI) and secondly, the other species, which are rare at State level (Rabinowitz type II). The large, fragmented range of these groups suggests that they are "old" species which have had a long time to disperse. Morphological differentiation evident in species of trans-Bassian distribution, such as *Acacia retinodes, Bossiaea obcordata, Pultenaea hibbertioides* and *P. paleacea,* supports this. *Acacia retinodes* populations in Tasmania, eastern Victoria and coastal south-eastern South Australia differ in leaf morphology, flower colour and habitat from populations in western Victoria and south-eastern South Australia. *Bossiaea obcordata* populations in Tasmania differ in habit from those on mainland Australia. *Pultenaea hibbertioides* is actually a form of the *P. mollis* complex and is restricted to northern Tasmania and South Gippsland. *Pultenaea mollis* extends across southern Victoria. *Pultenaea paleacea* is a variable species. The variety *sericea* differs in morphology and distribution from the other varieties. The Tasmanian stock of *P. humilis* may be another example; plants of these populations appear to be shorter than those in Victoria. These species are all common in Victoria, and their rarity in Tasmania may imply that they are on the edge of their ecological range. They may be limited in Tasmania physiologically and may be outcompeted, overpredated, or restricted by habitats rare in the State (Prober groups 1a($^+$/-2), 1b($^+$/-2)).

The Rabinowitz type VI species all have a much smaller range, and may be palaeoendemics ("old" species) or neoendemics ("recently diverged" species). The two *Acacia* species have fragmented distributions, medium to high altitude populations, and reproductive problems atypical for legumes. These are indications that these species are palaeoendemics currently in climatic disequilibrium. The Tasmanian and Victorian populations of *Hovea corrickiae* differ slightly morphologically, suggesting it also is a palaeoendemic. The populations differ in the indumentum of the branchlet, leaf and calyx, and in the flower size and colouring.

19.3 Possible Biogeographic Influences on the Rare Tasmanian Fabaceae

Analysis of the affinities and distribution of rare plants contributes to an understanding of the vegetation history of their habitats (Griggs 1940, Stebbins 1942). Griggs recognised that rare species were concentrated in particular environments, despite many of the species being of diverse ecologic and geographic affinity and occupying a diverse range of habitats (Griggs 1940).

For much of the Quaternary, Tasmania has been a part of mainland south-eastern Australia. The Quaternary has largely been a period of glacial conditions with the periods of maximum warmth being relatively short (Cranston & Naumann 1991). In Tasmania, five probable phases of glaciation are now recognised (Colhoun & Peterson 1986, Fitzsimmons 1988), with climatic fluctuations between alpine and temperate conditions. Cool, dry periods of low sea-level were interspersed with warm, moist periods when polar ice-sheets receded and sea-levels rose again (Cranston & Naumann 1991). Sea-levels were frequently 200 m below their present level during the glacials (Galloway & Kemp 1981), causing the Bassian Plain to be exposed and connecting Tasmania to the mainland.

The Bassian land-bridge formed a migration route for humans and non-arboreal or scrubland animals, at least seasonally (Hope 1978), but also for plant species. Migration of species would have occurred during earlier glacials once the Bassian Plain was exposed. However, all of the palynological evidence and therefore most of this discussion relates only to Last Glacial conditions. The average position of the land bridge over the last 50 000 years was proposed by Hope (1978) to extend from Wilsons Promontory down the eastern side of Bass Strait to include Flinders Island and north-east Tasmania. A similar wide ridge extended from north-west Tasmania northwards past King Island, but did not connect with Victoria. The north coast of Tasmania shelves gently into the Bassian Plain, and thus would have enjoyed a relatively continental and dry climate in glacial times (Kirkpatrick & Brown 1984a). At present, Tasmania has a temperate maritime climate with the proximity of the ocean moderating the climate to produce milder winters and cooler summers than normal for this latitude. However, the climate during the Last Glacial was markedly colder, drier and windier than present (Macphail 1979). Species preadapted to the colder, more arid conditions were able to extend their range onto the exposed land-bridge and continental shelf.

Palynological evidence from Hunter Island suggests that at the time of maximum glaciation, the land-bridge vegetation comprised a very open grassland with composite shrubs or annuals and scattered eucalypts (Hope 1978). This community has botanical affinities with present day semi-arid, warm temperate woodlands and with inverted treeline and alpine treeline communities of the driest part of Tasmania's Central Plateau (Hope 1978). The cold-steppe vegetation extended from eastern Tasmania, across the exposed Bassian Plain to parts of Victoria marginal to the basalt plains and the Adelaide Region (Hope 1978).

The flora of the land-bridge may not have been composed entirely of this composite grassland. Relict patches of closed forest and tall open forest elements, including *Phyllocladus aspleniifolius, Nothofagus* and *Eucalyptus globulus,* were able to persist on King Island and the Otway Ranges, probably in areas of orographic rainfall (Hope 1978). Myrtaceous, Epacridaceous and Fabaceous shrubs were also able to persist, although the phytosociology and species abundances varied considerably. Hope (1978) found pollen of myrtaceous shrubs and heath between 28 000 - 23 000 BP; an absence of most shrubs from 23 000 - 21 000 BP; the presence of *Banksia, Monotoca* and *Sprengelia* from 21 300 - 14 750 BP; and varying importance of *Monotoca, Acacia, Leptospermum* and *Banksia* from 8 200 BP to the present. This site is on the south-western side of Bass Strait.

The flora of islands in Bass Strait, such as Curtis Island and Rodondo Island, have been suggested to be mainly remnants of the old land-bridge flora (Kirkpatrick *et al.* 1974). The floras of these islands include eastern elements such as *Melaleuca armillaris,* whose nearest extant population occurs in East Gippsland 312 km to the north-east (Kirkpatrick *et al.* 1974). Elements of other Bass Strait islands and of Tasmania are present, such as *Dodonaea viscosa, Correa backhousiana, Eucalyptus globulus* ssp. *pseudoglobulus* and *Cyathodes juniperina* (Kirkpatrick *et al.* 1974, J. Kirkpatrick, pers. comm.). Western elements are also present on the Bass Strait islands; species such as *Albizia lophantha* which may be 2 080 km from the rest of its natural range (Kirkpatrick *et al.* 1974). *Ixiolaena supina* also shows a large disjunction of 850 km; it is most common on Kangaroo Island, but also occurs on Wright and Pearson Islands and at two mainland sites in South Australia, as well as in Bass Strait on Hogan and Curtis Islands and the Kent Group (Kirkpatrick *et al.* 1974). Kirkpatrick *et al.* (1974) imply that the exposed coastal plains would have contained habitat suitable for the continuous distribution of these species. The specific nature of some of the species' habitats, such as *Ixiolaena* and *Albizia* in coastal cliff sites, mean that their distributions were unlikely to have been linked. However, populations may have been more extensive and much less disjunct, thereby facilitating dispersal by bird species.

Many species currently have distributions disjunct between Victoria and Tasmania, and therefore, must have dispersed at some stage across the land bridge. This migration may have been either by autochory (dispersal by the plant itself) or by ornithochory (dispersal by birds). The flora of northern and eastern Tasmania is considered to be part of two phytogeographic provinces of maritime south-eastern Australia (Doing 1981). The Bassian province extends across southern Victoria into the southern tablelands of New South Wales, and across northern Tasmania, through the Midlands into south-eastern Tasmania. Climatically, this province varies from alpine to warm temperate (Doing 1981). Central eastern Tasmania is part of the Western Slopes Province which includes the western slopes of New South Wales and south-eastern Queensland. This province is semi-humid, warm to cool temperate and includes a relatively dry part of Tasmania (Doing 1981).

The considerable congruence in the distribution patterns of many dry sclerophyll species widespread on mainland south-eastern Australia but of restricted distribution in Tasmania suggests that they have had similar biogeographic histories (Cullen 1992). The trans-Bassian disjunction is displayed by many of the 16 Fabaceae species in this study: those classified as Type II (Rabinowitz 1981) and Group 1a/1b(+/-2) (Prober 1989).

One subgroup of these disjunct species has affinities with present day semi-arid, warm temperate woodlands (Cullen 1992). These include disjunct mallee and desert species such as *Eutaxia microphylla* and *Pultenaea prostrata.* They also include *Pimelea serpyllifolia, Geococcus pusillus, Lavatera plebeia, Lasiopetalum discolor* and *Myoporum parvifolium* (Cullen 1992). The mallee is a biogeographical "ecotone" between the Bassian and Eyrean Province biotas (Noble *et al.* 1990). The mallee vegetation is largely restricted and adapted to areas of low rainfall and landforms rich in sands (e.g. dunes, interdunal swales, sandplains; Noble & Bradstock 1989).

A second subgroup of species includes the rare Fabaceae *Bossiaea obcordata* and *Hardenbergia violacea.* Other examples include *Hakea sericea, H. ulicina* and *Helichrysum baxteri* (Cullen 1992). These species now are widespread in Victoria but rare in Tasmania, and may also have dispersed across the Bassian land bridge (Cullen 1992). The two Fabaceae are both common in the Bassian Province, although *Hardenbergia violacea* extends through New South Wales into south-east Queensland, that is, throughout the maritime zone.

The rare species in these two subgroups currently occupy seasonally droughted sites. They occur in sites with shallow, rocky, and/or infertile soils *(Bossiaea obcordata, Hardenbergia violacea, Pultenaea prostrata)* or sites with sandy, infertile soils *(Eutaxia microphylla, P. prostrata* (in Victoria)). *Eutaxia microphylla* and *P. prostrata* are common in the semi-arid mallee of Victoria. As well as existing in areas of low annual precipitation, these two species can tolerate sites exposed to full sun. Morphological characters such as small, inrolled leaves or hairy leaves increase the drought resistance of these species *(B. obcordata, E. microphylla, P. prostrata).*

A third subgroup of Type II species have affinities with temperate and warm temperate coastal communities of eastern and south-eastern Australia (Cullen 1992). These species are able to disperse in moister, coastal communities, and include *Viminaria juncea, Psoralea adscendens, Acacia retinodes, Pultenaea hibbertioides, P. humilis* and *P. paleacea* var. *sericea.* Cullen (1992) lists *Banksia serrata, B. integrifolia, Melaleuca armillaris, Leucopogon esquamatus, Helichrysum argophyllum, Sicyos australis* and *Eleocarpos reticulatus* as other examples. These species have a Bassian distribution, although *A. retinodes* extends into the more mediterranean conditions of the Wimmera region.

Similar to the other species of Type II, these rare Fabaceae also display drought resistance. They occur in sites with shallow, rocky, infertile soils *(Psoralea adscendens* (in Tasmania), *Pultenaea hibbertioides)* or sites with sandy, infertile soils *(Acacia retinodes, P. humilis, P. paleacea* var. *sericea, V. juncea). Pultenaea hibbertioides* and *P. paleacea* var. *sericea* can also withstand exposure to full sun. Most of these species have small, inrolled or hairy leaves *(Psoralea adscendens, Pultenaea hibbertioides, P. humilis, P. paleacea* var. *sericea, Viminaria juncea).* However, these species may be less drought tolerant than species of the other two subgroups. *Psoralea adscendens, Pultenaea humilis, P. paleacea* var. *sericea* and *V. juncea* occur in environments which are not water-stressed; the latter three inhabit waterlogged, infertile soils. In fact, the ranges of all the species of this subgroup include coastal or near coastal environments. These characteristics would enable these species to extend their range during the glacial in sites of poor drainage and in sites close to sea-level.

All of the Type II species occur in habitats with high disturbance regimes; either from fire, mechanical soil disturbance or coastal exposure. Such conditions enable secondary species which can resprout or regenerate from the soil seed bank to successfully compete. Tolerance of such disturbed, seasonally droughted sites with well drained, infertile soils suggests that these species could tolerate the presumed environments of the exposed Bassian plain and continental shelf. The land-bridge provided only limited habitat variation, largely of dry, sandy exposed dunes (Galloway & Kemp 1981). However, there would also have been moister areas close to sea-level in dune hollows, lagoon margins and flat areas of poor drainage. Shrub species tolerant of low nutrient, dry or water-logged soils, exposure to strong winds or to saline conditions may have been able to survive on the plain. Calcareous soils are likely to have been more widespread in southern Australia in the early Holocene (Ladd *et al.* 1992), perhaps extending the ranges of *Acacia retinodes, Eutaxia microphylla* and *Pultenaea prostrata.* Calcareous soils have been recorded from coastal Victoria, including Wilsons Promontory, and the Bass Strait islands: Hogan, Deal and Flinders Island (Hope *et al.* 1974).

Shrub species may also have been able to persist on the eastern side of the land-bridge. The climate of the eastern margin of the Bassian Plain may have been moderated by the east Australian warm sea-current which could extend further south, protected by the exposed plain (Cullen 1992). Environments on the eastern side may therefore have been warmer and moister, and been able to maintain heathy coastal communities. The eastern margin of Bass Strait includes a chain of granitic islands, part of a Late Devonian batholith extending from Victoria to north-eastern Tasmania (Hope 1969). The widest water barrier between the islands is the 48 km separating the Kent and Furneaux Groups (Hope 1969). The islands generally are mountainous, with some of the smaller northern islands, such as Rodondo, Curtis and Deal Island, reaching up to 330 m and Mt. Strzelecki on Flinders Island reaching 770 m (Hope 1969). This topographic variation leads to localised orographic variation and localised concentrations of drainage, such as at the base of rocksheets and boulders. Shrub species may have survived in these more moderate locations and in sheltered positions such as gullies, rock crevices and protected cliff areas. *Nothofagus cunninghamii* was reported to occur on Flinders Island in 1926, and wet sclerophyll forest currently occurs in mountain gullies (Hope 1969). Most of the extant uncommon shrub species on Hogans Island, including *Beyeria, Pomaderris* and *Pimelea,* are located in the heath - low shrubland gradations of the western cliffs (Scarlett *et al.* 1974). In the Kent Group, Flinders (1814 p. cxliv in Hope 1969) noted that "in the central parts of the larger islands, there are vallies in which trees of a fair growth make part of a tolerably vigorous vegetation". The Kent Group islands, Erith and Dover, are separated from Deal Island by Murray Pass, a 55 m deep chasm about a mile wide (Hope 1969). At the last glacial maximum, with sea-level approximately 90 m lower than present (Colhoun 1978), this chasm would have been exposed and may have provided a refuge for more mesic species.

Habitation of the plain by less drought tolerant species may also have occurred after the Glacial Maximum as the climate ameliorated. These taxa may have then been able to disperse across the Plain before rising sea-levels again isolated Tasmania (Cullen 1992), some of the species aided by bird dispersal across unsuitable habitat or narrow water channels. The influence of an alongshore warm current would have decreased farther south. Also, the migrating heath species may have been less competitive in south-eastern Tasmania where the dominant coastal lithology of Jurassic dolerite contrasted with the Devonian granite, Quaternary and Mathinna sediments in the northern coastal environments.

There is some evidence for the land bridge migration path having enabled species to migrate down the northern part of the west coast of Tasmania. This is reflected in the disjunct distribution of *Psoralea adscendens*, known only from three small sites on the north-west coast but common in Victoria.

The rarity of many species in Tasmania which are common in mainland south-eastern Australia may also be due to the environmental range of these species. These species may be outside their optimum habitat, and only able to compete successfully under much more limited conditions. The phenomenon of ecological compensation means that species may not indicate the same environmental specifics throughout their range but characterise the plant community and, therefore, the site and ecosystem, more distinctly near the margins of their distribution (Werger & van der Maarel 1978). Near the centre of its distribution, the ecological amplitude of a species allows it to meet the kinds and intensities of the governing environmental factors with strong competitive ability. Near its margins, however, the conditions differ and the tolerance limits of the species for the factors are reached until one becomes critical and delimits the species' presence (Werger & van der Maarel 1978). These extremities may be quite dissimilar in environmental attributes, such as altitude, soil types, etc, and in the associated species.

The occurrence of disjunct populations in atypical habitats supports the hypothesis that these populations may be on the edge of the species' environmental range. Tasmanian populations of *Psoralea adscendens*, *Eutaxia microphylla* and *Pultenaea prostrata* appear to display different environmental preferences to populations in the centre of their range. *Psoralea adscendens* is most common at moderate altitudes in Victoria in sites with fertile soils along watercourses or on wet forested slopes, whereas in Tasmania, it occupies very localised, coastal sites of weakly metamorphosed sediments. *E. microphylla* occurs in the mallee and western districts of Victoria on deposits of limestone and calcareous sediments, and in Tasmania is largely in exposed, coastal communities on calcarenite soils but also on dolerite. *Pultenaea prostrata* also occurs on sandy, calcareous soils of western Victoria, but in Tasmania is known from the Midlands grassy woodlands on sites of doleritic and basaltic soils. In these cases, there are factors which suggest, however, that calcareous and igneous environments may not be too dissimilar in terms of the habitat requirements of *E. microphylla* and *P. prostrata.* Firstly, soils derived from basalt have a high clay content and may develop a high water deficit in summer (Ladd *et al.* 1992). Drought resistance rather than edaphic tolerance may be the limiting factor in Tasmania since both areas are the drier parts of their respective States. Secondly, the tholeiitic magmas (basalts) which are common in Tasmania suffer from relatively low proportions of iron, sodium, potassium, titanium and phosphorous but have high levels of calcium in relation to the alkali basalts of Victoria and New South Wales (Joplin 1971). This kind of chemical composition may mean that these basaltic soils can support species usually associated with calcareous soils. Thirdly, some basaltic soils in the Midlands, Tasmania, are noted for their high alkalinity. The Tunbridge site of *P. prostrata* has been recorded to be highly alkaline near Crown Lagoon and fairly alkaline on the hill above, where *P. prostrata* occurs (S. Harris, unpublished data). Alkalinity is another characteristic that may equate the basaltic soils with calcareous soils of western Victoria. Doleritic soils in Tasmania have also been observed to contain lenses of calcium carbonate (J. Kirkpatrick, pers. comm.), and may contain up to 12% calcium oxide by chemical composition (Joplin 1971).

The morphological differentiation of Tasmanian and Victorian populations of Fabaceae implies that they are relatively old species which have been isolated by Bass Strait. These species may have dispersed in one of the earlier Pleistocene glacials rather than only the Last Glacial. The distribution of these species, particularly *A. retinodes, P. hibbertioides* and *P. paleacea,* close to Bass Strait emphasises the likelihood of the past existence of these species on the exposed plain.

The occurrence of the rare Fabaceae in stressful sites of low productivity (that is, rocky or sandy, shallow soils, dry, or low fertility) and high levels of disturbance supports the premise that these species are poor competitors. The models of Austin and Smith (1989) suggest that the niche of a species may only be realized outside the influence of superior competitors. Given this, it is feasible that at the limits of a species' environmental tolerance, the realized niche may only consist of the extremities of the species' potential range. The glacial conditions may have allowed Mediterranean and maritime environment flora to disperse across the

Bassian Plain and along the exposed continental shelf because of the increased extent of stressful environments from which species adapted to more productive sites were excluded.

Some of the rare Fabaceae have extremely limited numbers of populations in Tasmania and also are not present at other locations of apparently suitable habitat. It has been suggested for some of these species, in particular *Hardenbergia violacea* and *Viminaria juncea,* that the extant populations in Tasmania established recently from long distance dispersal or even from anthropogenic introductions. *Hardenbergia violacea* is common in a multitude of habitats on the mainland, but in Tasmania, occurs in only two populations within 1.5 km of each other. Similarly, *Viminaria juncea* occurs in all States of Australia excluding the Northern Territory, and is common in Victoria. In Tasmania, *V. juncea* is only known from three clusters of plants totalling less than 100 individuals. Evidence discounting that *H. violacea* was introduced is that it was first collected in its current location as early as 1834 (Buchanan 1994). While long-distance dispersal scenarios are plausible, the large number of species which are extremely rare in Tasmania suggests that long distance dispersals of so many species would require a long time. Species of Fabaceae are not generally considered to be bird-dispersed, and some populations have been isolated long enough to differentiate morphologically. If abundant suitable habitat was available in Tasmania and the species were capable of being bird-dispersed, then dispersal should be continuing within Tasmania and new populations should be establishing. One of the disjunct Bass Strait island species, *Albizia lophantha,* was considered unlikely to be dispersed by the bird species which visit the islands on which it occurs (Kirkpatrick *et al.* 1974). These authors stated that the large disjunctions and the large number of species with distributions centred on Bass Strait argued against their recent arrival by long distance dispersal.

The rarity of these species appears to be gradational, the extremely rare cases being the extreme of a continuous scale of rare species abundance. *H. violacea* and *V. juncea* may be limited to two and one populations respectively, however, *Pultenaea humilis* is known in Tasmania from only two populations, *Psoralea adscendens* and *Pultenaea paleacea* from only three populations, *Hovea corrickiae* from four populations, *Pultenaea hibbertioides* from five populations, *Glycine latrobeana* from six populations, *Desmodium gunnii* from seven populations, *Bossiaea obcordata* from ten populations, *Eutaxia microphylla* from twelve populations, and *Acacia retinodes* from 15 populations. Species such as *Psoralea adscendens, Pultenaea humilis* and *Pultenaea paleacea* are less extreme examples of this same phenomenon. Other Tasmanian plants of open, dry, warm habitats that are similarly disjunct are *Calocephalus citreus* (Asteraceae), *Isoetopsis graminifolia* (Asteraceae), *Thesium australe*

(Santalaceae), *Pultenaea pedunculata* (Fabaceae) and *Eryngium ovinum* (Apiaceae) (Buchanan 1994). *Thesium australe* has only been collected from one site in the Derwent River valley, and may now be extinct in Tasmania. It is nationally vulnerable (ANZECC 1993).

Some rare Fabaceae are uncommon across a wide geographic distribution; Type IV rarity (Rabinowitz 1981). *Desmodium gunnii* and *Glycine latrobeana* are examples of this type. These species do not appear to be limited by habitat availability, but possibly by predation and/or intraspecific competition. Both species are small perennial herbs and are susceptible to increased grazing pressure from stock and high numbers of native herbivores. Their habitats may be threatened by inappropriate management, such as fertilising, ploughing, clearing or too frequent firing. *G. latrobeana* is classified as nationally vulnerable, however, the rarity of *D. gunnii* in Tasmania suggests that this species may be another on the edge of its environmental range and unable to compete successfully.

Acacia axillaris and *A. pataczekii* may, like the Type II species, also be old species and better adapted to glacial environments. However, their adaptations are to colder conditions rather than drought tolerance. Both of these species have distributions disjunct within Tasmania. *A. axillaris* displays wide ecological amplitude, occurring from subalpine to lowland grassland communities. All locations of *A. pataczekii* occur at moderate to high altitude, and some sites contain subalpine species such as *Richea gunnii.* Williams (1990) suggested that *A. pataczekii* may have evolved on the margins of the subalpine zone, and that its habitat during the glacial would have been greater and relatively interconnected across the inland lowlands and valleys compared with its present fragmented range. Both of these species display reproductive problems. The level of seed production is very low in *A. pataczekii.* The level of germination achieved in trials with seed of *A. axillaris* was quite low, and may indicate low viability of the seed. Regeneration of both *A. axillaris* and *A. pataczekii* is better at higher altitude. The sites with more successful regeneration in *A. pataczekii* were located near the Ben Lomond plateau, and would experience substantial levels of cold air drainage. Exposure to cold temperatures is required to induce germination of *A. axillaris* seed. At high altitudes, where regeneration of *A. axillaris* without disturbance was evident, the species prefers drought-free sites and can withstand very cool conditions. At lower elevations, streamlines provide cold air drainage channels which can simulate the cooler montane conditions suitable for seed germination. Griggs (1940) cites the example of *Epilobium latifolium,* a typical plant of alpine meadows and rockslides, but also in great abundance and increased vigour on low altitude streambanks. He likens both habitats, regarding each as pioneer, very unstable and low in competition. He also cites Raup (1934) as noting 40 species of similar habitat range. Other species more typically found in wetter and cooler environments that have outlying populations in the Eastern Tiers include *Eucalyptus urnigera, E. gunnii, Telopea truncata* and *Helichrysum ericeteum* (Duncan 1988), as well as *Podocarpus lawrencii, Cotula alpina, Celmisia longifolia, Gnaphalium umbricola* and *Blechnum penna-marina* (Macphail & Moscal 1981). These latter five species are all typically subalpine - alpine species occurring on Ben Lomond at altitudes above 1 000 m (Macphail & Moscal 1981).. However, they also occur on the Douglas River in eastern Tasmania at altitudes between 60 to 440 m (Macphail & Moscal 1981).

The confinement of *Hovea corrickiae* to sites of riparian or poorly insolated characteristics in central eastern Tasmania and western Victoria suggests its preference for a more humid environment. Similarly, the patchiness of relict rainforest in eastern Tasmania supports the argument that mesic, drought intolerant species and communities can survive in pockets amidst the more drought tolerant communities. These patches occur outside the usual climatic range of rainforest (Neyland 1991). Callidendrous rainforest and associated mixed forest communities are restricted in eastern Tasmania to deep valleys and the deeply dissected eastern scarp (Duncan 1988). These sites characteristically are protected from fire by cliffs and streams, while the topographically reduced insolation levels of the southerly slopes creates high effective rainfall (Kirkpatrick 1981). There is a high degree of local habitat variability caused by the local relief (Kirkpatrick 1981). The State's southerly geographic position, mountainous topography and relative insularity have enabled the persistence of Gondwanan species in relatively stable environments similar to those which were widespread in Australia during the Tertiary. To some extent, rainforest and wet sclerophyll species were even able to survive within the Bassian Plain, for example, the existence of *Phyllocladus aspleniifolius* on King Island in western Bass Strait until destroyed by European settlement (Kirkpatrick & Brown 1984a). The highly disjunct distribution of *H. corrickiae* and the morphological differentiation between the Tasmanian and Victorian populations suggests that it is an old species and that these populations have been isolated for a long time. The habitat preference of the species for sheltered, moist environments indicates that this species would probably not have been more extensive during glacial conditions but in a past interglacial. It is able to persist in refugial habitats with wet forest species because of its high moisture requirement and because it does not require fire for germination of seed. The endangered species *Phebalium daviesii* co-occurs at two riparian sites with *H. corrickiae.* This species is now restricted to riparian environments in eastern Tasmania, but its closest relatives are also highly disjunct; they occur in Victoria (Lynch 1994).

Similar patterns of diversity have been suggested by the distribution patterns of invertebrates in central eastern to north-eastern Tasmania. The fauna of this higher rainfall block has a higher intrinsic diversity than the surrounding environments, and may represent a distinct, very old fauna preserved by stable geomorphological and microclimate patterning (B. Mesibov, pers. comm.).

Some species, such as *Pultenaea selaginoides,* occur in riparian situations and montane and ridgeline sites on the seaward slopes of the east coast. Kirkpatrick (1981) found vegetation distributions to be dependent in these environments on continentality, moisture availability and drainage. He found the seaward slopes to be more maritime and warmer than the inland plateau area. Cloudstripping of moisture by the vegetation in the montane environments and coastal ridgelines also increases the effective precipitation for species in these habitats. This may account for the habitat variability of *P. selaginoides.*

A number of other rare east coast rare species also occupy habitats varying from riparian to apparently drier ridge or hill environments, for example, *Spyridium microphyllum, Dodonaea filiforme, Melaleuca pustulata, Epacris limbata, Cyathodes pendulosa, Epacris acuminata, E. grandis, E. marginata* and *Eucalyptus barberi. E. barberi* was stated by Kirkpatrick (1981) to occupy sites with impeded drainage. Williams (1990) used the habitat and morphological differences between *E. barberi* and its closest taxonomic relative, *E. brookerana* (Ladiges *et al.* 1984), to suggest that the former species is a palaeoendemic that has largely been restricted to coastal communities during glacials. This species has also been located at Snow Hill, a montane environment in the Eastern Tiers.

Acacia axillaris, A. pataczekii, Hovea corrickiae and *Pultenaea selaginoides* may be old species persisting in refugia. Localised environments are able to support refugial species in eastern Tasmania; a small stand of the cool temperate rainforest species *Nothofagus cunninghamii* has existed continuously at a swamp site in south-eastern Tasmania through the last 9 000 years and most likely through the last glacial (Harle *et al.* 1993). All of the four species, except *A. pataczekii,* do not appear to be as drought tolerant as most of the other rare Tasmanian legumes. All except *P. selaginoides* have reproductive problems. *Hovea corrickiae* was observed to show marked variability in seed production. *Acacia axillaris* and *A. pataczekii* both appear to be better adapted to colder, glacial conditions, although *A. axillaris* may have still been limited by lesser drought resistance. *Hovea corrickiae* also appears to require moist conditions, and the question of how and when it was able to disperse across Bass Strait remains to be answered. *Pultenaea selaginoides* is also restricted to moist environments, and its present nuclear distribution suggests that its distribution may not have been extensive. It is possible that *A. pataczekii* was more extensive during cold and dry glacial conditions, but the other three species may require moister conditions to extend their ranges. All four of these species occupy sites with shallow, rocky soils. They may be restricted to stressful sites and not be competitive on more productive sites. Another consideration is that these species, and many of the endemic species, may not have had sufficient time to reach climatic equilibrium, either in expanding to their potential range (Kirkpatrick & Brown 1984a) or contracting to refugia.

In eastern Tasmania, the patterning of endemic and rare species can be seen to be more complex than previously assumed. The biogeography of the species may be a result of very different environmental pressures, complicated by the varying nature of the eastern topography. Gondwanan species and palaeoendemics have been able to persist because of the State's southerly geographic position, environmental variability and relative insularity; that is, long-term stability. Relict species and communities survive in discrete environments with high water availability. However, Quaternary environmental fluctuations have encouraged speciation, migration and local genetic variation. Many of the rare Tasmanian Fabaceae have distributions disjunct between Victoria and Tasmania, reflecting their past expansions and contractions of range during the Quaternary. Some rare Fabaceae are sparse across a wide environmental range, while others are localised to specific lithologies. All appear to be in specific habitats (*sensu* Rabinowitz 1981) in Tasmania. If the endemic or rare species exist in or have retracted into climatically unsuitable environments, or if the new stresses created by people are too great, then the continued survival of the species could be at risk. Reserve design and conservation management must take into account the varying evolutionary paths and environmental tolerances of such species, and consider whether species are expanding, contracting, or stable. Many of the species do not appear to be in climatic equilibrium.

20. SPECIES MANAGEMENT

Of the 16 Fabaceae considered in this study, three were classified as nationally threatened while seven were threatened at the State level (Table 20.1). Two of the species were rare nationally while four were rare in Tasmania. As a result of the survey work, five species were considered to be more threatened than they had previously been classified and were upgraded to a higher degree of rarity or threat. Four of the species were considered to be less threatened than previously and were downgraded to a lower degree of threatened. The downgradings were largely due to discovery of new populations of the species.

Table 20.1: Current and proposed conservation and reservation status' of the rare Tasmanian Fabaceae.

Species	Conservation & Reservation Status (Kirkpatrick *et al.* 1991b)	(Proposed)
Acacia axillaris	Rr2	Vv
Acacia pataczekii	Rur2	Rur1
Glycine latrobeana	Rr3	Vuv
Hovea corrickiae	r1	Rr1
Pultenaea selaginoides 1	Vv	Vv
Acacia retinodes	ur1	r1
Bossiaea obcordata	uv	ur1
Desmodium gunnii 1	uv	uv
Eutaxia microphylla	r2	r2
Hardenbergia violacea	uv	ue
Psoralea adscendens	r1	r1
Pultenaea hibbertioides 1	uv	uv
Pultenaea humilis	e	v
Pultenaea paleacea var. *sericea* 1	uv	uv
Pultenaea prostrata	e	u*v
Viminaria juncea	ue	u*e

1 Species' taxonomy under revision
* Species reserved inadequately in Tasmania

20.1 Management Considerations

20.1.1 Reservation

Reservation of several populations is recommended for all of the rare or threatened Fabaceae. This duplication reduces the possibility of stochastic disturbance of populations leading to extinction of the species in Tasmania. The species which are common in mainland Australia but rare in Tasmania are marginal to the species' distributions and may show genotypic differentiation. Conservation of these populations is essential to conservation of the species' genetic (intraspecific) biodiversity.

20.1.2 Legislation and Education

Protection by legislation of rare or threatened species wholly or mostly occurring on private land is desirable. Co operative agreements with landowners to protect these species is the most desirable option and punitive measures should only be a last resort. Liaison with landholders discussing the significance of species on their land, possible threats to the species, and appropriate management regimes is a necessary part of such protection. An awareness program targeting farmers and graziers operating within remnant grassy woodlands and grasslands should discourage clearance, ploughing and fertilising, but outline the benefits of native vegetation and the particular importance of grassy vegetation in Tasmania. Information on techniques to integrate agriculture and conservation sustainably should be made available.

20.1.3 Fire Ecology

Inappropriate management regimes may threaten some of the rare Fabaceae. It is important for rare species that regeneration trials are conducted prior to institution of management regimes. Trials should also incorporate assessment of the impacts of weed removal and disturbance so that interventive management is possible. The response of species either by resprouting or germination after future firing should be monitored. The most suitable regime will depend on the particular requirements of the species.

Most of the rare Fabaceae are secondary species; colonising after either physical disturbance or fire. However, a high frequency of disturbance may kill extant plants and also seedlings which germinated in response to the previous disturbance event, resulting in depletion of the species from both the community and the seed bank. This was shown for an *Acacia* species whose seedbank was exhausted by rapid repeated burning (Luke & McArthur 1978). Some of the *Bossiaea obcordata* sites are burnt with low intensity fires at five to seven yearly intervals for fuel reduction. Under such a regime, *B. obcordata* plants are able to resprout, however, regeneration of new individuals from seed is very limited. Sufficient time is needed after such events for the plants to mature, set seed and establish a seed bank or to be able to tolerate a low intensity fire by resprouting. Several of the rare Tasmanian Fabaceae were found to mature sexually early, being able to flower in their third Spring (Appendix 22.4). In comparison, a group of fire-sensitive species of the Hawkesbury sandstone flora was determined to reach regular flowering after 6 - 7 years, with another year required by the slowest flowering species to develop mature seed (Benson 1985). Several years of fruiting are required to replenish the soil seed bank, indicating that a minimum of 9 - 10 years is needed in a majority of fire cycles (Benson 1985) to perpetuate legume species. Bradstock and Auld (1987) recommended a firing frequency of 10 - 15 years for 34 legume species. This length period should enable leguminous species to reach flowering age and also give sufficient time to allow seed to be incorporated at various depths in the soil profile.

Bradstock and Auld (1987) recommended that controlled management burns should be of moderate to high intensity (500 - 7 000 kWm^{-1}) to accomplish abundant regeneration from seed. Auld and O'Connell (1991) found that dormancy was broken for most of the 35 eastern Australian Fabaceae studied once the critical temperature was reached, independent of the duration of heating. Most species responded to temperatures between 40 - 120^{o}C, although exposure to temperatures of 120^{o}C for more than one minute killed the seed of most species. Temperature trials of 40 - 100^{o}C effected germination in *Acacia patacekii, Hovea corrickiae, Pultenaea humilis, P. prostrata* and *P. selaginoides.* However, the response to the various temperatures varied considerably. Heat trials were only moderately better in effecting germination of *A. pataczekii* seed than no pretreatment, while temperatures of 100^{o}C were found to kill the seeds. In contrast, temperatures of 60 - 100^{o}C resulted in very high germination response of *H. corrickiae,* with even 60^{o}C effecting germination of 90% of seeds. The *Pultenaea* species were expected to respond to a wider range of temperatures than other genera of Fabaceae (Auld & O'Connell 1991). This was the case with *P. prostrata,* with which temperatures of 40^{o}C were able to effect 50% germination. The high temperatures of 100^{o} and 80^{o}C resulted in higher germination (90%). However, the germination of only 37% of seeds at 60^{o}C indicates either that there is some variability in response or experimental error. The germination response of *P. humilis* was also quite variable. However, the range of trials and sample sizes was limited. Germination of *P. selaginoides* displayed a trend of increasing levels with increased temperature. Germination response at 100^{o}C was equivalent to the viability of the seeds, that is, probably all viable seeds germinated.

The phenological study indicated that pod dehiscence in the rare Fabaceae generally occurred in January to February. Therefore, fires in late summer - early autumn are most likely to encourage regeneration, since they can induce germination from some seeds of the new season's crop as well as from the soil seed bank. Bradstock and Auld (1987) also recommended management burns be timed for late summer or autumn (February to April).

20.1.4 Forestry

Forestry operations may encourage regeneration of some species. However, the proliferation of some populations occurred when policies were inclined towards selectively logged rather than clear-felled coupes. It is imperative, in sites containing rare species, that the guidelines of the revised Forest Practices Code are adhered to and that operations are monitored by the Forest Practices Unit Botanist. Section 6 of the Forest Botany Manual (Duncan 1991) should be referred to for minimising the effects of forest operations on botanical values.

Rare species and their habitats should not be assumed to be tolerant of or compatible with forestry operations. If it is expected that the species does not recover easily, or at all, from logging activity, or is classified as vulnerable or endangered, then the site should be declared a special management area with a priority for conservation. Similarly, areas of low wood quality or difficult to log sites (for example, steep or easily eroded sites) with rare species should be designated special management areas primarily for conservation. If the species' response to operations is not known, then trials should first be instigated considering the impact particularly of disturbance and burning, before operations proceed. Particular importance during operations should be given to minimising the depth of soil disturbance, and the impacts of erosion, soil compaction, and changes in drainage patterns and runoff. Deep disturbance of the soil profile may overturn the A horizon and result in loss of the soil-stored seed bank. Severe erosion may have a similar result. Alteration of the soil structure or hydrology may reduce the suitability of the site for regeneration of the rare species. Consideration must be given to appropriate post-felling measures to best encourage on-site regeneration of the rare species, as well as the local community. The intensity of optimal regeneration burns will depend on the species' germination response to heat intensities and duration if previously determined, or the expected response from extrapolation of trials on congenerics or field observations. The biology of the species must also be considered where fuel reduction burns are proposed.

20.1.5 Agriculture, Stock grazing and Clearing

With little information on past distributions, management recommendations should be based on the *status quo* of known population abundance and extent. However, it is important that native communities or remnants proposed for clearing or development should be surveyed by qualified botanists, and that adequate legislative protection is available for populations threatened by development.

The effects of grazing intensity and timing need to be investigated for species subject to grazing by stock. Species such as *Acacia axillaris, Desmodium gunnii, Glycine latrobeana, Hardenbergia violacea, Psoralea adscendens, Pultenaea humilis, P. prostrata* and *P. selaginoides* occur in areas that are grazed by sheep or cattle as well as native herbivores. However, little is known of the tolerance of these species to past and current regimes. Some of these species are known to suffer from intensive grazing, but it is not clear whether grazing is preventing regeneration of seedlings or limiting seed production. The low, herbaceous species that are restricted to grassy to heathy woodland communities in the Midlands managed for grazing are particularly at risk. Another factor to be considered is the increasing population levels of native herbivores and whether their simultaneously reducing habitat range is placing higher grazing pressures on the remaining areas of native vegetation.

Apart from the major human-induced processes of clearing, ploughing and fertilising, agriculture- and grazing-related disturbance may actually encourage germination or at least not exclude it for most legume species. The abundance of *P. prostrata* at the highly disturbed Campbelltown golf course emphasises this phenomenon. However, many of the species are vulnerable to grazing at the seedling stage. Some species, such as *Acacia axillaris,* had extremely limited numbers of seedlings surviving at sites grazed by stock.

20.1.6 Mining

A different threat puts *P. hibbertioides* at risk in Tasmania, strip mining for gold. This type of mining involves intensive sifting of the soil and consequently massive environmental disturbance. Many of the sites occupied by *P. hibbertioides* in Tasmania have been mined in the past, while mining is currently occurring in the vicinity. The site with the largest and healthiest population of this species has a mining lease over it. Again, native communities or remnants proposed for a major change in management practices should be surveyed by qualified botanists and should have adequate legislative protection if necessary.

20.1.7 *Phytophthora*

Genera of Fabaceae susceptible to *Phytophthora cinnamomi* include *Acacia, Bossiaea, Hovea* and *Pultenaea* (Podger *et al.* 1990b), and the pathogen has been isolated from eight of the rare Fabaceae (Apendix 22.4; Barker 1994). Intra-generic susceptibility to the pathogen is highly variable, as demonstrated within *Pultenaea.* The level of resistance within species is also highly variable. *Pultenaea humilis* has been recorded as a host species elsewhere, but there has been no report of isolation of the fungus from naturally occurring plants in Tasmania (Podger *et al.* 1990b). The restriction of the species to the Midlands, which is generally too dry for the pathogen to survive (Podger *et al.* 1990a), means however, that the species is not likely to be at risk in Tasmania.

The genera *Desmodium, Eutaxia, Glycine, Hardenbergia, Psoralea* and *Viminaria* have not been tested. However, *Viminaria* is expected to be highly susceptible (Section 18.6). These and other rare species should be tested for their susceptibility to the fungus to enable the development of appropriate local management plans.

It is imperative that all persons working in *Phytophthora* infected or suitable areas follow appropriate procedures to prevent further transfer of the disease (see Duncan 1991, Wardlaw 1990, DELM 1993). Reserves containing such species should have topographic features such as hilltops and ridgelines as boundaries to maintain the integrity of the entire catchment. Access to, and operations within, such catchments should be restricted, and persons working within them made aware of measures required to prevent spread of the disease.

20.1.8 Propagation and Monitoring

Seed from all populations should be collected to maintain the possible genetic diversity of different populations. Some seed should be propagated by the Royal Tasmanian Botanic Gardens and some stored in a seed bank. This is especially important for populations which are senescing, are unreserved, or are threatened by habitat modification. Some species could be used in restoration work in local communities.

Representative populations should be monitored annually by the Parks and Wildlife Service and other relevant managing authorities, for example, the Forestry Commission, local Councils, or landholders or managers. Indications of regeneration and/or decline and the suitability of existing management practices should be assessed. The locations of populations should be mapped on management plans and made known to appropriate personnel, such as Rangers, Protection Officers, field workers, etc. The awareness of the land-holders and managers of the sites should be raised to the importance of conserving these species and to appropriate management regimes.

20.2 Specific Recommendations

20.2.1 *Acacia axillaris*

<u>Conservation status</u>

Most populations of *Acacia axillaris* occur in the St. Pauls and Elizabeth River catchments on private land. Survival of these sites is dependent on the health and management of these two river systems and activities close by or upstream which may affect the flow regime. These populations of *A. axillaris* have minimal regeneration and plants on sites at lower altitude are subject to high levels of seed predation. The conservation status of the species should, therefore, be considered vulnerable (**Vv**; Table 20.1).

<u>Reservation</u>

One population of approximately 100 plants is protected in the Mt. Barrow State Reserve. The boundary of the reserve should be extended to include the other nearby populations farther down Coquet Creek.

The Mt. Barrow sites are in the most extreme environment where the species occurs, and although this population was the most successful reproductively, a more typical population at less than 300 m altitude should also be reserved. This may be achieved by fencing of a current river reserve, extension of State forest with a forest reserve, or alternatively, proclamation of a conservation area. Since these populations are on private land, liaison with the landholders is essential.

A suitable mid-altitude location for reservation would be at Dukes Marsh, which is not viable for forestry operations and also contains *Euphrasia scabra,* classified as vulnerable nationally and in Tasmania (**Vv**; Kirkpatrick *et al.* 1991b).

The landholders with adjacent Crown river reserves on the Elizabeth and St. Pauls Rivers which include *A. axillaris* should be contacted by the Parks and Wildlife Service regarding management of this area accordant with the conservation requirements of this species. Extension of the reserve on the St. Pauls River would also reserve *Callitris oblonga,* a Tasmanian endemic listed as nationally vulnerable (**Vv**; Kirkpatrick *et al.* 1991b).

<u>Further research directions</u>

Populations of *A. axillaris* at the Midlands sites experience lower levels of seed regeneration and high incidence of seed predation. Investigation into the likely factors is required, whether due to insect predation of seed, dependence of the seed on particular environmental parameters such as temperature or soil moisture for germination, or some other factor. The spatial and temporal variability of these factors should also be addressed.

Permanent plots should be established and monitored long-term to monitor the vigour of the populations and assess whether regeneration is occurring.

Investigation of the soil-stored seed bank may aid further understanding of the species' fire ecology and regeneration. The impacts of flood disturbance, and various fire frequencies and intensities should be addressed. Information on the age at which viable seed is first produced is required, and also the time required for a soil seed bank to be established.

Specific management issues

Many of the populations suffer some degree of flood disturbance. Disturbance created during flood events may be a regeneration stimulus, or may be sufficient to maintain open microsites or limit competition by other species. Fire may have a similar role, but is not required for the regeneration of *Acacia axillaris.*

Plants on the St. Pauls River displayed a mid spring flowering pattern, with subsequent fruit production in mid January. The subalpine population on Mt. Barrow, however, had a later development of fruit, that is, in mid March, and pods at the mid altitude populations would also ripen later than at the St. Pauls site. Active management of sites, if needed, should post-date fruit production, so as to take advantage of the new seed crop.

20.2.2 *Acacia pataczekii*

Conservation status

Acacia pataczekii is a Tasmanian endemic restricted to dry sclerophyll forest in north-eastern Tasmania. Most of the populations occur within the Fingal forestry district while several occur in the Deloraine forestry district. *A. pataczekii* should remain at nationally rare status, and be classified with **r1** rather than **r2** status (**Rur1**; Table 20.1). It is not reserved.

Reservation

The two apparently most viable populations are those on the north-eastern slope of Ben Lomond and at Mt. Foster, south-west of Fingal. Both populations should be reserved. Reservation of the former population could be made by designation as a Forest reserve. Should this be seen to compromise the local forestry operations to too great an extent, an alternative would be to incorporate the area above Joy Road into the Ben Lomond National Park. The area is not suitable for conventional forestry operations, and the area is too close to the National Park for non-conventional operations, which would infringe on the values of the Park. The site of the summit population at Mt. Foster is not suitable for forestry operations, and could be reserved as a zone of special management if more secure tenure could not be gained. As many of the plants on the eastern slopes as possible should be included.

Further research directions

Investigation is required into the likely causes of low fecundity in *A. pataczekii*, and variability in reproductive success between populations and in time. Consideration should also be given to the effects of light availability, the variability of seed viability, and variation in proportions of soft versus hard seed. Greater sampling and observations of reproductively active plants, including of extrafloral nectary activity, is needed to determine the inhibiting factors. A more rigorous pollination trial should also be instigated.

Permanent plots should be established and monitored long-term to monitor the vigour of the populations and assess whether regeneration is occurring.

Investigation of the soil-stored seed bank may aid further understanding of the species' fire ecology and regeneration. The impacts of various fire frequencies and intensities should be addressed. Information on the age at which viable seed is first produced is required, and also the time required for a soil seed bank to be established.

The genetic distinctiveness and heterogeneity of populations should be assessed to indicate the long term viability of the species and the size of population required for viability. Estimates of total population size are confounded by the high degree of suckering by the species. Suckering also makes assessment of the age structure of populations difficult. Such information would assist in assessment of the dynamics and vigour of populations, as well as their reliance on vegetative over sexual reproduction.

Specific management issues

Small populations of *A. pataczekii* are probably scattered across Fingal Tier, to the south of Fingal and east of Mt. Foster, and persons surveying or working in the area should be familiarised with characteristics of the species. It has been mistaken in the past for *A. melanoxylon* and *A. mucronata*, having similar phyllodes.

A. pataczekii does not require fire for germination. Regeneration at most sites seems related to non-catastrophic disturbance, such as wind-throw or tree-fall of canopy species, or human-induced disturbance, with regeneration from seed after occasional hot fires. The species can resprout after firing and even larger scale physical soil disturbance generated by clear-fell logging of small coupes. Post-logging regeneration burns and fuel reduction burns, however, should be avoided. The germination trials indicated, however, that moderate levels of germination should occur after cool to moderate fires, if the soil seed store has built up sufficiently.

Plants at Tower Hill displayed a spring flowering pattern, with subsequent fruit production in early February. Active management of sites, if needed, should post-date this period, so as to take advantage of the new seed crop.

20.2.3 *Acacia retinodes*

Conservation status

The Tasmanian extent of *Acacia retinodes* var. *uncifolia* consists of several thousand individuals confined to calcareous soils on Flinders Island. The populations are restricted in distribution, and many are scattered along roadsides and in areas vulnerable to fire, destructive recreational activities and the increasing subdivision and clearing in the Emita - Wybalenna district. Its conservation listing should be considered as rare within Tasmania (**r1**; Table 20.1).

Reservation

Further reservation of this species is important for protection against destructive recreational activities and the increasing subdivision and clearing occurring in the Emita to Wybalenna district. Most of the populations occur on private land, although several small populations are reserved within the Wybalenna Historic Site, and populations occur in several small Lands Department reserves. The most suitable population would be at the northern extent of the species' distribution, that is, near Killiecrankie Bay or Leeka.

Further research directions

Permanent plots should be established and monitored long-term to monitor the vigour of the populations and assess whether regeneration is occurring.

Response of populations to firing of various intensities should be investigated, as well as the level of subsequent regeneration. Information on the age at which viable seed is first produced is required, and also the time required for a soil seed bank to be established.

Specific management issues

Fire is part of the ecology of this species, but it should be protected against too frequent burning. Although resprouting is apparent and also germination from seed after fire, an appropriate fire management plan should be devised.

Flowering time of *A. retinodes* is quite variable but records indicate that the Tasmanian populations predominantly flower in summer to mid-autumn. Active management of sites, if needed, should post-date fruit production, so as to take advantage of the new seed crop.

Vehicles should be prohibited from coastal reserve areas where this species occurs and tracks revegetated; there is no shortage of boat access to the water at other locations.

20.2.4 *Bossiaea obcordata*

Conservation status

The conservation status of *Bossiaea obcordata* should be downgraded to rare in Tasmania (**url**; Table 20.1) from its previous vulnerable (**uv**) listing. Seven sites are now known, and there is a strong possibility of finding more in State forests of the Fingal - Scamander district, on north-facing slopes of Mathinna sediments.

Reservation

All of the known populations occur in State forest. Reservation of several suitable populations is needed, with management appropriate to the species. The Golden Gate population is the largest and healthiest, and is not suitable for production forestry, being a steep, dry slope that would suffer substantial erosion and difficulties in regeneration under the current system of clear-felling or cable-logging. The plateau slope could be reserved as a buffer to the forest for conservation of this species and as habitat/ corridor, and managed for these reasons while still maintaining reasonable and non-threatening fuel loads. The population at Fehres Marsh is also significant due to its variation from the other populations in elevation, floristic dominance and substrate.

Further research directions

The morphological distinctiveness of the Tasmanian populations of *B. obcordata* should be quantified and its nature, whether genotypic or phenotypic, determined.

Permanent plots should be established and monitored long-term to monitor the vigour of the populations and assess whether regeneration is occurring.

Investigation of the soil-stored seed bank may aid further understanding of the species' fire ecology and regeneration. The impacts of various fire frequencies and intensities should be addressed. Information on the age at which viable seed is first produced is required, and also the time required for a soil seed bank to be established.

Specific management issues

Management plans for the sites where *Bossiaea* occurs should give priority to conditions suitable for sustainability of this species. Fire frequencies are currently too high at most sites. Soil erosion is evident, and plant diversity and cover are low. Most of the sites do not require fuel reduction burning as the litter cover is low. Sites should not be burnt at frequencies greater than nine to ten years.

Plants at Tower Hill displayed a late spring - early summer flowering pattern, with subsequent fruit production in early - mid February. Active management of sites if needed should post-date this period, so as to take advantage of the new seed crop.

20.2.5 *Desmodium gunnii*

Conservation status

Desmodium gunnii was listed as unreserved and vulnerable (**uv**) in Kirkpatrick *et al.* (1991b), based on three extant populations. *D. gunnii* is now known from six extant populations, however, two of them have less than 20 plants present, and only one similarly small population occurs on the boundary of a reserve, the Douglas-Apsley National Park. Conservation of the species is dependent on appropriate management of its ecosystem, however, knowledge of the species' ecological tolerances is lacking. *Desmodium gunnii* should, therefore, be listed as unreserved and vulnerable in Tasmania (**uv**; Table 20.1).

Reservation

Further reservation of the species is required. The populations at Bicheno, Bells Bottom, and Mt. Peter are all on private land, while the Douglas-Apsley population is neither very extensive or abundant. The most viable populations to reserve, therefore, may be those at Dogs Head Hill and the Gog Range; both of which are in State forest.

Further research directions

D. gunnii has a widespread but extremely localised distribution. The factors limiting its population distribution and abundance require investigation to determine what is suitable long-term habitat for the species. These factors may include trials on the species' competitive ability and ecological tolerances, its dispersal mechanisms, or preferred disturbance and fire frequencies and intensities. Information on the age at which viable seed is first produced is required, and also the time required for a soil seed bank to be established.

Permanent plots should be established and monitored long-term to monitor the vigour of the populations and assess whether regeneration is occurring.

Specific management issues

All sites should be noted on Forestry district maps locating areas restricted to logging activities. The sites do not appear to have been logged, and the effects of forestry activities are unknown. The species should cope with limited disturbance of the soil surface, but not disturbance to any depth.

Liaison with the landholders at other populations is required to ensure survival in Tasmania of this species, particularly regarding suitable management regimes of grazing and firing. Populations should not be grazed or burnt during November to February to allow the plants to successfully reproduce. Some disturbance was apparent at sites of extant *D. gunnii*, whether from grazing or firing, but most of the sites had not burnt recently. Not enough is known about the frequency or intensity of firing most beneficial to such native herbs. Some overstorey cover appears to be required in the Midlands populations, so a balance must be achieved between regeneration of canopy species and maintenance of an open shrubby to grassy understorey.

20.2.6 *Eutaxia microphylla*

Conservation status

The distribution of this species is very occasional (rare; **r2**; Table 20.1) in coastal communities from the north-east to the south-east of Tasmania; that is, to Flinders Island, Prime Seal Island and another three widely scattered sites (Cape Portland, Pittwater Bluff and Chronicle Point).

Reservation

E. microphylla is reserved on Flinders Island at Trousers Point, Strzelecki National Park. However, recognition in a management plan of the population at Cape Portland is desirable. This population occurs on a different substrate to those in the Furneaux Group, and the plants are much less spiny.

Another small population of *E. microphylla* is reserved within the Wybalenna Historic Site, along with *A. retinodes* (Section 20.2.3). Management to maintain the populations of both species would comply with conservation of the coastal flora at the site.

Further research directions

The Chronicle Point site differs from those on Flinders Island in substrate, while the plants of these populations differ in degree of spininess. Comparison of both the substrate and plant morphology across the range of *E. microphylla* may quantify some intra-species variation.

Permanent plots should be established and monitored long-term to monitor the vigour of the populations and assess whether regeneration is occurring.

Investigation of the soil-stored seed bank may aid further understanding of the species' fire ecology and regeneration. The impacts of various fire frequencies and intensities should be addressed. Information is required on the age at which plants first produce viable seed and on the time for a seed bank to establish.

Specific management issues

Vehicles should be prohibited from these coastal sites; there is no shortage of boat access to the water at other locations.

E. microphylla flowers in Spring (September to November), with subsequent fruit production until mid January. Active management of sites, if needed, should post-date this period to take advantage of the new seed crop.

20.2.7 *Glycine latrobeana*

Conservation status

G. latrobeana was listed nationally as rare (**3RCa**), with a distribution over more than 100 km, and considered adequately reserved (Briggs & Leigh 1988). More populations have been found in Victoria (J. Grace, pers. comm.), but the species is now considered nationally to be vulnerable (ANZECC 1993). In Tasmania, the species is of limited distribution and abundance. In Tasmania, there are seven populations recently recorded, two of which need to have specimens collected for the Tasmanian Herbarium. There are also two other sites which need to be confirmed. The sites are widespread but extremely restricted, usually over areas tens of metres across. They also tend to contain less than 60 plants at a site. The total number of individuals in Tasmania is less than five hundred. One population occurs within a Wildlife Sanctuary, however, *G. latrobeana* was extremely rare at this site andthe species is, therefore, inadequately reserved. For these reasons, the conservation status of this species should be reclassified as unreserved and vulnerable at both the State and national levels (**Vuv**; Table 20.1).

Reservation

Viable populations of *G. latrobeana* do not occur within any secure reserve, and reservation of two suitable populations is required. The only non-freehold site, however, is the one at Remarkable Rock, Ouse River, and is crown administered. This population should be reserved. Liaison with land-owners of the other sites should be instigated to determine another suitable population for purchase and reservation.

Further research directions

A vegetative specimen and seeds from all populations should be sent to the Division of Plant Industry, C.S.I.R.O., Canberra for use in trials on the genetic diversity and potential agricultural use of genetic parameters of *Glycine* species.

The genetic distinctiveness and heterogeneity of populations should be assessed to indicate the long term viability of the species and the size of population required for viability.

Permanent plots should be established to monitor long-term the vigour of the populations and assess whether regeneration is occurring.

Trials on the germination response of *G. latrobeana* and the resilience of its tap-root to heat and disturbance should be instigated to enable specific management application. Information on the age at which viable seed is first produced is required, and also the time required for a soil seed bank to be established.

Specific management issues

The Tasmanian records of distribution, literature references and some collections are not reliable sources for this species since there has been much misidentification and confusion regarding species within the genus *Glycine*. The key to distinguishing species of the genus *Glycine* occurring in Tasmania (Section 22.2) should be dispersed amongst botanists and field workers, particularly those working in grassy woodlands and forests.

A specimen population is currently under cultivation in Canberra, and another is being established in Hobart to provide a living reference collection, using seeds genetically determined and supplied by the Division of Plant Industry, C.S.I.R.O., Canberra. These plants should be maintained by the Royal Tasmanian Botanic Gardens. Fertile reference material should be lodged at the Tasmanian Herbarium.

G. latrobeana displays a spring flowering pattern (October to December), with subsequent fruit production until mid summer. Active management of sites, if needed, should post-date this period, so as to take advantage of the new seed crop.

20.2.8 *Hardenbergia violacea*

Conservation status

H. violacea is confined, in Tasmania, to two populations with a total of less than 50 plants, in an apparently over-grazed and senescing community on private land. Extinction of these populations may occur if regeneration is not adequate or grazing has prevented fruit development and incorporation in the soil seed bank. The conservation and reservation status of this species should, therefore, be coded as unreserved and endangered in Tasmania (**ue**; Table 20.1).

Reservation

The species is unreserved in Tasmania, and reservation of the populations is not a viable long-term option. The sites are small and very localised, and comprise senescent communities surrounded by pasture. No other species would gain significantly by reservation of the sites. The closest suitable site where an *ex situ* population could be established would be within the Meehan Range - Redgate Section State Recreation Area. However, this reserve is insecure for nature conservation purposes. It is therefore of paramount importance that liaison with the land-holder re management of the sites receives imminent attention and action, and also that seed of the plants is collected for a seed bank.

Further research directions

Morphological and genetic characters of the Pontos Hills populations of *H. violacea* should be compared to wild populations in Victoria and also to cultivated varieties of the species to determine the most likely origin of the populations and their distinctiveness. This information will assist in determining the importance of the Pontos Hills populations to the biodiversity of the species and also to the Tasmanian flora.

Permanent plots should be established and monitored long-term to monitor the vigour of the populations and assess whether regeneration is occurring.

Investigation of the soil-stored seed bank may aid further understanding of the species' fire ecology and regeneration. The impacts of various fire frequencies and intensities should be addressed. Information on the age at which viable seed is first produced is required, and also the time required for a soil seed bank to be established.

Specific management issues

Active management is required for this species. Discussion of recommended management actions should be immediately instigated with the landholder. Exclusion of grazing is required while activities encouraging regeneration of the species and the community are enacted. This will involve fencing of the sites and conducting a moderate to hot controlled burn. Sites should be burnt at different times in case regeneration is not successful, however, if efficiency demands that both sites are burnt during the same period, then a portion of the sites should be excluded from burning. Cuttings of vegetative material and collection of seed produced in spring, 1992, should be made prior to fencing and firing of either site. It is recommended that burning of the sites should take place after fruit has been collected in summer to autumn 1992 - 1993. The drought susceptibility of the sites suggests that later in the season would enable the greatest chance of successful germination.

20.2.9 *Hovea corrickiae*

Conservation status

The Tasmanian specimens of *H. corrickiae* differ from Victorian ones in several morphological characters, although they do appear to occur in similar habitats in both States. The populations are disjunct and discrete, localised populations with possible genetic diversity across their range. The conservation status of this species is secure, since most of the populations are securely reserved, but *H. corrickiae* should qualify for rarity status in both States and nationally because of its narrow and limited distribution to specific and localised habitats. In Tasmania, its conservation status should remain as rare, but nationally it should gain classifications of **3RCa** (Briggs & Leigh 1988 system) and **Rr1** (Kirkpatrick *et al.* 1991b system; Table 20.1).

Reservation

The species is adequately reserved: in Victoria, within the Grampians National Park; and in Tasmania, within the St. Columba Falls State Reserve and also the Lower Marsh Creek Forest Reserve.

Further research directions

Further germination trials are required to determine the level of non-dormancy and non-fire related germination stimuli in *H. corrickiae* seeds. Such information will aid further understanding of the species' regeneration ecology for specific management prescription.

Permanent plots should be established and monitored long term to monitor the vigour of populations and temporal variability in reproductive success.

Investigation of the soil-stored seed bank may aid further understanding of the species' fire ecology and regeneration. Field trials should be established to determine the impacts of various fire and disturbance frequencies and intensities. Information on the age at which viable seed is first produced is required, and also the time required for a soil seed bank to be established.

Specific management issues

Flower and fruit production was observed to be much greater on shrubs on the roadside at St. Columba Falls than farther into the woodland under a closer canopy. It is important that roadside management is not to the detriment of these shrubs, and the local Ranger responsible for management of the reserve should be familiar with this species and the location of its populations.

H. corrickiae occurs in environments adapted to fire, however, this species does not require fire for regeneration of seed. The species can regenerate after fire but a low fire frequency should be maintained at the sites, sufficient to maintain health of the populations.

The population of *H. corrickiae* at Mt. Elephant displays an early to mid spring flowering pattern (mid September to late October), with subsequent fruit production in early - mid February. Active management of sites, if needed, should post-date this period, so as to take advantage of the new seed crop.

20.2.10 *Psoralea adscendens*

Conservation status

This species should be classified as rare (**r1**; Table 20.1) in Tasmania. The total known population within Tasmania consists of fewer than 200 individuals. The three populations are quite small and restricted, being confined to small headlands of specific geology. They are all subject to recreation use, with one also subject to grazing by cattle.

Reservation

One population of *Psoralea adscendens* is reserved at the Sundown Point Aboriginal Site. Less than 100 individuals occur within this reserve. At least one other population of *P. adscendens* should be reserved *in situ*. The Couta Rocks population is in good condition and is currently within the Arthur-Pieman Protected Area. However, stronger reservation is required for this *Psoralea* site.

Further research directions

Specimens of *Psoralea* should be collected and referred to J. Grimes (New York Botanical Gardens), who is currently revising the genus. The Tasmanian populations show habitat and possibly morphological differences which may be expressed genetically, with the Tasmanian populations possibly a hardier genotype.

Permanent plots should be established and monitored long-term to monitor the vigour of the populations and assess whether regeneration is occurring.

Investigation of the soil-stored seed bank may aid further understanding of the species' fire ecology and regeneration. The impacts various disturbance and fire frequencies and intensities should be addressed. Information on the age at which viable seed is first produced is required, and also the time required for a soil seed bank to be established.

Specific management issues

Being so localised, the populations are vulnerable to disturbance, invasion of exotics and succession of heath species. Directed management for conservation of the *Psoralea* may become required. The sites should be monitored for regeneration of the *Psoralea*, and for continuing health of the community. Permanent plots should be established for this purpose. Firing may be needed to maintain an appropriate balance, so that heath species do not increase in dominance and outcompete the herb and grass species.

Records of *P. adscendens* indicate that this species displays a mid spring to summer flowering pattern (October to January), with fruit production following in February. Active management of sites, if needed, should post-date this period, so as to take advantage of the new seed crop.

20.2.11 *Pultenaea hibbertioides/ mollis*

Conservation status

P. hibbertioides is very localised, being only known to currently occur near Lefroy, in the Den Ranges, at Pipers River and at Badger Hill. None of the populations have security of tenure, and some of the populations in the Lefroy area may become subject to gold-mining or forestry operations. The actual methods and extent of soil disturbance will determine whether the species will survive in these areas. The species is also threatened by the pathogen *Phytophthora cinnamomi*, which has been isolated from it. Until it is reserved and managed to limit the threat of *Phytophthora*, *Pultenaea hibbertioides* must be considered vulnerable (**uv**; Table 20.1) to extinction in Tasmania.

Reservation

Adequate reservation of this possible genetic diversity and of the species as represented in Tasmania is required. *P. hibbertioides* is most abundant in State forest to the south-west of Pipers River, in the far north of Tasmania. In an area of almost four kilometres by 1.5 km, there were several thousand plants. This area was originally proposed as the Den Ranges RAP (Recommended Area for Protection; Williams 1989) and would have been the best location to reserve this species. A significant proportion of this area is, however, under gold lease until the end of this Century and this conflict of interests was seen as unresolvable. This may have been a case where sensitive mining and conservation could co-exist by management prescription for mutual benefit. However, such prescriptions would require strict monitoring and co-operation between relevant agencies. Should the Den Ranges RAP (Recommended Area for Protection) remain unresolved, the Lefroy RAP should be surveyed to determine if *P. hibbertioides* is present within the proposed reserve. If it is not and suitable sites are present, an *ex situ* population could be established from local seed within the RAP.

A second site for reservation should also be managed for conservation of *P. hibbertioides* to improve the long-term viability of the species in Tasmania.

Further research directions

The complex of *Pultenaea hibbertioides* and *P. mollis* may indicate genetic diversity, a significant component of which may be the Tasmanian populations. Quantification of this diversity across the species' range, especially considering the distinctiveness and heterogeneity of populations, would assist in assessment of the long-term viability and importance to the conservation of biodiversity of the Tasmanian populations.

Germination trials are required to determine the level of non-dormancy and ecological germination stimuli in *Pultenaea hibbertioides* seeds. Further trials on the impacts of various disturbance and fire frequencies and intensities should be instigated. Information on the age at which viable seed is first produced is required, and also the time required for a soil seed bank to be established. Such information will aid further understanding of the species' regeneration ecology for specific management prescription.

Permanent plots should be established and monitored long-term to monitor the vigour of the populations and assess whether regeneration is occurring.

Specific management issues

Current mining operations in the northern end of the species distribution involves intensive sifting of the surface metres of soil and rock in a water slurry. Disturbance of the vegetation and soil is absolute, with future revegetation of the sites to be made from the surrounding vegetation. Such an extreme level of disturbance is clearly incompatible with on-site regeneration of species, and pre-mining surveys should in future be conducted for rare species present in the area.

P. hibbertioides, at sites near Bridport, north-eastern Tasmania, displays a spring to early summer flowering pattern (late September to December). Fruit production follows until late January. Active management of sites, if needed, should post-date this period, so as to take advantage of the new seed crop.

20.2.12 *Pultenaea humilis*

Conservation status

P. humilis is very rare in Tasmania, with only two populations known, totalling about 1 600 plants. The sites are localised: one occurring along a 1.6 km road-side strip, the other in an area of woodland of 150 m by 200 m. One of these sites occurs on private land. The species should be considered vulnerable (**v**; Table 20.1) in Tasmania.

Reservation

P. humilis is reserved in the Tom Gibson Nature Reserve. However, the morphological distinctiveness of the Tasmanian stock and their geographic isolation means that it is important to conserve the presumed genetic diversity of the species as represented in Tasmania. It is, therefore, important to preserve both Tasmanian populations. The risks that one population faces in a fragmented, agriculturally pressured community can be marginally offset with careful management of at least one other population. Negotiations should be instigated with the landholder over management of the population and the possibility of declaring a conservation covenant on the area, declaring the site a conservation area, or of negotiating a lease over the land.

Further research directions

Quantification of genetic diversity across species range, especially considering the distinctiveness and heterogeneity of populations would assist in assessment of the long-term viability of the populations in Tasmania.

Permanent plots should be established and monitored long-term to monitor the vigour of populations and any temporal variability in reproductive success.

Investigation of the soil-stored seed bank may aid further understanding of the species' fire ecology and regeneration. Field trials should be established to determine the impacts of various fire and disturbance frequencies and intensities. Information on the age at which viable seed is first produced is required, and also the time required for a soil seed bank to be established.

Specific management issues

Both populations appear to be healthy, and some regeneration is evident. The species does not appear to require fire for germination, gaining adequate regeneration from soil disturbance imparted by animal digging and grazing.

The Council and the landholder(s) should be made aware of the extent of the species at the Powranna Road site, and liaison maintained regarding suitable management practices for survival of the species. Roadside mowing should be avoided during the development of flowers and fruit by the species. Attention should be paid to appropriate woodcutting, firing and grazing regimes.

P. humilis displays a mid spring to early summer flowering pattern (late October to early December) in Tasmania. Fruit production follows until late January. Active management of sites, if needed, should post-date this period, so as to take advantage of the new seed crop.

20.2.13 *Pultenaea paleacea* var. *sericea*

Conservation status

This species is unreserved and vulnerable (**uv**; Table 20.1) in Tasmania, with all sites being localised and the plant only locally abundant. The total numbers at each site are not high; less than 100 individuals at both Bridport (in an area of approximately 30 m by ten metres) and at Big Waterhouse Lake (in an area of 15 m by 15 m). The species is very rare at Croppies Point, and therefore the total number of individuals within Tasmania is only several hundred. Accordingly, reservation of the species as well as *ex situ* conservation is required.

Reservation

The heathland west of Bridport including the *P. paleacea* site would be the best site for reservation. It is currently undeveloped, but being encroached on by vehicle tracks and the dumping of rubbish outside the boundary of the town. Many tourists and Tasmanians visit Bridport during summer, and this site would be a good opportunity to interpret the values of such a heathland to the public while conserving a rare species.

A second site for reservation should also be managed for conservation of *P. paleacea* var. *sericea* to improve the long-term viability of the species in Tasmania. The reservation status of the population at Big Waterhouse Lake, in the Waterhouse Protected Area, should be upgraded for this purpose.

Further research directions

Permanent plots should be established and monitored long-term to monitor the vigour of populations and any temporal variability in reproductive success.

Investigation of the soil-stored seed bank may aid further understanding of the species' fire ecology and regeneration. Field trials should be established to determine the impacts of various fire and disturbance frequencies and intensities. Information on the age at which viable seed is first produced is required, and also the time required for a soil seed bank to be established.

Specific management issues

A history of fire within the communities should be developed by the ranger, Bridport district, to assist in management of this species. Too frequent firing should not be encouraged, especially until a greater knowledge of the regeneration mode of the species is gained. It is presumed that the species regenerates from seed after fire, however it may also resprout after "cool" burns.

Frequent firing should not be encouraged, especially until a greater knowledge of the regeneration mode of the species is gained. It is presumed that the species regenerates from seed after moderate to high intensity fires, however it may also resprout after "cool" burns.

Records of *P. paleacea* var. *sericea* indicate that this species displays a mid spring to early summer flowering pattern (mid October to mid November) in Tasmania. Fruit production follows until mid to late January. Active management of sites, if needed, should post-date this period, so as to take advantage of the new seed crop.

20.2.14 *Pultenaea prostrata*

Conservation status

Pultenaea prostrata is classified as endangered (e) in Kirkpatrick *et al.* (1991b). The recent declaration of Tunbridge Nature Reserve has restricted grazing at the site and given it security of tenure. Only two plants occur within the reserve, however, and this cannot therefore be considered adequate reservation. The discovery in 1991 - 1992 of two new populations (Hunterston Rivulet and Marsh Creek) and the extension of the other two populations (Tunbridge and Campbell Town) increases the known distribution of the species. The populations at Campbell Town and at Marsh Creek both comprise less than 1 000 individuals each. The conservation status *P. prostrata* should be downgraded to vulnerable and inadequately reserved (**u*v**; Table 20.1).

Reservation

Consultation should be instigated with the current landholders of the paddock at Tunbridge which contains more plants of *Pultenaea prostrata* regarding purchase and extension of the Tunbridge Nature Reserve. Alternatively, more of the species could be manually established within the reserve.

Further reservation of an additional suitable population is, however, also needed to improve the long-term viability of the species in Tasmania. The other populations are on private land, except for the one at Campbell Town, which is on a Crown reserve administered by the Lands Department.

Further research directions

Permanent plots should be established and monitored long-term to monitor the vigour of populations and any temporal variability in reproductive success.

Investigation of the soil-stored seed bank may aid further understanding of the species' fire ecology and regeneration. Field trials should be established to determine the impacts of various fire and disturbance frequencies and intensities. Information on the age at which viable seed is first produced is required, and also the time required for a soil seed bank to be established.

Specific management issues

Suitable habitat for the species is declining, with the continued clearance, ploughing and fertilising of grassy vegetation for agricultural use. Sixty percent of the grasslands present in pre-European times remain, but only ten percent of the grassy woodlands have survived (Kirkpatrick 1991). Awareness of the importance of the remainder needs to be encouraged. Liaison should be established with the owners and managers of the locations where the other populations occur, and discussion ensue regarding appropriate and realisable management regimes.

Winter disturbance (that is, grazing) and low intensity firing do not appear to be detrimental to the species' survival. The populations which are grazed over winter may need intervals of lighter grazing interspersed with heavy grazing to allow the species to fruit successfully. Grazing should be avoided during the flowering season, September to November, and the fruiting season, November through January, and possibly February, to allow completion of the plant's reproductive cycle. Mowing, as has been conducted at the Campbell Town Golf

Course, has also not been so severe as to prevent reproduction. Mowing may indeed encourage the species by reducing competition from native grasses.

20.2.15 *Pultenaea selaginoides*

Conservation status

Pultenaea selaginoides is endemic to Tasmania, and restricted to the central eastern region in only moderate numbers, approximately 1 000 plants. Only four extant populations are known, all locally restricted. *Pultenaea selaginoides* should retain a conservation status of vulnerable nationally and in this State (**Vv**; Table 20.1).

Reservation

The largest and healthiest population of *P. selaginoides* is reserved in the Douglas-Apsley National Park but is localised. The population on the Swan River is included in the proposed Hardings Falls Recommended Area for Protection (Working Group for Forest Conservation 1991). Reservation of this population should be followed up.

Further research directions

Further investigations for populations of *P. selaginoides* in the upper St. Pauls River area are warranted. One population was found in 1992 in riparian heath on the river near Horseshoe Marsh, 8 km upstream from a 19th Century record and about 17 km to the north-west of the Douglas-Apsley population. The species is likely to occur in similar heaths in the region.

Permanent plots should be established for all populations of *P. selaginoides,* so that they can be monitored for signs of senescence or continuing survival.

Further trials on the impacts of various fire and disturbance frequencies and intensities should be instigated. Information on the age at which viable seed is first produced is also required, as well as the time required for a soil seed bank to be established.

Specific management issues

Consultations should occur with the current landholders of the site on the Apsley River about the history of the site, and possible active management to protect (fencing on two sides of 15 m by 15 m), and encourage regeneration of, the species. Alternatively, more of the species could be manually established within the area. Liaison should ensue with the owner and manager regarding appropriate and realisable management regimes.

Fire and disturbance are a part of the regeneration ecology of communities in which this species occurs. Although the plants are currently successfully reproducing, they may require a moderate to hot fire to induce seed germination rather than coppicing. The populations personally observed (Blindburn Ridge, Apsley River, Swan River) are all older than twenty years, although one site at Blindburn Ridge has coppiced plants and seedlings evident after more recent fire. Active management to regenerate populations may be required within the next five to ten years. This may mean a controlled moderate to hot fire for abundant germination of the *Pultenaea*, with good predicted germination from temperatures above 60^{o} and above 80^{o} at two centimetres depth. Low intensity fires may induce adequate regeneration if timed shortly after fruit dehiscence, when quantities of seed are still present on the ground surface. *P. selaginoides* is a spring flowering species, peaking in November, with fruit ripening in mid January to early February, and other populations varing slightly.

20.2.16 *Viminaria juncea*

Conservation status

V. juncea is highly geographic restricted in Tasmania. The species is only known from three populations in eastern Tasmania totalling less than 100 individuals. The three clusters of plants are scattered over one and a quarter square kilometres. *V. juncea* should be classified as inadequately reserved and in danger of extinction in Tasmania (endangered; **u*e**; Table 20.1).

Reservation

The largest population is just inside the boundary of the Moulting Lagoon Game Reserve, however, the population is too small to constitute adequate reservation of a viable population. Legislative protection is needed for the other two sites nearby. Boundaries of the Moulting Lagoon Game Reserve should be extended to include all three populations of *Viminaria.*

Further research directions

All populations should be monitored annually for indications of regeneration and/ or decline. Permanent plots should be established and monitored long term for this purpose.

Investigation of the soil-stored seed bank may aid further understanding of the species' fire ecology and regeneration. The impacts of various fire and disturbance frequencies and intensities should be addressed. Information on the age at which viable seed is first produced is required, and also the time required for a soil seed bank to be established.

The species is fire sensitive and germinants require time after firing to reach maturity and replenish the soil-stored seed bank for subsequent post disturbance regeneration. Moderate intensity fires result in the best predicted germination, however it may also resprout after "cool" burns. A history of fire within the community should be developed to assist in determining appropriate management of the species. *V. juncea* has recovered from fire in the recent past, however, too frequent firing should be discouraged. The response of the species either by resprouting or germination after future firing should be monitored by the Ranger.

Specific management issues

The reserved site is not topographically distinct from the adjacent private land, and is at risk from fires in summer when the ground is less boggy. The other two groups of plants are both on private land and at risk from clearing as well as fire. Consultation with the landholders must be engaged to ensure appropriate management practices conducive to survival of this species.

Plants propagated from seed of the local plants, and donated by Alan Gray (Greening Australia) should be used to establish an *ex situ* population elsewhere, but in similar habitat, on the shores of Moulting Lagoon Game Reserve. This would help to reduce the possibility of stochastic disturbance or a too frequent fire regime destroying all three populations.

The district Ranger should be familiarised with the location of the sites.

Records of *V. juncea* indicate that this species displays a late spring to mid summer flowering pattern (mid November to mid January) in Tasmania. Fruit production occurs in December to February. Active management of sites, if needed, should post-date this period to take advantage of the new seed crop.

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22. APPENDICES

22.1 Personal Communications

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22.2 Key to Tasmanian *Glycine* Species

(adapted from Tindale 1986, Jessop & Toelken 1986, J. Grace & T. Brown (pers. comm.) and pers. obs.).

1. Stems non-stoloniferous. Leaves digitately trifoliolate, the 3 leaflets equally petiolulate and subsessile (i.e. all petiolules equal lengths). Veins of leaflets coarsely reticulate within the larger areolae. Stipels of the median petiolule absent or minute.

1a. Stems elongate, growth habit twining, with shoots all from the crown. Stipels absent on the median petiolule. Stipules oblong to lanceolate. Seeds of chasmogamous legumes 9-12, with a brown-coloured, rough surface. Seeds c. 1.5 x 1-1.2 mm.......*G. clandestina*

1b. Stems short, erect, decumbent or ascending, growth habit trailing and spreading rhizomatously. Petiolules densely covered with antrorse to reflexed hairs, obscuring stipels which are minute and caducous. Stipules suborbicular to broadly ovate or reniform, as wide as long or wider, and wrapping around stem. Seeds of chasmogamous legumes 3-5, with a dark-brown, smooth to muriculate surface. Seeds c. 2-2.75 x 1.75-2.25 mm.......*G. latrobeana*

2. Stems stoloniferous with adventitious roots at the nodes of above-ground stems. Growth habit prostrate and/or twining. Leaves pinnately trifoliolate, the terminal leaflet inserted on a short but distinct petiolule, lateral leaflets subsessile. Stipels always present on the median petiolules. Seeds of chasmogamous legumes 3-6, perisperm granular or smooth. Veins of the leaflets very finely reticulate within the larger areolae.

2a. Leaves weakly pinnately trifoliolate. Growth habit twining. Seeds 1.5-2.2 x 1-2 mm, perisperm smooth............................*G. microphylla*

2b. Leaves strongly pinnately trifoliolate. Growth habit trailing. Distinct, long stipules. Seeds 2-2.5 mm x 1.8-2.5 mm, perisperm smooth or in some forms granular. Not recorded from Tasmania..*G. tabacina*

22.3 Sizes of Seeds

(a, b and c groupings refer to length, width and depth of seed measured perpendicular to each other; measurements in millimetres).

	(largest of N=10)
	(a)
Bossiaea obcordata	2.74
Eutaxia microphylla	1.80
Pultenaea hibbertioides	2.90
Pultenaea humilis	3.08
Pultenaea paleacea var. *sericea*	2.30
Pultenaea prostrata	2.50
Pultenaea selaginoides	2.20

	(average of N=10)		
	(a)	(b)	(c)
Acacia axillaris	4.54	2.07	1.40
Acacia pataczekii	4.73	2.67	1.35
Hovea corrickiae	5.60	4.00	3.12

SPECIES	HABIT	COMMUNITY TYPE	SITE QUALITY	SCLEROPHYLLY/ GRAZING LEAF ADAPTATIONS	DEMOGRAPHY	REGENERATION TYPE	SEED PRODUCTION, VIABILITY	SEED DORMANCY, NON-DORMANCY
Acacia axillaris	Tall shrub/ low tree	Dry sclerophyll woodland/ scrub	History of disturbance	Phyllodinous leaves			High, annual production; Low viability (29%)	Physiological and physical dormancy; 0% non dormant
Acacia pataczekii	Tall shrub/ low tree (single-stemmed)	Dry/wet sclerophyll forest/woodland	History of disturbance	Thickened, leathery leaves			Low, annual production; Viability high (100%)	Physical dormancy; 27% non dormant
Acacia retinodes	Tall shrub/ low tree (single-stemmed)	Coastal heath	History of disturbance	Thickened, leathery leaves				
Bossiaea obcordata	Low shrub	Dry sclerophyll woodland	History of disturbance; frequent firing	Small leaves; spinous branches		Disturbance enhanced	High, annual production; Viability high (99%; Auld & O'Connell 1991)	Physical dormancy; 8.6% non dormant (Auld & O'Connell 1991)
Desmodium gunnii	Perennial herb	Grassy/heathy woodland	History of grazing	Small leaves				
Eutaxia microphylla	Low shrub	Coastal heath/ woodland/forest	History of disturbance	Small, linear leaves; spinous branches				
Glycine latrobeana	Perennial herb	Dry sclerophyll shrubby/grassy woodland	History of grazing; frequent firing	Small leaves; reflexed hairs on stems			Viability high (100%)	Physical dormancy; Some seeds non dormant (% unknown)
Hardenbergia violacea	Low shrub	Dry sclerophyll heathy woodland	History of disturbance and grazing	Thickened, leathery leaves				
Hovea corrickiae	Tall shrub/ low tree (single-stemmed)	Dry/wet sclerophyll forest	Frequent firing	Thickened, leathery leaves; hairy lower surface	Can flower 3 seasons after germination		High, annual production; Viability high (100%)	Physical dormancy; 0% non dormant
Psoralea adscendens	Perennial herb	Coastal heath/ heathy herbfield	History of disturbance and grazing	Small leaves				
Pultenaea hibbertioides	Medium shrub	Dry sclerophyll heathy forest/ woodland	History of disturbance	Small, involute, pilose leaves	Can flower 3 seasons after germination	Disturbance enhanced		

SPECIES	DISPERSAL MECHANISM	*PHYTOPHTHORA* SUSCEPTIBILITY
Acacia axillaris	Ants? (elaiosome present)	Moderate (Barker 1994)
Acacia pataczekii	Ants? (elaiosome present)	Slight (Barker 1994)
Acacia retinodes	Ants? (elaiosome present)	
Bossiaea obcordata	Ants? (elaiosome present)	Slight (Barker 1994)
Desmodium gunnii		
Eutaxia microphylla	Ants? (elaiosome present)	
Glycine latrobeana		
Hardenbergia violacea	Ants? (elaiosome present; Berg 1979)	
Hovea corrickiae	Ants? (elaiosome present)	Moderate (Barker 1994)
Psoralea adscendens		
Pultenaea hibbertioides	Ants? (elaiosome present)	High (Barker 1994)

SPECIES	HABIT	COMMUNITY TYPE	SITE QUALITY	SCLEROPHYLLY/ GRAZING LEAF ADAPTATIONS	DEMOGRAPHY	REGENERATION TYPE	SEED PRODUCTION, VIABILITY	SEED DORMANCY, NON-DORMANCY
Pultenaea humilis	Low shrub	Dry sclerophyll heathy woodland	History of disturbance	Small, linear, involute, pilose leaves; pubescent stems		Disturbance enhanced	High, annual production; Viability high (80%)	Physical dormancy; 0% non dormant
Pultenaea paleacea var. sericea	Low shrub	Saggy sedgeland/ heathland		Small, linear, pilose leaves; pubescent stems				
Pultenaea prostrata	Low shrub	Grassland, grassy shrubland/ heathy forest	History of disturbance and grazing	Small, linear, involute, pilose leaves; pubescent stems	Can flower 3 seasons after germination	Disturbance enhanced	High, annual production; Viability high (98%)	Physical dormancy; 10% non dormant
Pultenaea selaginoides	Medium shrub	Heathy scrub/ dry sclerophyll woodland	History of disturbance and grazing; frequent firing	Small, narrow, slightly involute leaves	Can flower 3 seasons after germination	Disturbance enhanced	High, annual production; Viability high (93%)	Physical dormancy; 0% non dormant
Viminaria juncea	Tall shrub/ low tree (single-stemmed)	Coastal heath		leaves reduced to filiform petioles			High, annual production; Viability high (99%; Auld & O'Connell 1991)	Physical dormancy; 2.3% non dormant (Auld & O'Connell 1991)

SPECIES	DISPERSAL MECHANISM	*PHYTOPHTHORA* SUSCEPTIBILITY
Pultenaea humilis	Ants? (elaiosome present)	Susceptible
Pultenaea paleacea var. sericea	Ants? (elaiosome present)	High (Barker 1994)
Pultenaea prostrata	Ants? (elaiosome present)	High (Barker 1994)
Pultenaea selaginoides	Ants? (elaiosome present)	Resistant (Barker 1994)
Viminaria juncea		Probably high