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AcaciaSearch

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By B.R. Maslin and M.W. McDonald

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By B.R. Maslin[1] and M.W. McDonald[2]

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Foreword

There is currently no large-scale commercial use of *Acacia* within the southern Australian agricultural zone despite the fact that this genus, in terms of species numbers, is the largest plant group in the area. This study addresses the need to undertake large-scale commercial plantings with perennial plants as a treatment for salinity control in these regions.

This report identifies, evaluates and provides detailed information for *Acacia* species considered prospective as new woody crop plants in the agricultural region of southern Australia (within the 250–650 mm annual rainfall zone).

Emphasis is given to fast growing species with potential for producing large amounts of wood biomass that may find uses as solid and reconstituted wood products and for bioenergy, and which may possess commercially attractive by-products such as extractives (especially tannin and gum) and fodder.

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Access to herbarium specimen records were of fundamental importance as they helped us determine what taxa occurred in the target area, enabled the production of distribution and bioclimatic maps, and provided useful information on the morphology, biology, ecology and geography of the species. The heads of the herbaria listed below are therefore gratefully acknowledged for making their data so freely available to us. Special thanks are extended to Dr Judy West who facilitated the transfer of much of these data via the Australian Virtual Herbarium through the Biodiversity Audit project: Centre for Plant Biodiversity Research (Canberra); Queensland Herbarium (Brisbane); National Herbarium of Victoria (Melbourne); National Herbarium of New South Wales (Sydney), South Australian Herbarium (Adelaide); Western Australian Herbarium (Perth).

This report contains information taken from the Forestry Compendium (2000) with kind permission of CAB International. The Forestry Compendium is a unique compilation of information on tree species, available on CD-ROM or internet. For further information on the Forestry Compendium, visit www.cabicompendium.org/fc.

Although photographers are acknowledged in the captions of Figures 1 to 37, we again wish to thank the many people whose photographs have added so much to this report: Inez Armitage, Stan Armstrong, J.M. Baldwin, the late Doug Boland, Ian Brooker, Jerome Carslake, Laurie Jessup, Jo Kenrick, Paul Macdonell, Jock Morse, Martin O'Leary, Wayne O'Sullivan, Suzette Searle, John Simmons and John Williams.

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Contents

Executive summary

This report identifies, evaluates and provides detailed information for *Acacia* species considered prospective as new woody crop plants in the agricultural region of southern Australia (within the 250–650 mm rainfall zone). The impetus for the study is the need to undertake large-scale commercial plantings with perennial plants as a treatment for salinity control in these regions. Emphasis is given to fast growing species with potential for producing large amounts of wood biomass that may find uses as solid and reconstituted wood products and for bioenergy, and which may possess commercially attractive by-products such as extractives (especially tannin and gum) and fodder. There is currently no large-scale commercial use of *Acacia* within the southern Australian agricultural zone despite the fact that this genus, in terms of species numbers, is the largest plant group in the area.

Acacia is a diverse and enormous genus with almost 1 000 species currently recognized for Australia. Species of this genus represent a vast resource for economic, environmental and social utilisation, but to date their major usage has been abroad. Many Australian acacias produce good quantities of wood biomass and display a range of variation in growth form, growth rate, longevity and coppicing/suckering ability. They are adapted to a wide range of soil types and climates, including drought- and frost-prone areas. *Acacia* species have hard-coated and relatively large seeds (which are amenable to direct-sowing techniques), have the ability to improve soil fertility through nitrogen fixation, are usually easy to germinate and grow, and generally show good survival and rapid growth rates under cultivation. These favourable attributes provide the encouragement for considering *Acacia* species for development as new woody crop plants for southern Australia.

The target area for this study encompasses the States of Western Australia, South Australia, Victoria and New South Wales and includes the predominantly winter rainfall region (south of the Lachlan River, N.S.W.) from about 650 mm annual precipitation down to the limits of agriculture (which coincides with the 250 mm isohyet in eastern Australia and the 300 mm isohyet in Western Australia). Species were considered for this project if their natural distribution occurred wholly or partially within the target area, although a few species with known agroforestry potential that occurred just outside the region were also assessed. The areas of greatest species richness for *Acacia* within Australia are located within, or are peripheral to, this target area.


Acacia saligna (30 month old) in trial at Coorow (Photo: B.R. Maslin)

Species were evaluated against a set of plant characteristics that indicate their potential suitability as feedstocks for selected products. These selection criteria were developed in consultation with appropriate specialists, especially those associated with the Search and FloraSearch projects, and are summarised in Table 3. Emphasis was given to products that have large markets, require large amounts of biomass for their manufacture, and for which short cycle

Acacia crops could provide suitable feedstock. Therefore, the most important plant characteristic was the ability for rapid production of commercial volumes of harvestable wood biomass, particularly low density wood .

Existing knowledge was adequate to enable all species within the target area to be assessed on the basis of their expected growth rate, and their ability to produce acceptable quantities of wood biomass. These two important attributes took pre-eminence in the selection process and in the ranking of species, but they were supplemented by other plant characteristics relating to morphology, biology, ecology, silviculture and wood quality where these data were available (from both published and unpublished sources, and from our field assessment of the taxa). A knowledge of the taxonomic relationships among species was also helpful in screening the large numbers involved. Unfortunately not all information necessary for a thorough evaluation of *Acacia* as a woody crop is currently available. There are critical data relating to wood and plant characteristics, and silviculture which need to be obtained from field trials and from further detailed study of plants in their native habitats. Also, there is a need for technical testing to determine how well the species meet the feedstock requirements of various end products.

Seed pods of *Acacia saligna* (Photo: M. McDonald)

There are 462 *Acacia* species (comprising 538 taxa) that occur naturally within the target area (these taxa are listed in Appendix 1). Thirty five taxa (referred to herein as 'species') have been identified as having some crop potential for the southern Australian agricultural zone; however, because these species vary considerably they have been subjectively ranked to indicate how well each might be expected to perform as crop plants capable of delivering anticipated end products. The rankings used are 1 (most prospective) through 4 (least prospective) and are shown in Table 6 which also lists some of the more important growth characteristics that render the species prospective. It is important to remember that these rankings are provisional and should be treated with caution because they may change in the light of future studies. Furthermore, it is not expected that all 35 species will become new crop plants. Some will undoubtedly be eliminated after testing their growth rates, wood attributes, performance under cultivation, or by their inability to meet end-product requirements. In some cases their potential weed risk may constrain use to their native range.

Acacia victoriae flowers (Photo: M. McDonald)

Species ranked 1 and 2 are considered the most prospective. They can be expected to display fast or moderately fast growth rates and produce high or moderately high volumes of wood biomass. They have potential to be cultivated over a reasonably wide geographic area, although in a number of cases this area is restricted to the temperate outer peripheral regions of the target zone.

Species ranked 3 and 4 are regarded as less prospective. While these species possess acceptable growth characteristics, they display certain attributes that tend to reduce their potential for crop development (most commonly these attributes are poor growth form, reduced wood biomass production, or relatively slow growth rates). Nevertheless, they should not be discounted at this early stage of the testing process.

Species ranking and Australian States of occurrence (given in parentheses) for the 35 prospective species are as follows:

Category 1:

A. *saligna* .... (W.A.)

Category 1-2:

A. *leucoclada* subsp. *leucoclada* .... (N.S.W.)
A. *linearifolia* .... (N.S.W.)
A. *retinodes* 'typical' variant .... (S.A.)
A. *salicina* .... (N.S.W., N.T., Qld, S.A., Vic., ?W.A.)

Category 2:

A. *decurrens* .... (A.C.T., N.S.W.)
A. *lasiocalyx* .... (W.A.)
A. *mearnsii* .... (A.C.T., N.S.W., S.A., Tas., Vic.)
A. *microbotrya* .... (W.A.)
A. *pycnantha* .... (A.C.T., N.S.W., S.A., Vic.)
A. *retinodes* 'swamp' variant .... (S.A., Vic.)

Category 2-3

A. *bartleana* .... (W.A.)
A. *dealbata subsp. dealbata* .... (N.S.W., Tas., Vic.)
A. *murrayana* .... (N.S.W., N.T., Qld, S.A., W.A.)
A. *neriifolia* .... (N.S.W., Qld)
A. *rivalis* .... (S.A., ?N.S.W.)

Category 3

A. *acuminata* .... (W.A.)
A. *baileyana* .... (N.S.W.)
A. *doratoxylon* .... (A.C.T., N.S.W., Vic.)
A. *filicifolia* .... (N.S.W., Qld.)
A. *hakeoides* .... (N.S.W., Qld., S.A., Vic., W.A.)
A. *implexa* .... (N.S.W., Qld, Tas., Vic.)
A. *melanoxylon* .... (A.C.T., N.S.W., Qld, S.A., Tas., Vic.)
A. *parramattensis* .... (A.C.T., N.S.W.)
A. *retinodes* 'Normanville' variant .... (S.A.)
A. *retinodes* var. *uncifolia* .... (S.A., Tas.)
A. *rostellifera* .... (W.A.)
A. *stenophylla* .... (N.S.W., N.T., Qld., S.A., Vic., W.A.)
A. *victoriae* .... (N.S.W., N.T., Qld., S.A., Vic., W.A.)
A. *wattsiana* .... (S.A.)

Category 3-4

A. *argyrophylla* .... (S.A.,?Vic.)

Category 4

A. *cyclops* .... (W.A., S.A.)
A. *dodonaeifolia* .... (S.A.)
A. *euthycarpa* .... (S.A., Vic.)
A. affin. *redolens* .... (W.A.)

A comprehensive cluster of information is presented for each of these 35 prospective species. This includes a summary of available information, assembled from both published and unpublished sources, covering plant growth and morphological characteristics, taxonomy, phenology, biology, ecology, distribution, silviculture and utilisation. The crop potential of each species is also discussed. Maps showing species natural distributions and bioclimatic maps showing their predicted growing areas are provided. The bioclimatic maps represent a first approximation of areas where the species may possibly grow and should be treated with some caution because there are many factors (especially soils) that may preclude species from being successfully cultivated in the areas indicated by these maps. The climatic and soil conditions under which the species grow naturally are summarised in Table 5. The plate of photographs provided for each species shows variation in growth form, wood characteristics and attributes useful in identification.

Of the 35 prospective species, 10 occur in Western Australia, 19 in South Australia, 12 in Victoria and 18 in New South Wales (these numbers do not include naturalized occurrences). The significant number of prospective species in each state provides the opportunity to focus early commercial development on species within their natural geographic range (or within the IBRA region in which each occurs), thereby avoiding the need to translocate species to more distant botanical regions and thus invoking the complex issue of environmental weed risk.

Twenty of the 35 prospective species occur in the botanical section *Phyllodineae* and a majority of these species are not too far removed taxonomically from the seven species of section *Botrycephalae*. It is these two sections that contain a majority of the most highly ranked species. The other two sections, *Plurinerves* and *Juliflorae*, contain only eight species and, except for *A. lasiocalyx*, are not highly ranked. Species from these last two sections are commonly slow growing and produce dense wood; in fact, many of the arborescent species occurring in or near the target area that were not considered prospective for this project are contained in these two sections (see Table 4).

Salt lakes near Wongan Hills (Photo: B.R. Maslin)

While all the 35 prospective species produce at least reasonable quantities of wood biomass the largest volumes of wood are generally found in the arborescent species which grow in (or just outside) the temperate peripheral parts of the target area in eastern Australia (e.g. *A. dealbata*, *A. decurrens*, *A. implexa*, *A. leucoclada*, *A. linearifolia*, *A. mearnsii*, *A. melanoxylon*, *A. neriifolia*, *A. retinodes* 'swamp' and 'Normanville' variants). In the drier inland regions of N.S.W., S.A. and W.A. many species are smaller in stature and often develop a form resembling the 'mallee' growth habit with wood contained in many rather slender stems (e.g. *A. argyrophylla*, *A. euthycarpa*, *A. hakeoides*, *A. murrayana*, *A. rivalis*, *A. wattsiana*). However, *A. salicina* and *A. stenophylla* are notable exceptions in that they develop into substantial trees, despite growing (along water courses) in the driest inland parts of the eastern target area. Some arborescent species do, however, occur in the drier semi-arid parts of the target zone (e.g. *A. bartleana*, *A. lasiocalyx*, *A. microbotrya*, *A. pycnantha*, *A. retinodes* 'typical' variant, *A. saligna*).

Although woody crops could take many forms there are three commercial crop types likely to be suitable for salinity control in southern Australian agricultural systems. These three types can be briefly defined as follows (more detail is provided in Table 2):

1. Long cycle crops: trees of erect form selected and managed over a growth period of 10 to 100 years.
2. Coppice crops: long-lived species that readily re-sprout or coppice from the cut stump after harvest. These crops could be harvested every 2 to 5 years. Usually grown in narrow belts within annual agricultural crops.
3. Phase crops: short-lived woody species used as a de-watering phase within the crop rotation, harvested at 3 to 6 years after which the land reverts to annual crops or pasture. Usually planted in large blocks.

Long cycle crops are most likely to be grown for solid wood products such as fence posts, firewood and sawn timber, while coppice and phase crops would produce material suitable for reconstituted wood products, chemical extracts and bioenergy.

Current indications are that a majority of the prospective Acacias from the southern Australian agricultural zone have potential as phase crops. Indeed, 31 of the 35 prospective species are assessed here as having some potential for development as phase crop plants; 13 species may possibly have prospects as long cycle crops while only 8 species appear to have any prospects as coppice crops (see

Agricultural landscape near Truro, S.A. (Photo: B.R. Maslin)

Table 6). Plant establishment by direct seeding is essential for the commercial viability of phase crops, and also confers a cost advantage in the establishment of coppice crops and long cycle crops. Therefore, one of the attractive attributes of Acacias as potential crop plants (apart from their rapid growth rate, nitrogen fixation capability, etc.) is their large seeds that are amenable to direct-seeding technology (possibly using conventional large-scale cereal seeding equipment). The ability to reliably and vigorously re-sprout after harvest is an essential character for coppice crops. Although very little is known about this characteristic in *Acacia* it is seemingly uncommon among the 35 prospective species. *Acacia saligna* would appear to have the best potential as a coppice crop although *A. implexa*, *A. linearifolia*, *A. microbotrya*, *A. murrayana*, *A. retinodes* 'Normanville' variant, *A. salicina* and *A. stenophylla* may possibly have some prospects.

Erosion on the Murray River near Berri, S.A. (Photo: B.R. Maslin)

Some potential difficulties for the management of *Acacia* as a tree crop include the early prolific seed production and/or the capacity to root sucker that occurs in a number of the species. Precocious seed production in cultivated stands may create a soil seed bank that may cause weed problems in adjacent or subsequent annual crops. However, in an agricultural context such regeneration might be regarded as fodder or green manure, or be easily controlled by modifying existing weed control methods.

Vigorous or moderately vigorous root suckering appears to be common in a number of the highly ranked species, namely, *A. bartleana*, *A. leucoclada*, *A. microbotrya*, *A. retinodes* 'typical' variant and *A. salicina*. However, very little is known about this character, including how it varies within species or what factors (apart from root disturbance) are responsible for promoting it. The ability to root sucker may or may not be advantageous in cultivation, it depends upon whether or not this attribute is desirable in the farming system in which the species is placed. Suckering may be advantageous in situations where soil stabilization is required, or where regeneration by this method has a commercial advantage, but it also has the potential to complicate the management of *Acacia* as a tree crop. If ways were devised to manage suckering to advantage in crop systems it would substantially increase the value of about one third of the species detailed here.

Many *Acacia* species have the potential to display various aspects of weediness. A primary strategy adopted in this study to minimize the environmental weed risk was to assess only those species that occurred naturally within, or very close to, the target zone. It was considered inappropriate at this early stage of the selection process to preclude or unduly negatively weight species on the basis of weed potential. To do so would preempt the development of effective control measures through management, breeding and other strategies, should these be deemed necessary. As crop development progresses the knowledge of the biology and ecology of the species will expand, thus allowing a more rigorous prediction of weed risk that might occur should species be considered for translocation outside their natural area of occurrence. This strategy provides a safe development pathway for *Acacia* crops. Based on existing knowledge the following eight species perhaps have the greatest weed potential: *A. baileyana*, *A. cyclops*, *A. dealbata*, *A. decurrens*, *A. mearnsii*, *A. melanoxylon*, *A. pycnantha* and *A. saligna*. However, half of these species express weediness in relatively high rainfall areas, so it is not known to what extent (if at all) they will develop similar tendencies in the drier, semi-arid environments of the target area. It is important therefore to assess weed risk within the environment where species are intended to be cultivated. The three species that might pose greatest weed risk in the target area are *A. cyclops*, *A. pycnantha* and *A. saligna*. Notwithstanding the above it is noted that a number of prospective species grow naturally in disturbed agricultural landscapes with no recorded weed problems, e.g. *A. argyrophylla, A. acuminata, A. doratoxylon, A. microbotrya*, and more. Weed issues are discussed in the introduction to this report (where some weed reduction strategies are suggested) and also under each of the 35 species profiles. A subjective assessment of the weed potential of the 35 species is summarised in Table 6.

Identification of the 35 prospective species that are detailed in this report provides the crucial first step in the development of Acacias as potential new crops for the southern Australian agricultural zone. However, to further progress the domestication of these species much essential data is still needed. The most critical areas of need (excluding obvious ones like wood sampling and conducting field trials) include the following.

1. A major objective in any development of new large scale *Acacia* crops will be to make some progress in water use and salinity control. Unfortunately, however, there is very little data available specific to *Acacia* in these matters. A need therefore exists to develop knowledge of root architecture and function within at least those species considered to have the greatest potential as crop plants.

2. Given the prevalence of root suckering in *Acacia* there is a need to know much more about this character, the nature of its variation and the factors that promote its expression. In *A. saligna* for example, which is the most highly ranked species in this report, root suckering is common but it is not known if naturally occurring non-suckering (or low-propensity suckering) provenances exist, or what factors promote suckering in plants of this species under cultivation.

3. The ability to reliably and vigorously re-sprout after harvest is an essential character for coppice crops. However, the coppicing ability of most Acacias is largely unknown. For those species where coppicing has been recorded very little is known about its frequency and vigor, its variation within the species, or the factors that control this response (for example, the effect of cutting height above ground level, and the time of the year). Research aimed at understanding coppicing in *Acacia* would be an essential part of any crop development program.

4. Because most of the 35 prospective species discussed here possess the capacity to produce large quantities of hard-coated seed this could lead to the creation of a soil seed bank that may cause

Acacia microbotrya seedlings (3 month old) (Photo: G. Olsen) weed problems in adjacent or subsequent annual crops. Harvesting plants before they reach biological maturity is one way of avoiding this problem. However, there is very little reliable quantitative information available on seed production or longevity, or at what age plants first flower and fruit. These crucial data will need to be acquired for any species considered for widescale crop development.

5. Judging from observations of plants growing in their natural habitats it is clear that most, if not all, of the 35 prospective species have variable growth form. Since these attributes have management implications for plants under cultivation, the selection of appropriate provenances for future assessments will therefore be critically important. A better understanding of provenance variation for plant form in naturally occurring populations is needed.
6. During the course of this study it became evident that some arborescent Acacias that occurred naturally outside the target area might possibly perform well under cultivation within the region, and produce good quantities of wood biomass. To broaden the planting base of *Acacia* within the southern Australian agricultural regions, particularly the more temperate peripheral areas, it would be useful to comprehensively assess species from the wetter coastal regions of eastern Australia. Similarly, closer inspection of some arid zone species may yield additional prospects. A closer inspection of species in the Murray-Darling system north of the Lachlan River (which represents the northern limit of the target area in N.S.W.) is also recommended.
7. To be effectively utilised it is essential that species be meaningfully circumscribed, properly named and their variation understood. This is clearly demonstrated by the taxonomic work that is currently in progress within *A. acuminata*, *A. microbotrya*, *A. retinodes* and *A. saligna*. While the taxonomy of most of the 35 prospective species is acceptable, further work on the highly ranked species *A. linearifolia*, *A. murrayana*, *A. neriifolia* and *A. pycnantha* is likely to yield productive results.
8. Some Acacias have the potential to become environmental and/or agricultural weeds. It is therefore essential that appropriate research be undertaken to facilitate thorough weed risk assessments for species considered for wide-scale cultivation.

Introduction

The aim of this report is to identify, evaluate and present detailed information for those *Acacia* species that may have potential as woody crop plants for large-scale commercial planting in the 250–650 mm rainfall zone of southern Australia, primarily for use in recharge areas as a means of salinity control. Emphasis is given to fast growing species with potential for producing large amounts of wood biomass that may find uses in solid and reconstituted wood products and for bioenergy, and which may possess commercially attractive by-products such as extractives (especially tannin and gum) and fodder.

Acacias exhibit great diversity in growth form (with many species producing good quantities of wood biomass), in longevity, in coppicing/suckering and other important morphological, biological and ecological attributes. They are adapted to a wide range of soil types and climates, including drought- and frost-prone areas. Acacias have hard-coated and relatively large seeds (which are amenable to direct-sowing techniques), have the ability to improve soil fertility through nitrogen fixation, are usually easy to germinate and grow, and generally show good survival and rapid growth rates under cultivation. Some species have already proved suited to commercial development (especially for timber, pulpwood and tannin) while others have been shown to be useful for a wide range of purposes such as environmental amelioration, fuelwood, stock fodder and human food. It is the above-noted attributes of *Acacia*, and the imperative for identifying perennial crops as a remedy for salinity, that provide the setting for considering species of this enormous genus as candidates for development as new woody crop plants for agriculture in southern Australia. These issues were discussed at a Symposium recently held in the small Western Australian wheatbelt township of Dalwallinu, the proceedings of which are published in *Conservation Science Western Australia* vol. 4, no. 3 (2002). Of particular relevance to the present study are the overview papers by Bartle *et al.* (discussing the broad settings for large-scale crop development in the Western Australian wheatbelt), Seigler (the economic potential of secondary plant products from *Acacia*), Byrne (genetic techniques as aids to effective utilisation) and Maslin (the role and relevance of taxonomy in the effective utilisation of *Acacia*); other papers having a more specific focus are also relevant, namely, Howard *et al.* and Dynes & Schlink (the fodder potential of Acacias), Woodall & Robinson and Brand (Sandalwood silviculture).

There is currently no large-scale commercial use of *Acacia* in the agricultural zone of southern Australia. However, in terms of species numbers this is the largest genus in the area. From within the great diversity found among these species it is likely that some would have the potential for development as new commercial crops. Identification of these species is the crucial first step in the domestication process. Although 35 potential woody crop prospects have been identified in this report it is not expected that all will become new crop plants. Some will undoubtedly be eliminated after testing their growth rates, wood attributes, performance under cultivation, or by their inability to meet end-product requirements. In some cases their potential weed risk may constrain use to their native range. It is important to bear in mind that the plants being considered here are wild organisms, ones which by their very nature are variable. In fact, it is this variation that has contributed to their success in nature and provides the diversity from which the domestication process can choose desirable attributes. Bringing native species into cultivation is a process of continuous selection and improvement over many generations. The objective of this project is to commence this process by systematically selecting *Acacia* species that may have potential to be commercially viable and to improve the environmental sustainability of southern Australian agricultural systems.

Classification of *Acacia*

Acacia is the largest genus of woody plants in Australia with almost 1 000 species currently recognized (Maslin 2001c). Worldwide there are more than 1350 *Acacia* species. The classification of this large, cosmopolitan genus is currently under review. As presently defined *Acacia* is most commonly regarded as comprising three large subgenera, subgenus *Acacia* (161 species), subgenus *Aculeiferum* (235 species) and subgenus *Phyllodineae* (960 species), but there is evidence to suggest that the number of taxa at this level should be increased to at least five (Maslin, Miller & Seigler 2003). Furthermore, there is a proposal to treat these infrageneric groups as separate genera. Subgenus *Acacia* and subgenus *Aculeiferum* have pan-tropical distributions and are poorly represented in Australia; subgenus *Phyllodineae* on the other hand is largely confined to Australia and all the species detailed in this report are contained in this group (for distribution maps of the subgenera see Maslin, Miller & Seigler 2003). In the event of *Acacia* being split, and if the *International Code of Botanical Nomenclature* is strictly applied, then the generic name *Racosperma* may need to be applied to most Australian species; however, attempts are being made to retain the name *Acacia* for them (Orchard & Maslin, 2003). See Pedley (1986), Chappill & Maslin (1995) and Maslin, Miller & Seigler (2003) for discussion of the generic classification of *Acacia* and reference to other relevant literature.

At the infrageneric level it is regrettable that there is no meaningful classification of subgenus *Phyllodineae* and to some extent this shortcoming has constrained the effective utilisation and conservation of this 'Australian group'. Nevertheless, the classification provided by Pedley (1978), in which seven sections are recognized, is a useful framework for discussing higher-level groupings within the subgenus and is the scheme which is adopted here. The seven sections recognized by Pedley are *Botrycephalae* (44 species), *Phyllodineae* (408 species), *Plurinerves* (212 species), *Juliflorae* (235 species), *Alatae* (21 species), *Lycopodiifoliae* (17 species) and *Pulchellae* (27 species). Discussion and distribution maps of these sections are provided in Hnatiuk & Maslin (1988), Maslin & Pedley (1988), Maslin & Stirton (1998) and Maslin (2001c), and a simplified key to their recognition is given below.

1 Leaves (mature plants) reduced to phyllodes or scales, or absent
- 2 Flowers arranged in cylindrical spikes .... Section Juliflorae
- 2: Flowers arranged in globular or oblongoid heads
  - 3 Branchlets winged by decurrent phyllodes .... Section Alatae
  - 3: Branchlets not winged
    - 4 Phyllodes arranged in whorls .... Section Lycopodiifoliae
    - 4: Phyllodes not in whorls
      - 5 Phyllodes 1-nerved per face (4-7 nerved when terete or quadrangular) .... Section Phyllodineae
      - 5: Phyllodes more than 1-nerved per face (8 or more nerved when terete or quadrangular) .... Section Plurinerves

1: Leaves all bipinnate
- 6 Heads arranged in elongated racemes .... Section Botrycephalae
- 6: Heads on axillary peduncles (solitary to clustered) or in very short racemes
  - 7 Plants with prominent stipular spines (at least when young) or with prickles
    - 8 Trees or shrubs with stipular spines .... Subgenus Acacia
    - 8: Lianes with prickles on stems .... Subgenus Aculeiferum
  - 7: Plants without prominent stipular spines, prickles absent .... Section Pulchellae

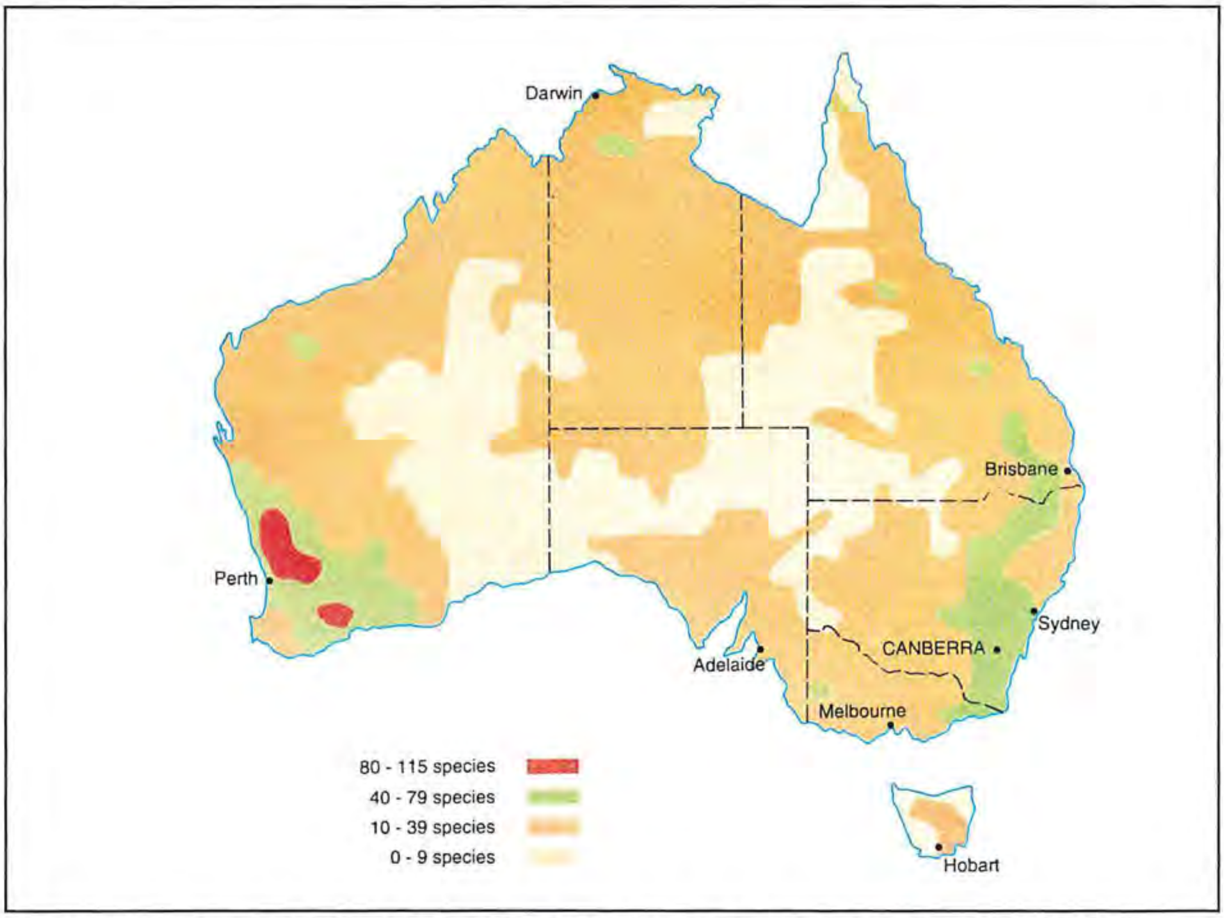
Simplified key to the major infrageneric groups (subgenera and sections) of Acacia. This key was originally published in Maslin (1995).

The 35 taxa assessed in the present report as being prospective from an agroforestry perspective are contained in the sections *Botrycephalae*, *Phyllodineae*, *Plurinerves* and *Juliflorae*. Notes on these four sections are provided under **Taxonomy** in the respective species profiles below. Although the relationships between the sections are not fully resolved it is apparent that the *Botrycephalae* and *Phyllodineae* (in part) are closely related and differ significantly from the (perhaps) related sections

Plurinerves and *Juliflorae*. Having knowledge of these affinities has practical implications: species within the *Botrycephalae/Phyllodineae* are more likely to share similar morphological, biological and ecological characters (e.g. wood morphology, growth rates, longevity, suckering propensity) than they are with species within the *Plurinerves* and *Juliflorae*, and vice versa. Similarly, understanding species relationships greatly facilitates the search for desirable characteristics because when found in one species the search is immediately focused on its close relatives to see if they, too, share its attributes.

Distribution of Australian Acacias

Acacia is ubiquitous in Australia. Species of this genus are represented in almost all major terrestrial habitats where they form a conspicuous and dominant element of many ecosystems, particularly in arid and semi-arid areas. The areas of greatest species-richness occur in the flat, edaphically complex, semi-arid wheatbelt region of south-west Western Australia and south of the Tropic of Capricorn in areas associated with the rocky tablelands of the Great Dividing Range in eastern Australia (see Map 1). These areas are located within, or peripheral to, the target area of the present study (see below). Details of the patterns of species richness of *Acacia* within Australian are provided in Hnatiuk & Maslin (1988) and Maslin & Pedley (1988) and distribution maps of individual species are given in Maslin & Pedley (1982) and the Flora of Australia volumes 11A and 11B (Orchard & Wilson 2001 & 2001a).



Map 1. Patterns of species-richness of the Australian Acacia flora. This map was originally published in Maslin (1997).

A brief overview of the utilisation of *Acacia*

With such great biological diversity the Australian *Acacia* flora represents a vast resource for economic, environmental and social utilisation. Historically, Australian acacias have been used in a variety of industries for their gums, perfumes, tannins, as ornamentals and in medical applications, but in recent years there has been increased recognition of their potential as commercial timber (e.g. construction and high-value timber, pulp and fuelwood), as a source of seed for human consumption, and for fodder. Today, Australian *Acacia* species are grown in about 70 countries where they cover about 2 million hectares. As summarised by Midgley & Turnbull (2003) the most widely cultivated species are *A. mearnsii* (for tannin, fuelwood and charcoal: about 300 000 ha in South Africa, Brazil, China and Vietnam), *A. saligna* (for fuelwood, fodder and land amelioration: over 500 000 ha in North Africa, the Middle East, western Asia and Chile), *A. mangium* (for paper pulp and timber: over 800 000 ha in Indonesia and Malaysia), *A. crassicarpa* (for paper pulp and timber: about 50 000 ha in Indonesia and Vietnam) and *A. colei* (as a human food in India and sub-saharan Africa). Domestication of some of the major commercial species of *Acacia* has been assisted by genetic evaluation studies, e.g. Moran *et al.* (1992), Butcher *et al.* (1999), Moran *et al.* (2000) and Byrne *et al.* (2002).

Australian Acacias have been more commonly utilized abroad than within Australia where they largely represent an under-exploited resource. Although some commercial timber is derived from *A. melanoxylon* (Searle 1996) and *A. celsa* (McDonald & Maslin 2000), most species grown in Australia are used in amenity and land amelioration plantings (McDonald *et al.* 2001). For specific examples see Hall *et al.* (1972), Simmons (1988), Boland (1989), Lefroy *et al.* (1991), Simpfendorfer (1992), Whibley & Symon (1992), Wrigley & Fagg (1996), Lithgow (1997) and Doran & Turnbull (1997). In recent years there has also been some interest in developing a major bushfood industry based on wattle seed (see Maslin *et al.* 1998, Simpson & Chudleigh 2001, Olsen 2002, Hele 2002). Furthermore, as evidenced by the present report and discussed by Bartle *et al.* (2002) there is a growing interest in exploring the potential of *Acacia* in Australia for large-scale commercial crops in the southern agricultural regions for salinity control.

A summary of the main uses of *Acacia* is presented in Table 1. More detailed information on the utilisation of a wide range of Australian Acacias is provided in Maiden (1889), Boland *et al.* (1984), Turnbull (1986), House & Harwood (1992), Thomson *et al.* (1994), Searle (1995, 1996), Doran & Turnbull (1997), Turnbull *et al.* (1998), McDonald *et al.* (2001) and Midgley & Turnbull (2003). References to other relevant literature are given in the species profiles below.

Table 1 (facing page). Uses of Australian Acacias. This list includes utilisation both within Australia and abroad; only selected representative species are given for each use. This list was originally published in Maslin (1997).

Uses of Australian Acacias

WOOD PRODUCTS

- **Sawn timber**. *Acacia auriculiformis, A. crassicarpa, A. mangium* (these tropical acacias are very important plantation species in Asia).
- **Furniture (solid wood and veneers)**. *Acacia celsa, A. melanoxylon* (the best known, high quality Australian timber species), *A. salicina*.
- **Pulp**. *Acacia peregrinalis, A. crassicarpa, A. mearnsii* and *A. mangium* (plantation grown for pulp production).
- **Reconstituted wood products**. *Acacia mangium, A. mearnsii* (the potential of *Acacia* for this purpose has not yet been fully assessed).
- **Fuelwood & charcoal**. *Acacia colei, A. stenophylla* (many acacias are excellent for these purposes).
- **Posts and small poles**. *Acacia acuminata, A. aneura, A. dealbata* (many species have hard, durable wood).
- **Tool handles**. *Acacia falciformis, A. silvestris.*
- **Musical instruments**. *Acacia papyrocarpa* (see *Landscope*, Spring 1995 issue).
- **Craftwood/Turnery**. *Acacia acuminata, A aneura, A. implexa, A. papyrocarpa* (many acacias are excellent for these purposes).

BARK PRODUCTS

- **Tannin**. *Acacia mearnsii, A. pycnantha* (used mainly in the production of leather products; Australia imports most of its tannin requirement, about $6.5 million per annum).
- **Adhesives**. *Acacia falciformis, A mearnsii, A. parramattensis* (Wattle tannin adhesives can produce the highest quality bonding, used in reconstituted wood products).
- **Anticorrosive agent**. *Acacia mearnsii* (recent U.K. technology shows some promise for future development).

GUMS

- Gum arabic (from *A. senegal)* is an important food additive and industrial emulsifier; Australia imports approximately A$1.5 million of gum arabic annually. The gums of certain Australian acacias have excellent properties but are not produced naturally in commercially viable quantities.

ENVIRONMENTAL UTILISATION

- Numerous species of *Acacia* have been used for a range of environmental protection purposes. Species such as *A. auriculiformis, A. dealbata, A. decurrens, A. mearnsii* and *A. saligna* have been used for soil erosion control and windbreaks in a number of countries overseas. Species such as *A. ampliceps* and *A. stenophylla* have been used for the remediation of alkaline and saline soils. In Australia in recent years, a wide range of species, including *A. mearnsii, A. microbotrya* and *A. saligna*, have been incorporated into large-scale revegetation projects.

SEEDS FOR HUMAN FOOD

- Overseas the seeds of *A. colei* and *A. elachantha* are used as a source of human food in parts of sub-saharan Africa, particularly during times of famine. In Australia, *A. victoriae* is the main species currently marketed as 'wattleseed' by the native bushfood industry.

FODDER

- Acacias generally have low fodder value but some species, especially *A. aneura*, are nevertheless important drought feed in arid rangeland areas. In some semiarid regions *A. victoriae* and *A. saligna* are widely planted mainly as a forage plant, despite their low to moderate digestibility.

ABORIGINAL UTILISATION

- Apart from seed for food, the Australian Aborigines utilised most of the other parts of the acacia. They used the leaves, twigs and bark mostly for medicinal purposes, whilst the wood was used for fuel and ash for pituri, as well as for making a variety of tools (e.g. spears and clubs) and artefacts. Furthermore, there were a variety of insect infestations that were also a food source, for example witchetty grubs in the roots of *A. kempeana*.

HORTICULTURE/FLORICULTURE

- Having great variation in growth form, foliage, bark, flowers and pods *Acacia* offers much scope for horticultural and floricultural utilisation, and for amenity planting. *Acacia baileyana, A. dealbata, A. podalyriifolia* are popular in Europe as cut flowers. *Acacia redolens* is used in median strip plantings in California; *A. auriculiformis* is widely used as a street tree in Asia.

MISCELLANEOUS

- **Pollen**. *Acacia baileyana, A. dealbata, A. silvestris* (bee food for honey production).
- **Essential oils**. *Acacia dealbata, A. farnesiana* (French perfumeries; wattle oil sold in Australia for fragrance are generally synthetic because pure wattle oil is very expensive).
- **Medicinal**. See under *Aboriginal Utilisation* above. Also, recent research suggest that triterpenoid saponins from *A. victoriae* have potential as novel anticancer agents.

Acacia as a crop for agriculture in southern Australia

The clearing of native perennial vegetation and its replacement with annual agricultural crops and pastures has caused very serious problems of land degradation across the agricultural regions of southern Australia, most notably salinity (Stirzaker *et al.* 2002). Revegetation with woody perennial plants is a well recognized treatment for salinity control but the scale of planting required is enormous and will only be achieved if plantings are commercially attractive and integrated with existing agricultural systems (Bartle 1999, Bartle *et al.* 2002).

Although woody crops could take many forms there are three commercial crop types likely to be suitable for salinity control in southern Australian agricultural systems (see Table 2 for more detail). They can be briefly defined as follows:

- Long cycle crops: trees of erect form selected and managed over a growth period of 10 to 100 years for solid wood products such as fence posts, firewood and sawn timber.
- Coppice crops: long-lived species that readily re-sprout or coppice from the cut stump after harvest. These crops could be harvested every 2 to 5 years. Usually grown in narrow belts within annual agricultural crops.
- Phase crops: short-lived woody species used as a de-watering phase within the crop rotation, harvested at 3 to 6 years after which the land reverts to annual crops or pasture. Usually planted in large blocks.

Of these three crop types, coppice crops and phase crops are most likely to offer commercial returns that are competitive with other farming enterprises. Long cycle trees struggle to break even in dry environments due to the slow growth rates and long wait for returns, so they are likely to remain a very minor component of wheatbelt woody crops.

Within the enormous diversity found in *Acacia* there are many species that could be developed for any of these crop types. This potential has been overviewed by Bartle & Maslin (2002 and 2002a) and the information that follows here is largely taken from these papers. (Note: In the Bartle & Maslin papers the terms 'short rotation phase' and 'short rotation coppice' were used for what are called 'phase' and 'coppice' above. These shorter terms avoid confusion arising from use of 'rotation' in the context of both the agricultural system and the woody crop harvest cycle.)

Attractive attributes of *Acacia* species include large seeds that enable ready establishment by direct-seeding, possibly using conventional large-scale cereal seeding equipment. Direct seeding is essential for the commercial viability of phase crops, and also confers a cost advantage in the establishment of coppice crops and long cycle crops. The large seeds borne in pods that are common in Acacias are likely to be relatively cheap to harvest, enabling low cost seed to be available for propagation.

Some potential difficulties include early prolific seed production that may create a soil seed bank that may cause weed problems in adjacent or subsequent annual crops. The capacity of some *Acacia* species to sucker (produce shoots from along the root system at some distance from the base of the plant), may also present a difficulty for their management as a tree crop. However, in an agricultural context such regeneration might be regarded as fodder or green manure, or be easily controlled by modifying existing weed control methods.

To be successful coppice crops, Acacias will need to possess strong coppice ability, be long-lived under regular short rotation harvest, develop a deep root system, and have low palatability, to avoid the need for belts to be fenced to exclude animals.

Different characteristics are desirable in phase crops, which need to establish rapidly and grow vigorously (in other words, express the 'pioneer' capability that is evident in so many *Acacia* species).

Their management will be simplified if they do not produce seed prior to harvest, and neither coppice nor sucker (or these characteristics are only weakly developed).

Table 2. Categories of woody perennial crop types suited to salinity management in the southern Australian cropping zone.

Crop type	Characteristics
Long cycle	• Requires long-lived trees with good form. • Crop production cycle usually exceeds 10 years (may reach 100 years). • Suited to planting in belts or small blocks; requires careful site selection. • Suited to solid wood products such as fence posts, firewood and sawn timber.
Coppice	• Requires long-lived trees or shrubs with strong coppicing ability. • Harvested every 2 to 6 years with successive crops regenerating by coppice growth. • Suited to planting in belts where the woody plants can intercept down slope water movement. • Belts of woody plants can be integrated into large-scale annual cropping enterprises to form alley farming systems. • Deep root systems needed for crop yield (through increased water use), salinity control, and to minimise competition with adjoining annual crops. • Low palatability to sheep is desirable, to minimise fencing requirement. • Suits the production of bulk biomass for the extraction of chemical products, and biomass conversion to reconstituted wood products, manufactured fodder, and bioenergy.
Phase	• Suits woody plants that establish easily by direct seeding, and produce rapid early growth. Longevity is not required. • Annual crops or pasture are replaced by a 3 to 6 year woody plant phase, to take up surplus water from the soil. After the woody crop is harvested, the land reverts to annual agriculture. • This system is most useful where soil characteristics limit the rate of lateral movement of subsurface water. • The ideal woody plant for phase cropping lacks coppicing or suckering ability (or these attributes are only weakly expressed), does not produce seed prior to harvest, has high fodder value, and has little crop residue to remove at the end of the phase (or crop residues are easy to remove). Most real-world plants will be less than ideal, and will require extra management or cost. • Phase crops can provide benefits to subsequent annual crops (N fixation, weed management, soil structure improvement etc). • Suits *in situ* grazing, the production of bulk biomass for the extraction of chemical products, and biomass conversion to reconstituted wood products, manufactured fodder, and bioenergy.

The value of *Acacia* phase crops grown in rotation with conventional annual crops will be enhanced if they provide an effective 'break' or 'resting phase' to arrest the build up of annual crop pests, pathogens and weeds. Other potential benefits of periodic, extensive coverage of crop land with an *Acacia* phase would be improved soil structure and enhanced nitrogen nutrition. This ability to improve soil fertility through nitrogen fixation gives *Acacia* an advantage over many other potential candidates for development into new woody crops.

A major objective in any development of new large scale *Acacia* crops will be to make some progress in water use and salinity control. Unfortunately, however, there is very little data available specific to *Acacia*, in this regard. Knight *et al.* (2002) observed impressive dewatering under a mixed *Eucalyptus* and *Acacia* stand: 399 mm of stored soil water was removed over 4 years from a depth of 5 m, from a silty clay loam at Bridgewater (Victoria). These authors also provide an indication of the rapidity of root penetration, a characteristic that may be important for phase crops. In a sandy soil, they observed roots to a depth of 16 m under a 4-year-old belt of *Acacia saligna* and *Atriplex nummularia*.

The optimal duration of an *Acacia* phase will be a compromise between several factors - number of years before a weed or pest break is needed, time needed to produce a reasonable *Acacia* crop yield, required depth of dewatering of the soil profile, availability of soil moisture to sustain rapid Acacia growth, and the proportion of the rotation period needed under conventional (and probably more profitable) annual crops to maximise profitability. Given the interplay of these factors it is possible that the *Acacia* phase will be limited to 3 to 6 years in a rotation period of 10 to 12 years or more.

Table 6 summarizes our assessment of the crop type potential for each of the 35 Acacias detailed in this report; further notes are provided in the species profiles below.

Methods

The method adopted here for evaluating the woody crop potential of *Acacia* involved the following steps, each of which is detailed below:

- define target area (i.e. the region from which species will be selected and in which they are intended for growing);
- establish selection criteria (i.e. relevant plant characteristics against which species will be evaluated);
- identify species occurring within the target area and determine and rank those that best meet the selection criteria (these are referred to herein as the 'prospective species');
- collate relevant data for the prospective species to facilitate their further assessment as crop plants (these data are presented in the species profiles below).

Target area

The target area encompasses much of the cropping zones of southern Australia. It comprises two disjunct regions, an eastern region in South Australia, Victoria and New South Wales (Map 2) and a western region in Western Australia (Map 3).

The *northern boundary* of the eastern region in N.S.W. is defined approximately by the Lachlan River which is near latitude 33° S. South of this boundary is mostly the winter rainfall zone (although a small proportion of the uniform rainfall zone occurs in the far northeast of the target area, around Parkes). This boundary also coincides with the northern limit of growth of 'cool season' woody species (Peter Milthorpe pers. comm.). That is, woody plants which have a 'cool season' growth phase and which respond best to winter rainfall (in contrast to 'warm season' woody species which respond best to summer rainfall and which become dormant once the mean daily temperature drops below 13°C).

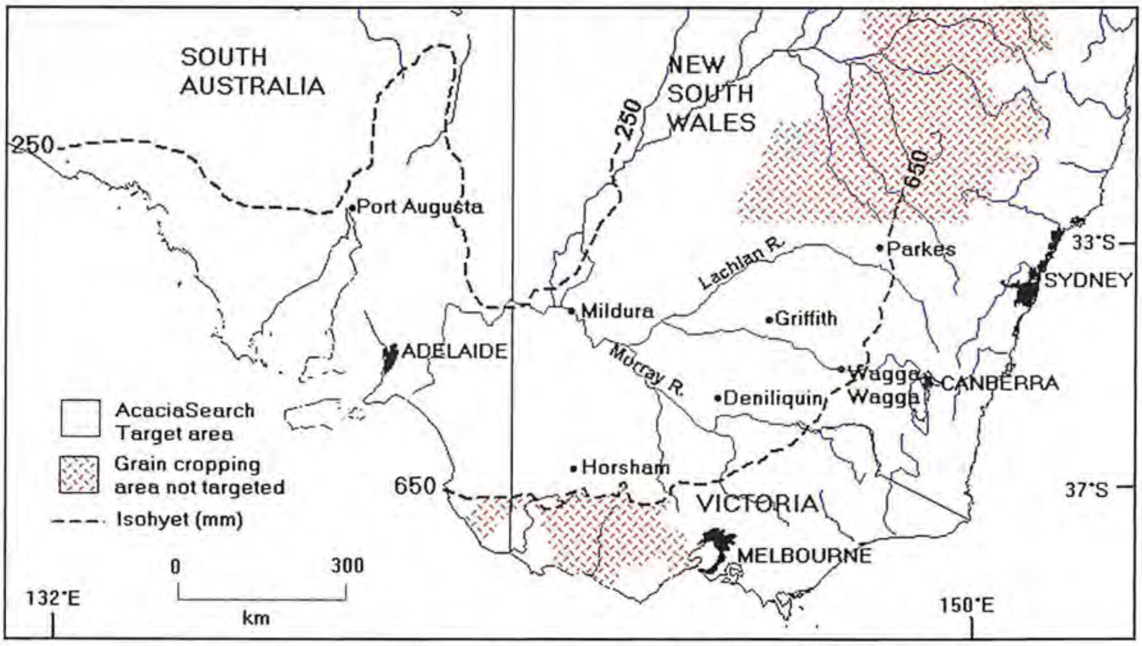
The *inland boundary* (in all States) is represented by the limit of grain cropping which corresponds fairly well with the 250 mm isohyet in eastern Australia and the 300 mm isohyet in Western Australia.

The *eastern and southern boundaries* (N.S.W., Victoria, S.A.) and *western boundary* (W.A.) are defined approximately by the 650 mm isohyet. In N.S.W. and Victoria this boundary roughly corresponds to the 500 m contour.

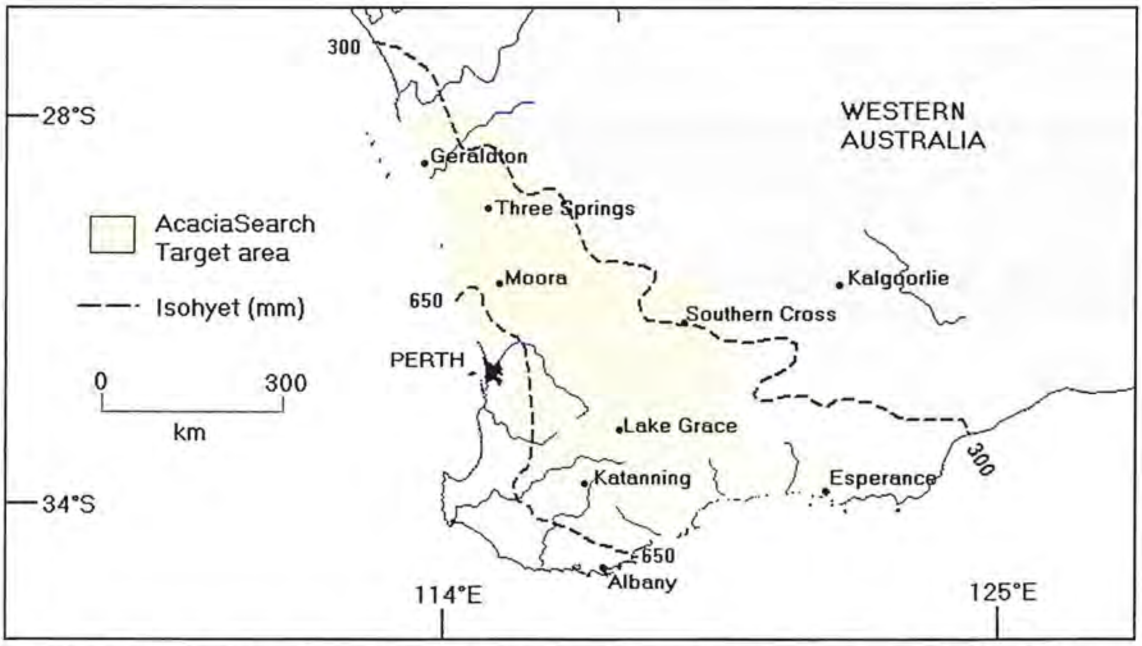
Species were considered for this project if their natural distribution occurred wholly or partially within the target area. In a few cases, however, species with known agroforestry potential but whose distributions were entirely outside the target area (but extended close to its borders) were also considered. These species are marked with an asterisk (*) in Tables 5 and 6.

Species were assessed on the premise that they would be planted in recharge areas on non-irrigated and non-saline land, where potential growth rates are moderate to high, and are not limited by salinity. Therefore, the salt tolerance of species was not a major consideration in this study. Furthermore, it was assumed that *Acacia* crops would be grown on land suited to broad-acre mechanical harvesting, which limited the target area more or less to the land currently used for broad-acre grain cropping in southern temperate Australia.

Within the target area there are marked variations in regional climate and biogeographical features. Many of the biophysical characteristics of the target area are described in the *Interim Biogeographic Regionalisation for Australia* (IBRA) (Environment Australia 2000). The target areas show a steady decline in rainfall along an inland gradient. There is also a marked inland gradient of decreasing altitude in the eastern target area. Along these gradients growing conditions vary considerably, therefore the performance and biomass yield for many species can be expected to be enhanced by strategic site selection.



Map 2. Eastern Australian target area. The 650 mm isohyet which approximates the eastern and southern boundaries in New South Wales and Victoria corresponds roughly to the 500 m contour.



Map 3. Western Australian target area. The inland boundary corresponds approximately to the 300 mm isohyte whereas in eastern Australia it approximates the 250 mm isohyte.

Selection criteria

A list of plant characteristics against which species were assessed was developed in consultation with appropriate specialists, especially those associated with the following two projects, Search (National Heritage Trust project no 973849) and FloraSearch (RIRDC project no. SAR-38A). These characteristics are discussed in the species profiles below and are summarised in Table 3.

Not all information necessary for a thorough evaluation of *Acacia* as a woody crop is currently available. As indicated in Table 3 there are critical data relating to wood (both physical and chemical attributes) and plant characteristics (such as bark type, coppicing/suckering ability, root and stem architecture, habitat requirement for productive growth, etc.) and silviculture which will only be obtained from further technical testing, field trials and detailed study of plants in their native habitats. Nevertheless, available knowledge has enabled all species within the target area to be assessed at least for their ability to produce acceptable quantities of wood biomass. Although a reasonable estimate was made of expected growth rate for each species, this will require further investigation in specific areas where the species are intended to be cultivated. These two important attributes took preeminence in our selection process, but they were supplemented by other plant characteristics relating to morphology, biology, ecology, silviculture and wood where these data were available (from both published and unpublished sources, and from our field assessment of the taxa). A knowledge of the taxonomic relationships among species was also helpful in screening the large numbers involved. Clearly, not all of the prospective species thus identified meet the selection criteria equally and for this reason the species have been ranked in importance (see below).

The following brief notes on the more important selection criteria explain the rationale for our species selection and ranking which are discussed below.

Table 3. Characteristics used for evaluating potential of Acacia as a wood crop. Many critical attributes are presently unknown and will only be obtained from further technical testing, field trials and detailed study of plants in their native habitats. An asterisk (*) indicates that many data are currently lacking or only partially known.

Broad characteristics	**Specific attributes**
Plant form	*Habit (e.g. tree, shrub), dimension (plant size), wood/crown ratio*, stem structure (e.g. stem no., straightness & branching), *bark characters, *root architecture*
*Plant growth	*Growth rate, longevity, coppice/suckering ability*
*Wood	*Colour, density, extractives content, fibre attributes*
Weediness	*Seed production and *phenological precocity, age of plant harvest, suckering propensity*
Soil	*Broad edaphic preferences*
Taxonomy	*Species relationships, variation and hybridization*
Distribution	*Geographic range and abundance, avoid rare taxa; predicted climatically-determined growing area*
Biology	*Flowering biology/phenology, seed phenology/production*
*Silviculture	*Established management data, propagation methods, pests & diseases*

Plant form

The ideal form for biomass production is a large plant that produces good quantities of wood biomass on one or more strong, straight stems which are sparingly branched (at least low down the stem). Good stem form is important for ease and cost of harvesting. The number of stems produced, their straightness, the length of the boles and the extent and nature of the branching system are all relevant in this regard. Stem size is critical because it relates directly to the volume of wood produced. The relationship between some of these plant-form characteristics and production and silviculture are discussed by Searle *et al.* (1998). Bark attributes, such as its thickness and the ease of removal from the stems, has relevance to at least those species with potential for tannin production (Barbour 2000).

The ability of plants to use water effectively, control salinity and improve soil structure (which are major objectives in any development of new woody crops) relates significantly to their root system. It is therefore regrettable that little is known about root architecture and function in *Acacia*. The lack of knowledge in this important and neglected area should be addressed in the future, at least for those species considered to be most promising in this report.

Plant growth

Attributes relating to plant growth rate, longevity and suckering/coppicing ability are very important.

'Fast growing' species are considered most prospective although it is difficult to define what is meant by 'fast'. Growth rates are influenced by many biological, ecological and management factors and how well or otherwise a species performs will not be known with certainty until it is grown in the selected area.

Many Acacias have the capacity to sucker by producing shoots from along the root system at some distance from the base of the plant. This character varies both within and between species, and ranges from absent to very vigorous. The ability of a species to root-sucker in nature may or may not be advantageous in cultivation, depending on whether or not this attribute is expressed in cultivation, and whether or not it is desirable in the farming system in which the species is placed. Suckering may be advantageous in situations where soil stabilization is required, or where regeneration by this method has a commercial advantage, but it also has the potential to complicate the management of *Acacia* as a tree crop, with respect to its silvicultural requirements, and the control of weed risk (see below). Given the prevalence of suckering in *Acacia* there is a need to know much more about this character, the nature of its variation and the factors that promote its expression. If ways were devised to manage suckering to advantage in crop systems it would substantially increase the value of about one third of the species detailed here.

The ability to reliably and vigorously re-sprout after harvest is an essential character for coppice crops. However, the coppicing ability of most Acacias is largely unknown. For those species where coppicing has been recorded very little is known about its frequency and vigor, its variation within the species, or the factors that control this response (for example, the effect of cutting height above ground level, and the time of the year). Research aimed at understanding coppicing in *Acacia* would be an essential part of any crop development program.

Weediness

Because most of the prospective species discussed below have the capacity to produce large quantities of hard-coated seed this could lead to the creation of a soil seed bank that may cause weed problems in adjacent or subsequent annual crops (i.e. an economic weed). Harvesting plants before they reach biological maturity is one way of avoiding this problem. However, generally it is not known at what age the plants first flower and fruit and these crucial data will need to be acquired for any species considered for widescale crop development. See **Weed potential of *Acacia* in target area (p.18)** for further discussion of weeds.

Wood

The focus of this study is to identify species capable of quickly producing large volumes of wood biomass with characteristics suitable for anticipated end products such as solid and reconstituted wood products (including panelboards, pulp and paper) and bioenergy; end products such as extractives and fodder are of secondary importance. Emphasis is given to products that have large markets, require large amounts of biomass for their manufacture, and for which short cycle *Acacia* crops could provide suitable feedstock.

Information concerning critical wood attributes such as density, extractive content, fibre length, water repellence, colour, etc. is scarce or unavailable for most species; these data will be acquired by the Search and FloraSearch projects for those species we identify here as prospective. In the present study we used information from published and unpublished sources, and our anecdotal field observations, to estimate wood characters for the taxa examined.

Taxonomy

To be effectively utilised it is essential that species be meaningfully circumscribed and properly named; also, having knowledge of species variation and relationships greatly facilitates their utilisation. Poorly circumscribed species have little biological meaning. Furthermore, names are the principal 'hooks' by which information about an organism is stored and retrieved so if names are misapplied then the information that is assembled and disseminated for the species is compromised. An understanding of species relationships is useful, because if a desirable characteristic (such as low density wood) is found in one species, it immediately focuses the search on its close relatives to see if they, too, share this attribute. These taxonomic issues are discussed by Maslin (2002).

We have applied our taxonomic knowledge of *Acacia* in assessing species for this project. Also, for reasons given above we provide notes on taxonomy under each of the species profiles. In the case of A. *acuminata*, A. *retinodes* and A. *saligna* taxonomic work is currently in progress and the most recent classifications are presented for these species in order to facilitate the investigation of their potential as crop plants.

Distribution

Determining which species occur in the target area and mapping the distributions of those considered most prospective as woody crop plants was made possible by using point source data supplied in December 2001 through the Australia's Virtual Herbarium project. These data are based on specimen records from relevant State and Commonwealth herbaria whose responsibility it is to maintain the currency of the data. Any changes subsequent to our usage of these geocodes may be found by accessing an AVH node via the CHAH (Council of Heads of Australian Herbaria) website at www.chah.gov.au.

Climatic profile maps

Bioclimatic maps, based on species natural distributions, were produced for the 35 best prospects to show the predicted areas where each is climatically suited for cultivation. The climatic profile maps were produced using the program AUSGRD (Booth & Jovanovic in prep.). The climatic parameters used in the bioclimatic analyses were generated using the program ESOCLIM (Houlder *et al.* 2000) and are shown in Table 5. In nearly all cases a minimum of 20 representative sites were used to generate climatic parameters. For species with very wide natural distributions as many as 150 sites were used. The climatic parameters shown in Table 5 used to generate the bioclimatic maps for each species were:

1. Annual rainfall range.
2. Rainfall seasonality or natural rainfall regime (mainly the winter and uniform rainfall zones).
3. Length of the dry season (i.e., months with less than 40 mm rainfall).
4. Mean annual temperature range.

The 250 mm isohyet, which defines the inland boundary of the eastern target area and the 300 mm isohyet for the western target area, were the respective minimum rainfall values used to generate the climatic profile maps. This only affected species such as A. *salicina* and A. *stenophylla* that have distributions extending into the arid zone. This was to focus the climatic match of these lower rainfall species to the target areas rather than map areas outside the zones of interest. Similarly, for most species the summer maximum rainfall zone was excluded from the analysis.

It is important to remember that these bioclimatic predictions do not take into account limiting factors other than climate. Therefore, the climatic profile maps presented for each species below should be treated with some caution and regarded as a first approximation that provides a general indication of areas where the species may possibly grow. There are many factors (especially soils) that may well preclude a species from being successfully cultivated in the areas indicated by these maps. There are also methodological issues relating to the way that the bioclimatic programs generate predicted surfaces that influence the results produced. Clearly trials are warranted for most species to assess if the cultivation potential predicted by the bioclimatic program can be realised.

It should be emphasised here that despite presenting these bioclimatic maps we are not recommending that species be cultivated outside their native geographic range unless accompanied by thorough weed risk assessment (see **Weed potential of Acacia in target area** below).

Soils

Because this study focused on landforms not seriously affected by waterlogging or high salinity the importance of edaphic factors in the initial selection process was somewhat reduced. Nevertheless, edaphic tolerance was one of the attributes considered when ranking the prospective species, with those occurring on a wide range of soils usually ranked higher than those with more restricted preferences. Edaphic preferences of the 35 prospective species are summarised in Table 5 and are discussed under each species profile. It should be noted that soil pH is a critical factor for the successful establishment of most acacia species.

Assessment and ranking of species in the target area

There are 462 *Acacia* species (comprising 538 taxa) that occur naturally within the target area (see Appendix 1). Thirty-five of these species are identified as having some potential for crop development when evaluated against criteria used in this study. These 35 prospective species are listed in Tables 5 and 6 and comprehensive details concerning them, together with distribution maps and photographs, are given in the species profiles below. Because the species vary considerably with respect to their growth characteristics they have been subjectively ranked to indicate how well each might be expected to perform as a crop capable of delivering anticipated end products. It is not expected, however, that all 35 species will become new woody crop plants. Some will undoubtedly be eliminated by subsequent performance trials, by testing of wood characteristics, or by their ability to meet end-product requirements. In other cases their potential weed risk may constrain use to their native range.

Our ranking of the 35 prospective species is shown in Table 6. Species were ranked largely from our subjective assessment of how well we considered each species met the selection criteria listed in Table 3. However, as discussed under **Selection criteria** above, not all information necessary for a thorough evaluation of species is currently available. We have therefore used as an initial guide the most important characters that could be reasonably assessed for all species, namely, anticipated plant growth rates and biomass production. Initial rankings made using these criteria were then re-assessed in the light of other important plant characters where information was available (or could be reasonably assumed). Characters of particular relevance in this regard were coppicing/suckering ability, stem architecture and wood attributes. Weed potential was also considered but species were not precluded (or unduly negatively weighted) at this early stage of the selection process on the basis of this character. To do so would preempt the development of effective control measures (should these be necessary) through management, breeding and other strategies that are discussed below under **Weed potential of Acacia in target area.**

These species rankings are provisional and should be treated with caution; they may change in the light of future studies. An obvious problem in assigning rankings is that a species may be highly prospective in one part of the target area but be unsuitable for cultivation elsewhere. Notwithstanding these constraints the ranking of taxa does provide a general guide for prioritising future work on the species that are detailed here.

Species ranked 1 and 2 are considered the most prospective. They can be expected to display fast or moderately fast growth rates and produce high or moderately high volumes of wood biomass. They have potential to be cultivated over a reasonably wide geographic area, although in a number of cases this area is restricted to the temperate outer peripheral regions of the target zone. The species included in these categories are (ranking in parentheses): *A. bartleana* (2-3), *A. dealbata* subsp. *dealbata* (2-3),

A. *decurrens* (2), A. *lasiocalyx* (2), A. *leucoclada* subsp. *leucoclada* (1-2), A. *linearifolia* (1-2), A. *mearnsii* (2), A. *microbotrya* (2), A. *murrayana* (2-3), A. *neriifolia* (2-3), A. *pycnantha* (2), A. *retinodes* 'typical' variant (1-2), A. *retinodes* 'swamp' variant (2), A. *rivalis* (2-3), A. *salicina* (1-2), A. *saligna* (1).

Species ranked 3 and 4 are regarded as moderately prospective. While these species possess acceptable growth characteristics, they display certain attributes that tend to reduce their potential for crop development (most commonly these attributes are relatively poor growth form, reduced wood biomass production, or relatively slow growth rates). Nevertheless, they should not be discounted at this early stage of the testing process. The species included in these categories are (ranking in parentheses): *Acacia acuminata* (3), A. *argyrophylla* (3-4), A. *baileyana* (3), A. *cyclops* (4), A. *dodonaeifolia* (4), A. *doratoxylon* (3), A. *euthycarpa* (4), A. *filicifolia* (3), A. *hakeoides* (3), A. *implexa* (3), A. *melanoxylon* (3), A. *parramattensis* (3), A. affin. *redolens* (4), A. *retinodes* 'Normanville' variant (3), A. *retinodes* var. *uncifolia* (3), A. *rostellifera* (3), A. *stenophylla* (3), A. *victoriae* (3), A. *wattsiana* (3).

Of the 35 prospective species 10 occur in Western Australia, 19 in South Australia, 12 in Victoria and 18 in New South Wales (these numbers do not include naturalized occurrences; also, a number of the 35 species have distributions that extend beyond the target area into Queensland, Northern Territory and Tasmania, see Table 5). Only A. *baileyana* (N.S.W.), A. *bartleana* (W.A.), A. affin. *redolens* (W.A.), and A. *wattsiana* (S.A.) have distributions entirely confined to the target area; these four species have very narrow geographic ranges, although A. *baileyana* is naturalized over a wide area. There are, however, a number of species whose geographic ranges are mostly contained within the target area, namely, A. *acuminata* (W.A.), A. *argyrophylla* (S.A., Vic.), A. *dodonaeifolia* (S.A., ?Vic.), A. *euthycarpa* (S.A., Vic.), A. *lasiocalyx* (W.A.) and A. *microbotrya* (W.A.). Conversely, A. *dealbata*, A. *decurrens*, A. *filicifolia*, A. *implexa*, A. *mearnsii*, A. *melanoxylon*, A. *parramattensis*, A. *neriifolia* and A. *retinodes* 'swamp' variant (all eastern Australia) have their main areas of occurrence to the east and south of the target area. Most of these species reach the temperate periphery of the target area except A. *decurrens*, A. *filicifolia* and A. *neriifolia* which occur entirely outside the region. *Acacia rivalis* (S.A.) is the only other species whose distribution lies entirely outside the target area. Only four species, A. *cyclops*, A. *hakeoides*, A. *murrayana* and A. *victoriae*, occur in both the eastern and western target areas. *Acacia murrayana* and A. *victoriae* along with A. *salicina* and A. *stenophylla* have wide distributions in the Australian arid zone, and these four species reach the target area in the drier inland regions. Species that are particularly widespread and common in at least parts of the target area include A. *acuminata* (W.A.), A. *doratoxylon* (N.S.W.), A. *hakeoides* (W.A., S.A., N.S.W. Vic. and Qld), A. *lasiocalyx* (W.A., around granite rocks), A. *microbotrya* (W.A.), A. *pycnantha* (S.A., Vic., N.S.W.), A. *salicina* (along water courses) and A. *saligna* (W.A., but naturalized in other areas).

The significant number of prospective species in each state provides the opportunity to focus early commercial development on species within their natural geographic range, thereby avoiding the need to translocate species to distant botanical regions invoking the complex issue of environmental weed risk.

Twenty of the 35 prospective species occur in section *Phyllodineae* and a majority of these species are characterised by having racemose inflorescences (A. *dodonaeifolia* is the only member of the section that has simple inflorescences). Not all species within this large racemose assemblage are closely related to one another, but they can be arranged into a number of informal groups:

1. Acacia microbotrya group: A. *argyrophylla*, A. *bartleana*, A. *euthycarpa*, A. *microbotyra*, A. *retinodes* (all variants) A. *rivalis*, A. *wattsiana*.

2. Acacia pycnantha group: A. *hakeoides*, A. *neriifolia*, A. *pycnantha*.

3. Acacia rostellifera group: A *rostellifera*, A. *salicina*.

4. Acacia victoriae group: A. *murrayana*, A. *victoriae*.

5. Acacia saligna group: A. *saligna*.

The A. *microbotrya* and A. *pycnantha* groups are related to one another but distinct from the other three; these two groups are not far removed taxonomically from section *Botrycephalae* (see below). The other three groups do not show particularly close affinities to one another or to any other group or section listed here.

The seven species of section *Botrycephalae* (A. *baileyana*, A. *dealbata*, A. *decurrens*, A. *filicifolia*, A. *leucoclada*, A. *mearnsii*, A. *parramattensis*) are probably reasonably closely related to one another. However, the five species of section *Plurinerves* (A. *cyclops*, A. *implexa*, A. *melanoxylon*, A. affin. *redolens*, A. *stenophylla*) are not particularly closely related. Of the three prospective section *Juliflorae* species A. *doratoxylon* and A. *lasiocalyx* are somewhat related, but A. *acuminata* stands apart. The importance of understanding these taxonomic affinities is discussed above on p.13 under **Selection criteria**. Except for A. *lasiocalyx* (section *Juliflorae*) all species ranked 1 and 2 are members of sections *Phyllodineae* and *Botrycephalae*.

A majority of the *Acacia* species considered prospective for crop development in the southern Australian agricultural zone have potential as phase crops. Indeed, 31 of the 35 prospective species are assessed here as potential phase crop plants, 13 species as long cycle crops and only 8 species as coppice crops (see Table 6; see also each species profile under **Potential for crop development**). Plant establishment by direct seeding is essential for the commercial viability of phase crops, and also confers a cost advantage in the establishment of coppice crops and long cycle crops. Therefore, one of the attractive attributes of Acacias as potential crop plants (apart from their rapid growth rate, nitrogen fixation capability, etc.) is their large seeds that are amenable to direct-seeding technology (possibly using conventional large-scale cereal seeding equipment). The ability to reliably and vigorously re-sprout after harvest is an essential character for coppice crops. Although very little is known about this characteristic in *Acacia* it is seemingly uncommon among the 35 prospective species. *Acacia saligna* would appear to have the best potential as a coppice crop although A. *implexa*, A. *linearifolia*, A. *microbotrya*, A. *murrayana*, A. *retinodes* 'Normanville' variant, A. *salicina* and A. *stenophylla* may possibly have some prospects. Many of the species assessed as long cycle crops have been provisionally ascribed to this category. Perhaps A. *bartleana*, A. *implexa*, A. *retinodes* 'typical' and 'Normanville' variants and A. *salicina*. have the best prospects as long cycle crop plants, however, they also have phase crop potential. *Acacia acuminata*, A. *doratoxylon* and A. *melanoxylon* seem suited only as long cycle crops, however, the first two species are rather slow growing and the latter is likely to be suited to a very restricted part of the target area.

As already noted the ability to produce at least reasonable quantities of wood biomass is a characteristic common to all 35 prospective species, however, they are not equally productive in this regard. Good wood volumes are generally found in the arborescent species which grow in (or just outside) the temperate peripheral parts of the target area in eastern Australia (e.g. A. *dealbata*, A. *decurrens*, A. *implexa*, A. *leucoclada*, A. *linearifolia*, A. *mearnsii*, A. *melanoxylon*, A. *neriifolia*, A. *retinodes* 'swamp' and 'Normanville' variants). In the drier inland regions of New South Wales, South Australia and Western Australia many species are smaller in stature and often develop a form resembling the 'mallee' growth habit that is found in many eucalypts, with wood contained in many rather slender stems (e.g. A. *argyrophylla*, A. *euthycarpa*, A. *hakeoides*, A. *murrayana*, A. *rivalis*, A. *wattsiana*). However, A. *salicina* and A. *stenophylla* are notable exceptions in that they develop into substantial trees, despite growing (along water courses) in the driest inland parts of the eastern target area. Some smaller arborescent species also occur in the drier semi-arid parts of the target zone (e.g. *A. bartleana, A. lasiocalyx, A. microbotrya, A. pycnantha*, A. retinodes 'typical', *A. saligna*).

Judging from observations of plants growing in their natural habitats it is clear that most, if not all, of the 35 prospective species have variable growth form (i.e. plant height, nature of the branching pattern and straightness of the stems, and the number of main stems arising from ground level). Since these attributes have management implications for plants under cultivation, the selection of appropriate provenances for future assessments will therefore be critically important. Furthermore, plant form (along with most other critically important characteristics) will only become apparent after species have been grown in the areas and under the conditions where it is intended that they be cultivated. *Acacia saligna* is an example of a species that exhibits an extreme range of variation with the 'cyanophylla' and 'Tweed River' variants generally displaying the best growth forms (see Figures 33 & 34). Some species such as *A. melanoxylon* and *A. dealbata* may have an excellent bole form in the more temperate parts of their range, but under the drier conditions of the target area there are indications that their form may become crooked, shrubby or multistemmed. While all of the 35 species include at least some good forms, in some species, such as *A. cyclops* and *A. victoriae*, there is a preponderance of plants with relatively poor form with the plants much-branched from low down and the stems often somewhat crooked (these two species are ranked 4 and 3 respectively). Conversely, the more highly ranked species such as *A. lasiocalyx, A. leucoclada, A. linearifolia, A. retinodes* 'typical' and 'swamp' etc. generally display a preponderance of well-formed plants.

Vigorous or moderately vigorous root suckering appears to be common in a number of the highly ranked species, namely, *A. bartleana, A. leucoclada, A. microbotrya, A. retinodes* 'typical' variant, *A. salicina*, and *A. saligna*. However, very little is known about this character, including how it varies within species or what factors (apart from root disturbance) are responsible for promoting it. Based on our limited field observations of this character it appears that some species which have the ability to sucker do so more readily when they grow in areas marginal to their preferred habitat, or when adverse environmental factors prevail (e.g. severe insect predation, severe frost, prolonged drought, fire, etc). Some species, *A. saligna* for example, apparently rarely root sucker in cultivated stands but in nature sucker regrowth is common. In this case it is not known if non-suckering (or low-propensity suckering) provenances happen to be the ones that are most commonly cultivated.

The ability to produce strong coppice regrowth is seemingly uncommon among the 35 prospective species (see Table 6) but very little is known about this important character. Of the 35 species *A. saligna* would appear to have the best potential as a coppice crop although *A. implexa, A. linearifolia, A. microbotrya, A. murrayana, A. retinodes* 'Normanville' variant, *A. salicina* and *A. stenophylla* may possibly have some prospects.

Species of *Acacia* are found naturally on most soil types within the target area, including both recharge and discharge sites. Edaphic preferences of the 35 prospective species are summarised in Table 5 and are discussed under each species profile. At least one species, and often up to four or five, appear to be well-suited for cultivation on most soil types found in the target area. Species such as *A. saligna, A. pycnantha, A. retinodes* show considerable edaphic tolerance and may be suited for cultivation on a wide range of soil types. Others appear to be more habitat specific, for example, *A. rostellifera* and *A. retinodes* var. *uncifolia* (deep calcareous sands), *A. argyrophylla* and *A. hakeoides* (calcareous clay loams), *A. stenophylla* (heavy alkaline clays) and *A. mearnsii* (acidic clays).

Excluded species

Not all arborescent Acacias that occur in or near the target area are considered to be prospective for crop development within the context of the present selection criteria. Species that were excluded did not meet one or more of the requirements of fast growth rates, good growth form, reasonable quantities of wood biomass and moderate to low wood density. The excluded arborescent species are given in Table 4, along with the reasons for their exclusion. Thirty-one of these 43 species occur in section *Juliflorae* and section *Plurinerves* and although a number of them show good growth form and good wood biomass production they have very slow growth rates and develop very dense wood. Some of these species, e.g. *A. melvillei, A. omalophylla* and *A. pendula*, are common in parts of the eastern target area and may possibly be suited for growing as long cycle crops for timber, furniture and other specialty wood products.

During the course of this study it became evident that there is a considerable number of Acacias occurring outside the target area that might possibly perform well under cultivation within the region. These species occur primarily in the wetter coastal areas of eastern Australia. A few of the more obvious taxa include *A. binervia* (which performs well in cultivation at Burrendong Arboretum near Wellington, N.S.W.), *A. caerulescens, A. falciformis, A. fulva, A. kettlewelliae, A. obliquinervia, A. prominens*, and *A. schinoides* (performs well in cultivation at Burrendong Arboretum near Wellington). It is recommended that a proper assessment be made of these wet zone species because some may be suited for cultivation in the target area, at least in the more temperate peripheral areas. These species were not assessed in this project because they do not occur naturally within the target area or very close to its border. Similarly there are a few arid zone species (not occurring in the target area) that might be worth considering for future trials, e.g. *A. confluens, A. pruinocarpa*. Although we examined some species in inland N.S.W. north of the Lachlan River a more comprehensive survey of the Murray-Darling system in northern N.S.W. and southern Queensland. would be instructive.

Table 4. Arborescent Acacias occurring in target area (see Maps 2 and 3), or near target area in similar habitats, but which are not ranked prospective for potential crop development. The primary reasons for their exclusion are: **1** – growth form poor and/or woody biomass insufficient; **2** – expected growth rate (within the target area) comparatively slow to very slow; **3** – wood dense and commonly with an extensive development of dark-coloured heartwood. Thirty one of these 43 species occur in either section *Plurinerves* or section *Juliflorae*.

A. alcockii 1	*A. cowaniana* 2,3	*A. inceana* 1,2,3
A. aneura 2,3	*A. crassa* 1,2	*A. inophloia* 2,3
A. anthochaera 2?,3	*A. cretacea* 1	*A. iteaphylla* 1
A. beauverdiana 2,3	*A. deanei* 1	*A. jibberdingensis* 1
A. blakelyi 1	*A. difformis* 1,2	*A. leiocalyx* 1,2
A. burkittii 2,3	*A. enervia* 1,2,3	*A. leiophylla* 1
A. burrowii 2,3	*A. eremaea* 1,2,3	*A. ligulata* 1
A. caesiella 1	*A. fauntleroyi* 2,3	*A. loderi* 2,3
A. caroleae 1	*A. gillii* 1	*A. longifolia* 1,2
A. cheelii 1	*A. harpophylla* 2,3	*A. melvillei* 2,3
A. coolgardiensis 2,3	*A. heteroclita* 1	*A. mollifolia* 1

Weed potential of *Acacia* in target area

Many *Acacia* species have potential to display various aspects of weediness. The primary strategy to minimize the environmental weed risk is to select species for development within their natural range of occurrence. Fortunately, there appear to be sufficient prospective native species options in every botanical (IBRA) region, to make this a viable strategy across southern Australia (see Table 5). As crop development progresses the knowledge of the biology and ecology of the species will expand and allow more rigorous prediction of weed risk that might occur in translocation to other botanical regions. This strategy provides a safe development pathway for *Acacia* crops.

However, it is important to briefly review the issue of weediness and to provide an indication of its possible dimensions.

Within the context of the present discussion there are two major types of weeds:

- Environmental weeds: where a species escapes the confines of cultivation to become passively naturalized or aggressively invasive in the wider natural environment.
- Economic weeds: species that require regular management to reduce their economic cost in the agricultural or urban environment.

Hence, a species taken into cultivation within its natural range can be an economic weed but not an environmental weed, or a species from outside its natural range taken into cultivation can potentially be both an environmental and an economic weed. Note that the degree of weediness can vary over a wide range from passive (involving little cost or minor presence in the environment) to aggressively invasive (requiring costly control on farms and/or in the natural environment).

Perhaps the eight species listed below pose the greatest potential risk although to what extent (if any) they become environmental or economic weeds will depend upon a complex interplay of factors, including biological, environmental and management. Not all known *Acacia* weed species are invasive environmental weeds. Furthermore, species may be considered weedy in some situations yet innocuous, and perhaps even desirable, in another. *Acacia saligna*, for example, is a major environmental weed in parts of Australia and South Africa (and elsewhere); however, weediness is not considered a significant problem with this species in north Africa, despite the fact that it has been grown there for about 100 years (for soil stabilization and fodder) and where there currently exists over 200 000 ha in cultivation (Le Houerou 2002). It is therefore important to assess weed potential in relation to the environment where it is expected that some risk may occur. Furthermore, it may be possible to develop and implement management (e.g. buffer zones), breeding and other strategies to effectively control potential economic or environmental weed species. It is for these reasons that weed potential in itself is not regarded here as sufficient justification for eliminating species from consideration as potential new crop plants at this early stage of assessment.

Notwithstanding the above many Acacias, including some in this report, have become environmental weeds, both within Australian and abroad (see Table 6). For example, *A. baileyana*, *A. cyclops*, *A. dealbata*, *A. decurrens*, *A. mearnsii*, *A. melanoxylon*, *A. pycnantha* and *A. saligna* are regarded in South Africa as invasive weeds and both herbicides and biological control methods have been employed to suppress them (Dennill *et al.* 1999, Morris 1999, Adair *et al.* 2000, Henderson 2001). These species are also invasive in parts of Australia. *Acacia cyclops* and *A. saligna* for example were recently assessed as posing a very high weed risk in parts of the agricultural region of South Australia (Virtue & Melland 2002) while *A. pycnantha* is regarded as a potential serious weed in the southern wheatbelt of Western Australia and in parts of New South Wales. For practical purposes it might be safest to regard all 35 species detailed in this report as having some weed potential although there are a number of species (e.g. *A. argyrophylla*, *A. acuminata*, *A. doratoxylon*, *A. microbotrya* and more) which grow naturally in disturbed agricultural landscapes but for which there are no recorded weed problems. Weediness is discussed under **Weed potential** in each of the 35 species profiles below and a subjective assessment of their weed potential is given in Table 6. The comprehensive information provided in Virtue & Melland (2002), although focused on South Australian weeds, has relevance to weed issues in agroforestry and revegetation in general. An abbreviated version of that paper appears in Jacob *et al.* (2002) together with many other papers that deal comprehensively with weeds, including their management and ecology in forestry and tree cropping systems.

Ironically it is some of the desirable agronomic characteristics of Acacias that can lead to them becoming serious environmental weeds. *Acacia* species are generally regarded as primary colonizers ('pioneer' species) and as such they often germinate, establish and spread rapidly in open disturbed sites. The particular attributes of Acacias that enables this development (and which may result in weediness) include the following:

- Production of large quantities of hard-coated seeds that are easily dispersed and which remain viable in the soil for many years. The hard seed coats render *Acacia* susceptible to having 'sleeper weed' status, that is, its weediness may not become apparent for many years following introduction, until such time as the stored soil seed bank becomes substantial and there is some disturbance event that promotes germination. This has potential to occur both in nature and in crop situations (and has particular relevance to plants used for phase crops). Also, species such as A. *cyclops* and A. *melanoxylon* which have conspicuous red seed arils are likely to be more prone to dispersal by birds than the other species included in this report. Most are also unpalatable or not preferred fodder of domestic or native mammals.
- Rapid growth rate and often reaching biological maturity (i.e. flowering and fruiting) at an early age, sometimes when only one or two years old.
- Root nodulation that enables them to fix atmospheric nitrogen and survive and prosper in nutrient-deficient soils.
- Ability to root sucker (which may increase the difficulty of eradication once a species has been introduced to an area). Species such as A. *dealbata*, A. *implexa*, A. *salicina*, etc., which are listed in Table 6 as having a high suckering propensity, may be particularly troublesome in this regard.

Plant propagules are dispersed by humans, animals (domestic and native) and natural environmental processes (e.g. streams). Being aware of these factors can help guard against the inadvertent spread of weed species. Within an agricultural context a number of specific weed reduction strategies are possible (although not all are practical insofar as *Acacia* is concerned) of which the following are some examples:

- Cultivate species only within their natural geographic range; hence, select and develop an array of species to provide a range of native plant options within any region being considered for planting. This may involve compromise with the practicality of crop genetic improvement programs and the scale of production that might be necessary. Environmental weed risk is also likely to be low in the wider botanical province (e.g. IBRA region) within which that species occurs naturally. Hence these regions are listed in Table 5.
- Use local seed provenances which will minimize both weed risk and the risk of dispersal of pollen that could change the genetic endowment of seed production from natural stands of the species (and perhaps its relatives) near their area of cultivation.
- Harvest wood crop before seed is set (there is an element of risk here in that plants will not be harvested before seed is set).
- Develop sterile hybrids and propagate these by vegetative techniques (this is a difficult and costly option).
- Develop triploid plants and use their seed for propagation (the resulting plants will be sterile) (again this is a difficult and costly option).
- Select for naturally-occurring sterile plants, or plants with reduced flower production or seed set, and propogate by vegetative techniques (a costly option).

Understanding and managing weediness are complex issues that require knowledge of both the biological attributes of the species and the environment in which they are grown. In an agricultural context the situation may be further confounded by competing interests, the need to protect the environment from unwanted infestations on the one hand and the need to tackle salinity by lowering water tables through the wide-scale planting of commercial perennial crops on the other. What is important is that any agroforestry development of *Acacia* be accompanied by weed risk assessments and that appropriate strategies be adopted to minimize the risk of them becoming problems in the future.

Table 5 (following pages). A summary of the natural occurrence and natural climatic conditions for the 35 prospective species. The climatic parameters below (which are derived from an analysis of the species natural distribution) were used to generate the bioclimatic maps that are presented under each species profile. These maps show the predicted areas where species are climatically suited for cultivation.

Taxon name. An asterisk (*) indicates that the species natural distribution lies entirely outside the target area. **State distribution**. **A** = Australian Capital Territory; **N** = New South Wales; **NT** = Northern Territory; **Q** = Queensland; **S** = South Australia; **T** = Tasmania; **V** = Victoria; **W** = Western Australia. States in parentheses indicate naturalized occurrences. **IBRA regions** = Interim Biogeographic Regionalisation for Australia (codes are given in Environment Australia 2000, see also http://www.ea.gov.au/parks/nrs/ibraimcr/ibra_95/cont-col.html). The **Climate** parameters **Annual rainfall range (mm), Natural rainfall regime (u =** uniform, **w =** winter, **s =** summer**), Months of less than 40 mm rainfall, Mean maximum of the hottest month (°C), Mean minimum of the coldest month (°C)** and **Mean annual temperature (°C)** were generated using the ESOCLIM program of Houlder *et al.* (2000). **Frost incidence**: **low** = nil or very low incidence of frosts throughout range; **moderate** = moderate to heavy incidence of frosts at least in some years and in some part of the range; **high** = heavy frosts in most years over a substantial part of the range.

	OCCURRENCE				CLIMATE						
Taxon name	State distribution	IBRA regions (within target area)	Landforms and soils	Alt. range (m)	Annual rainfall range (mm)	Natural rainfall regime	Mths <40mm rainfall	Mean max. hottest mth (°C)	Mean min. coldest mth (°C)	Mean annual temp. (°C)	Frost incidence
A. acuminata	W	AW, COO, ESP, JF, GS, MAL, YAL	Gently undulating hills, alluvial plains or near granite rock outcrops, mainly on loams and clay loams (see text for further details).	40-470	225-600	w,u	7-12	27-37	4-7	10-24	Moderate
A. argyrophylla	S,?V	EYB, FLB, MDD	Mainly gently undulating hills on calcareous clay loams.	5-550	250-500	w,u	7-12	24-32	2-9	9-21	Moderate
A. baileyana	N	NSS	Stony hills or gullies on gravelly clay or clay loams.	300-400	500-650	u (w)	0-2	30-31	1-2	8-22	High
A. bartleana	W	SWA	Low hills on brown sandy loam.	200-275	450-600	w	6-8	32-33	6-7	11-24	Low to moderate
A. cyclops	S,W	ESP, EYB, GS, MAL, SWA	Mainly coastlines on calcareous sands, sandy loams or heavy waterlogged clays.	2-300	230-1340	w,u	3-12	23-31	5-11	11-22	Low
A. dealbata subsp. *dealbata*	N,T,V (S,W)	NSS, RIV, SEH	Undulating to steep hills or along creek banks mainly on clay or clay loams.	5-1550	500-1800	u,w,s	0-5	16-30	− 3-7	6-17	High
*A. decurrens**	A,N (A,N,Q,S,T,W,V)	SEH	Hillsides or gullies on clay loams and clays.	10-975	600-1485	u (w)	0-6	23-29	− 1-8	9-20	High
A. dodonaeifolia	S (V)	EYB, FLB, KAN, NCP	Mainly undulating hills on acidic clay loams or alkaline sandy clay loams.	2-300	385-760	w,u	5-8	22-29	5-9	10-20	Moderate
A. doratoxylon	A,N,V	CP, ELB, EYB, KAN, NCP, NSS, RIV, SEH, VM	Mainly rocky ridges, hillsides and footslopes; mainly on skeletal gravelly sands or sandy clay loams.	50-920	350-800	u (w)	0-12	24-35	− 2-4	8-22	Moderate
A. euthycarpa	S,V	EYB, FLB, KAN, MDD, VM	Plains or gently undulating country in deep sand or alluvial loam.	2-300	280-540	w,u	6-12	33-32	2-9	9-21	Moderate
*A. filicifolia**	N,Q	NSS	Undulating to steep hills or creek banks; soils range from sands to gravelly clays.	10-1320	550-1360	u,s (w)	0-6	21-32	− 1-7	8-21	High

Taxon name	State distribution	IBRA regions (within target area)	Landforms and soils	Alt. range (m)	Annual rainfall range (mm)	Natural rainfall regime	Mths <40mm rainfall	Mean max. hottest mth (°C)	Mean min. coldest mth (°C)	Mean annual temp. (°C)	Frost incidence
A. hakeoides	N,Q,S,V,W	CP, EYB, FLB, KAN, MAL, MDD, NCP, NSS, RIV, SEH, VM	Mainly on gently undulating plains on calcareous sandy loams, but sometimes on rocky ranges.	2-550	250-875	u,w	0-12	24-37	1-7	10-23	Moderate
A. implexa	A,N,Q,T,V	CP, NSS, RIV, SEH	Mainly undulating hills, plains or creek banks; soils range from sandy loams to clays and are often shallow.	3-1320	530-1980	u,w,s	0-6	21-34	− 2-10	10-22	Moderate to high
A. lasiocalyx	W	AW, COO, ESP, GS, JF, MAL	Granite hills and rock outcrops on sand, loamy sand, clayey sand and loam.	35-470	250-550	u,w	6-12	26-35	4-9	10-23	Moderate
A. leucoclada subsp. *leucoclada*	N	NSS	Undulating to moderately steep hills or along creek banks; soils range from sands to clays.	200-780	535-850	u,w,s	0-6	29-34	0-3	9-23	Moderate to high
A. linearifolia	N	NSS	Lower slopes and foothills or steep rocky slopes; mainly on shallow or colluvial sands or sandy loams.	130-650	540-720	u,w	0-6	21-32	2-3	9-22	Moderate to high
A. mearnsii	A,N,S,T,V (N,S,W)	SEH, VM	Undulating hills, plains or along creek banks; mainly on loams, sandy loams or clays.	2-1070	520-1340	u,w	0-5	21-27	− 2-7	10-18	High
A. melanoxylon	A,N,Q,V,S,T	EYB, FLB, KAN, MDD, NCP, NSS, SEH, VM	Undulating to moderately steep hills, gullies or creek banks; soils range from sandy loams to clays.	5-1500	540-2800	u,w,s	0-6	17-30	− 3-13	8-18	High
A. microbotrya	W	AW, ESP, JF, MAL,SWA	Gently undulating hills, alluvial plains or near granite rock outcrops; soils range from sands to clay loams.	75-430	320-625	w	7-8	27-34	4-8	10-23	Moderate
A. murrayana	N,NT,Q,S,W	AW, MDD, COO, YAL	Sandhills, sandplains and swales mainly on deep sands.	50-550	150-500	u,s	10-12	34-38	4-6	10-27	Moderate
*A. neriifolia**	N,Q	on border of NSS	Hillsides and footslopes; mainly on shallow gravelly sands or clay loams.	200-1115	610-970	u,s	0-6	24-33	− 1-6	10-23	High
A. parramattensis	A,N (N, ?T)	NSS, SEH	Undulating hills, plains or creekbanks; mainly on sandy loams or clays.	5-1044	660-1370	u,w	0-2	23-30	0-5	9-21	Moderate to high

Taxon name	State distribution	IBRA regions (within target area)	Landforms and soils	Alt. range (m)	Annual rainfall range (mm)	Natural rainfall regime	Mths <40mm rainfall	Mean max. hottest mth (°C)	Mean min. coldest mth (°C)	Mean annual temp. (°C)	Frost incidence
A. pycnantha	A,N,S,V (N,T,V,W)	EYB, FLB, KAN, MDD, NCP, NSS, RIV, SEH, VM	Hills and plains on range of soils including acidic clay loams and calcareous loams and sands.	5-1100	190-850	w,u	0-12	22-34	– 2-9	8-20	Moderate to high
A. redolens affin.	W	ESP	Waterlogged depression on either clay loam or sand over clay.	160-200	420-475	w	6-7	27-28	5-6	10-22	Low to moderate
A. retinodes 'typical variant'	S (S)	FLB, KAN	Rocky hillsides or plains on clay loams or loams.	100-510	340-940	w,u	3-12	27-30	3-6	8-20	Moderate
A. retinodes 'swamp variant'	S,V	KAN, FLB, NCP, MDD, VM	Seasonally waterlogged swamps and along watercourses on acidic sands or clays.	5-600	480-1065	w,u	0-8	22-29	2-9	9-19	Moderate
A. retinodes 'Normanville'	S	KAN	Creekbanks of coastal dune system on sandy loam.	20	500-600	w,u	4-6	25	7	15-23	Low
A. retinodes var. *uncifolia*	S,V,T	EYB, KAN	Coastal dune systems on calcareous sands.	0-190	530-980	w,u	0-6	20-24	5-10	11-18	Low
*A. rivalis**	S (?N)	FLB	Ridges, hills or along creeks on shallow calcareous loams.	30-740	150-400	u,w	3-12	30-35	2-5	10-24	Low to moderate
A. rostellifera	W	AW, ESP, GS, MAL	Coastal dune systems or granite hills mainly on deep sands.	0-280	280-950	w	5-10	25-36	5-10	12-24	Low
A. salicina	N,NT,Q,S,V,?W	EYB, FLB, MDD, NSS, RIV, VM	Creek banks and floodplains, often on heavy clays.	5-600	(110-) 250-1660	u,w,s	4-12	32-36	4-8	14-25	Moderate to low
A. saligna	W (N,Q,S,T,V)	AW, ESP, GS, JF, MAL, SWA	Coastal dunes systems, granite rock outcrops or creek banks, on calcareous sands, acidic sandy loams or alluvium.	5-370	300-1120	w	5-9	25-35	4-9	11-23	Moderate
A. stenophylla	N,NT,Q,S,V	CP, MDD, NSS, RIV, VM	Creek banks on heavy, often alkaline clays.	5-625	(120-) 250-650	u,w,s	1-12	35-38	4-7	14-27	Moderate
A. victoriae	N,NT,S,Q,V,W	EYB, FLB, MDD, RIV, YAL	Various: clay plains,sand plains, sandhills, creeklines; soils are mainly heavy alkaline clays or loams.	50-750	(100-) 250-1000	u,w,s	4-12	35-39	5-10	15-28	Moderate
A. wattsiana	S	FLB	Undulating hills on alkaline clay or loam.	225-560	280-660	w	5-7	28-31	3-5	9-21	Moderate

Table 6. Ranking and some important attributes of the 35 prospective species, and what crop type they may be suited for in the southern Australian agricultural zone. **Taxon name**. An asterisk (*) indicates that the species natural distribution lies entirely outside the target area. **Ranking**. A somewhat subjective assessment of how prospective we regard the species for development as a woody crop plant. **1** = highly prospective; **2** = reasonably prospective; **3** = moderately prospective; **4** = not especially prospective. **Coppicing ability, Suckering propensity** and **Growth rates**. A synopsis of discussions provided under species profiles. **Weed potential**. Subjective assessment of weediness based on available information. Regardless of these assessments it is generally not known how problematic or otherwise a species might be when grown under cultivation in the target area (see text for discussion): **low** = no records of weediness or weed potential regarded as insignificant, **moderate** = weed impact recorded but not highly significant, **high** = recorded as an invasive weed in some areas. **Wood density** (kg/m^3). Values represent basic densities unless otherwise stated. **Longevity**. Age estimates (from literature) given in years where known. Long-lived may be interpreted as about 40–50 years or more. **Crop type.** See Table 2 for definitions of crop types, **phase**, **coppice** and **long cycle**.

[A]*Subject to coppicing ability being acceptable;* [B]*But would need to account for suckering.*

Ranking attributes and crop type suitability of the 35 prospective species

Taxon name	Rank	Coppicing ability	Suckering propensity	Growth rate	Weed potential	Wood density	Longevity	Crop type	Plant Height
A. acuminata	3	Absent (or very low frequency)	Unlikely	Moderate	Low	899-1171	Perhaps >50	Long cycle	Shrubs/trees 2-7(-10)m
A. argyrophylla	3-4	Present (but probably low frequency)	Unlikely	Moderate	Low	Unknown	Perhaps to 30	Phase	Shrubs 2-3 m
A. baileyana	3	Unlikely	Absent	Fast	High (especially in wetter areas)	Unknown	10-20(40)	Phase	Shrubs/trees 5-10 m
A. bartleana	2-3	Unknown (but likely)	Probably low to moderate	Probably moderately fast	Low	718-959	Probably 20-30 years	Phase[B], long cycle	Trees 4-8(-12) m
A. cyclops	4	Absent or rare	Unlikely	Moderate	High	780-826	Unknown	Phase	Shrubs/trees 1-4(-8) m
A. dealbata subsp. *dealbata*	2-3	Present (but vigor unknown)	Vigorous	Fast	High	570 (540-720 air-dry density)	Several decades	Phase[B], long cycle	Shrubs/trees 2-15(-30) m
*A. decurrens**	2	Absent or poor	Absent (or poor)	Fast	High	457-520 (air-dry density c.720)	10-15	Phase	Trees 5-10(-22) m
A. dodonaeifolia	4	Unknown (but likely)	Occasional	Fast	Low or (wet areas) moderate	Unknown	About 20	Phase	Shrubs/trees 2-6 m
A. doratoxylon	3	Unknown	Absent	Moderate	Low	720	Long-lived	Long cycle	Shrubs/trees 3-12 m
A. euthycarpa	4	Unknown	Unlikely	Moderate	Low	Unknown	About 30	Phase	Shrubs/trees 2-6(-10) m
*A. filicifolia**	3	Unlikely	Absent (or poor)	Unknown (but probably moderate)	Low (presumably)	Unknown	Unknown	Phase	Shrubs/trees 3-14 m

Taxon name	Rank	Coppicing ability	Suckering propensity	Growth rate	Weed potential	Wood density	Longevity	Crop type	Plant Height
A. hakeoides	3	Unknown	Vigorous	Moderate to fast	Moderate	Unknown	Several decades	Phase[B]	Shrubs/trees 1-4(-6) m
A. implexa	3	Present (sometimes strong)	Present (sometimes vigorous)	Moderate to fast	Low to moderate	583-640	Long-lived	Long cycle, ?coppice	Trees 5-12(-15) m
A. lasiocalyx	2	Unknown (but unlikely)	Unlikely	Moderate to fast	Low	593-912	20-40	Phase, ?long cycle	Shrubs/trees 2-5(10-15) m
A. leucoclada subsp. *leucoclada*	1-2	Absent (or present at low frequency)	Vigorous	Fast	Low (? to moderate)	626	Unknown (but probably several decades)	Phase[B], ?long cycle	Shrubs/trees 4-9(-15) m
A. linearifolia	1-2	High	Absent (apparently)	Fast	Low	Unknown	Unknown (but probably several decades)	Phase, ?coppice, ?long cycle	Shrubs/trees 5-10 m
A. mearnsii	2	Absent	Absent	Fast	High	550-750 (air dry density)	10-20(40)	Phase	Shrubs/trees 5-10 (-20)m
A. melanoxylon	3	Present but variable frequency	Vigorous	Moderate	Moderate	390-670	Long-lived	Long cycle[B]	Trees 10-20(-40) m
A. microbotrya	2	Unknown (but likely)	Vigorous	Fast	Low	654-959	20-30	Phase[B], ?coppice[A,B]	Shrubs/trees 2-4(-7) m
A. murrayana	2-3	High	Vigorous	Fast	Low - moderate	522-850	10-25	Phase, ?coppice[A]	Shrubs/trees 2-6(-8) m
*A. neriifolia**	2-3	Poor to fair	Unlikely	Fast	Low	Unknown	Perhaps 10-15 (sometimes more)	Phase	Shrubs/trees 2-8(-15) m
A. parramattensis	3	Unlikely	Probably low to moderate	Fast	Low (presumably)	606	Probably 10-20	Phase	Shrubs/trees 2-7(-15) m
A. pycnantha	2	Absent or (in older plants) poor	Absent	Moderately fast	High	Unknown	15-30 typically	Phase	Shrubs/trees 4-10 m
A. redolens affin.	4	Unknown	Unlikely	Unknown	Low	732-835	20+	Phase	Trees 4-7(-10) m
A. retinodes 'typical variant'	1-2	Present (but vigor unknown)	Moderate	Moderately fast	Low	Unknown	30-40	Phase, long cycle	Trees 5-6 (-10) m
A. retinodes 'swamp variant'	2	Absent (or low frequency)	Absent	Very fast	Low	Unknown	10-20	Phase	Trees 5-6 (-10) m
A. retinodes 'Normanville'	2-3	Present	Seemingly absent	Unknown	Low	Unknown	Relatively long-lived	Coppice[A], long cycle, ?phase	Trees 6-10 m

Taxon name	Rank	Coppicing ability	Suckering propensity	Growth rate	Weed potential	Wood density	Longevity	Crop type	Plant Height
A. retinodes var. *uncifolia*	3	Unknown	Present and absent	Fast	Low	Unknown	Unknown	Phase	Shrubs/trees 5-10 m
*A. rivalis**	2-3	Absent (or low frequency)	Absent (seemingly)	Moderate - fast	Low	Unknown	10-15	Phase	Shrubs/trees 3-5 m
A. rostellifera	3	Unknown (but possible)	Vigorous	Moderate	Low - moderate	727-948	About 20	Phase[B]	Shrubs/trees 2-5 m
A. salicina	1-2	High (young plants)	Vigorous	Relatively fast	Low - moderate	550	Greater than 50	Phase[B], long cycle, ?coppice[B]	Shrubs/trees 7-13(-20) m
A. saligna	1	High (at least in some plants)l	Moderate or vigorous	Fast to very fast	High	469-735	10-20	Phase, coppice	Shrubs/trees 2-10 m
A. stenophylla	3	High	Vigorous	Moderate to fast	Moderate to high in some areas	690-750	Long-lived	Phase[B], long cycle[B], ?coppice[B]	Shrubs/trees 4-12(-20) m
A. victoriae	3	Present (but variable)	Vigorous	Fast	Low to moderate	739 - 890	10-15	Phase[B]	Shrubs/trees 2-5(-9) m
A. wattsiana	3	Unknown (but possible)	Moderate	Moderately fast	Low	Unknown	Unknown	Phase	Shrubs 1-4(-6) m

Species profiles of most prospective taxa

The information in the 35 species profiles presented below was derived from published and unpublished sources, through discussions with relevant specialists, by accessing national herbarium collections and databases, and from field study of the taxa. We have identified information sources insofar as possible. However, authors do not always cite their sources, thus in some cases we may have inadvertently presented derived information. Also, it has not been possible to verify the accuracy of all information presented here from cited sources.

The following classes of information are presented for each species.

Botanical name. Currently accepted names and authors are those cited in the two recent reviews of Australian Acacias, namely, the *Flora of Australia* vols. 11A and 11B (Orchard & Wilson 2001) and/or the *WATTLE CD* (Maslin 2001a). In the case of A. *bartleana* and A. affin. *redolens* these taxa came to light subsequent to the publication of these reviews.

Common name. Only the most frequently cited common names are listed, including the Standard Trade Name (as cited in Standards Association of Australia 1983) in cases where these have been applied.

Distribution map. Information used to generate species distribution maps was obtained from point source data supplied in December 2001 through the *Australia's Virtual Herbarium* project. Only the natural distributions (not naturalized occurrences) of species are mapped here. For further information **Methods** above.

A brief description of the species geographic range is presented under the **Distribution** heading and notes on its ecological preferences are given under **Habitat** (references to more detailed ecological information are provided).

Climatic profile maps. These maps show (in blue) the predicted growing areas based only on climatic attributes; other factors (such as edaphic requirements) may well preclude the species from being successfully cultivated in the areas shown. See above text under **Selection criteria: distribution** for cautionary note on interpreting these distributions.

Photographs. These show a range of relevant plant attributes. Growth form, including plant size and stem architecture, and wood characters were our primary focus, but also included are photographs to aid in the identification of the species.

Habit. The short plant descriptions focus on growth characteristics relevant to the project. References to more detailed botanical descriptions are provided under each species treatment.

Taxonomy. Relevant taxonomic notes are presented under this heading. Notes on the value of taxonomic information are given above in the Introduction under **Classification of Acacia.**

Flowering and fruiting. Details of flowering and fruiting were derived mainly from herbarium label information and as such are commonly only approximations of when flower and fruits can be expected to occur. In a few cases more precise information was available from published sources. Flowering and fruiting can vary with seasonal conditions, especially the timing and intensity of rainfall events; furthermore, widespread species in particular can be expected to vary across their range. Our phenological information should therefore generally be treated as only a guide to expected flowering and fruiting times.

Biological features. This information was collated primarily from published sources, supplemented by our somewhat limited field experience of the species. Information on **Genetics** and **Toxicity** is presented if these data exist.

Cultivation. Apart from the relatively few taxa that have been extensively tested abroad there are relatively few relevant propagation data available for the 35 prospective species. Within Australia some of these species have been used in revegetation programs and this has yielded useful information. Nevertheless, most of the critical silvicultural information necessary for crop development of these species in the semi-arid agricultural zone is yet to be acquired.

Weed potential. A subjective assessment of weed potential for each species has been made. Weediness is clearly an important issue but it is not considered appropriate at this early stage of the selection process to preclude or unduly negatively weight species on this character (see discussion above under **Weed potential of *Acacia* in target area**).

Wood. For the majority of species relatively few wood details are known. Basic density information is given where these data could be obtained from either published or unpublished sources. However, density and other important wood characteristics are likely to vary depending upon plant age, growing conditions and perhaps provenance. Detailed wood testing will soon be conducted under the auspices of the 'Search' and 'Florasearch' projects for the 35 prospective species identified in this report.

Utilisation. Published suggested uses for species are presented under this heading. This does not include wood crop usage that is covered under the following heading.

Potential for crop development. Based on our assessment of available information the potential of species as wood crops for agriculture in southern Australia is discussed under this heading. A subjective assessment of their relative importance (i.e. ranking) is given together with the crop type(s) we consider each is best suited to (see Table 6). Both the desirable attributes of each species and the potential constraints for its development are discussed.

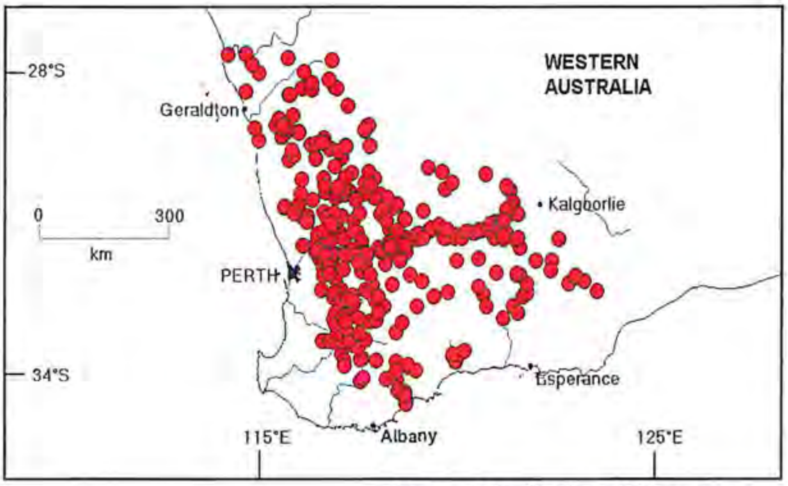
Acacia acuminata Benth.

Common Name

Jam.

Special note

Maslin *et al.* (1999) conducted a preliminary taxonomic review of *A. acuminata* and showed that the species appears to comprise five main variants. Insofar as the current project is concerned it is *A. acuminata (typical variant)*, *A. acuminata (narrow phyllode variant)* and *A. acuminata/burkittii (Variant 2)* that have the best potential for wood biomass production and therefore it is these taxa that are detailed here. Most publications on *A. acuminata* appeared prior to the Maslin *et al.* (1999) study and it is likely that the information they contained refer to the typical and narrow phyllode variants; the name *A. acuminata* is used in the broad sense below to identify these previously published data.



Map 4. Distribution of *A. acuminata*.

Habit

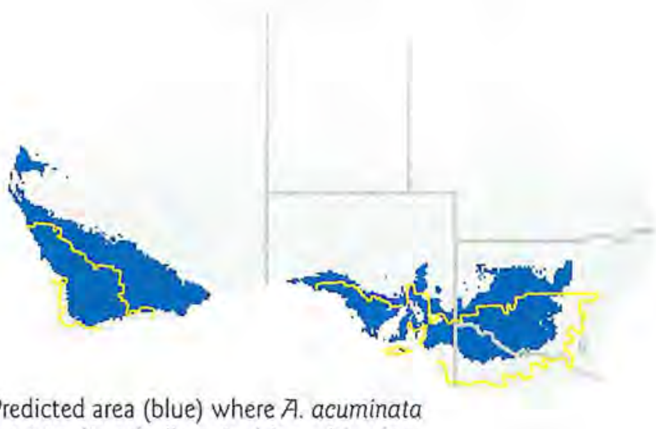
Typical variant. Tall obconic shrubs or trees 3–7 (–10) m high, plants in open sites away from competition tend to have wider and more rounded crowns (to about 8 m across) than those from within closely spaced (about 1–3 m apart), often monospecific, populations; branchlets ascending to erect or rarely pendulous to sub-pendulous; few-branched at ground level (2–6 main stems) or with a single, straight to almost straight bole 0.3–1.5 (–2) m long and 10–30 (–45) cm dbh; crowns dense, rounded to sub-rounded and up to 7–8 (–10) m across.

Narrow phyllode variant. Obconic or rounded shrubs or small obconic trees commonly 2–5 m tall and 1.5–4 m wide, sometimes (e.g. around granite rocks) trees 6–7 m tall and spreading to about 7 m across, plants in open sites away from competition tend to have more rounded crowns than those in dense populations; with 2–6 main stems arising from ground level, sometimes with a single bole up to 0.5 (–1) m long, the main stems rather straight, slender and ascending to erect; crowns dense to mid-dense, rounded to sub-rounded, spreading and occupying 20–40% of the total plant height.

Acacia acuminata/burkittii (Variant 2). Rounded or obconic shrubs or trees 3–6 m tall, dividing at or up to 1 m above ground level into a few main stems.

Bark (all variants) longitudinally fissured on main stems (especially near base), smooth on upper branches, grey.

Botanical descriptions and illustrations/photographs of the above three variants are given in Maslin *et al.* (1999).



Map 5. Predicted area (blue) where *A. acuminata* (all variants) is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 4), see also Table 5. Target area shown in yellow.

Figure 1. *Acacia acuminata* 'typical' variant

A – Mature tree showing characteristic obconic outline. (Photo: B.R. Maslin)

B – Single-stemmed tree. (Photo: M.W. McDonald)

C – Regeneration from rootstock (apparently rare in this species) following fire. (Photo: B.R. Maslin)

D – About 8 year old *A. acuminata* plants in Sandalwood host trials near Katanning, W.A. (Photo: J. Brand)

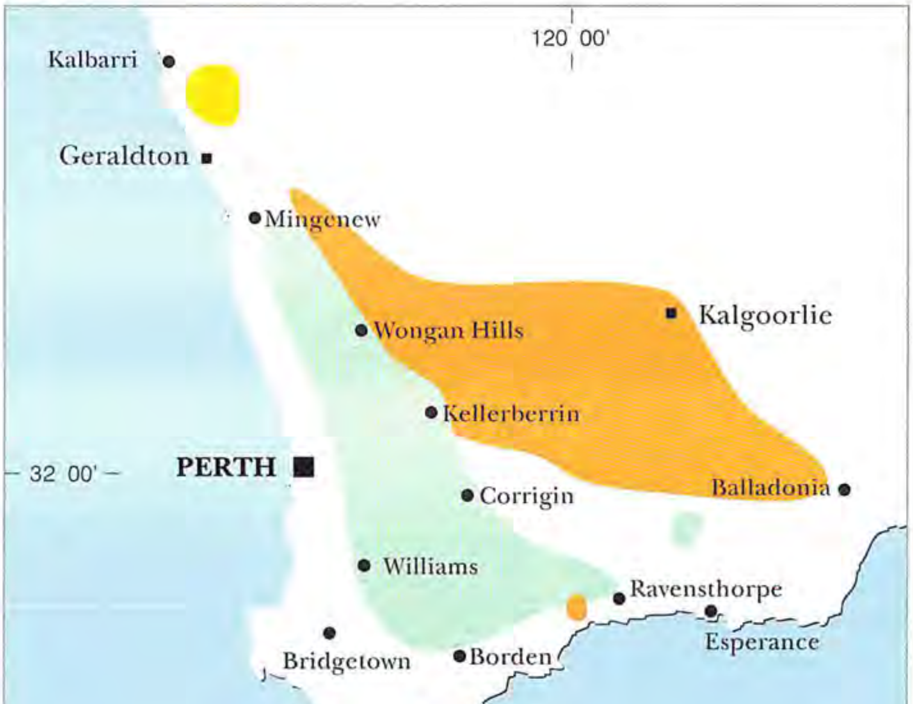
E – Flowering branch showing sessile spicate inflorescences. (Photo: M.W. McDonald)

Taxonomy

Acacia acuminata is referable to *Acacia* section *Juliflorae* a diverse, and probably artificial, group of about 235 species (Maslin 2001) which are characterized by having plurinerved phyllodes and flowers arranged in cylindrical spikes (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Section *Juliflorae* is widespread in Australia with the main centres of species richness occurring in the north, northwest and southwest of the continent and secondary centres of richness located along the Great Dividing Range in eastern Australia; although plants of this group often form a conspicuous element of the arid zone flora, species numbers in these areas are generally not great (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). Only three species of section *Juliflorae* are detailed in this report, namely, *A. acuminata*, *A. doratoxylon* and *A. lasiocalyx*.

As discussed by Maslin *et al.* (1999) *A. acuminata* is a polymorphic species showing complex variation patterns in phyllodes, pods and growth form. Most of the variation is contained in three informal variants, namely, *A. acuminata* typical, narrow phyllode and small seed variants. Two additional variants, referred to as *A. acuminata/burkittii* Variant 1 & 2, which may represent hybrids involving *A. burkittii*, occur in the Geraldton area. These taxa are separated by finely graded morphological differences (mainly phyllode and pod/seed features) and are broadly supported by chloroplast DNA and isozyme data. However, further study is needed before they can be formally described and their complex patterns of variation and evolutionary relationships fully understood.

Acacia acuminata has very close affinities to the widespread arid zone species *A. burkittii*, a relationship that is embodied in a recent classification by Kodela & Tindale (1998) where they are treated as subspecies, namely, *A. acuminata* subsp. *acuminata* and *A. acuminata* subsp. *burkittii*. Although this classification is not adopted here the rank of all taxa in the *A. acuminata* group will need to be reassessed in the light of further taxonomic study. Other species (all from Western Australia) closely related to *A. acuminata*, but which are not considered worthy of inclusion in the present report, are *A. drepanophylla*, *A. jibberdingensis*, *A. multispicata*, *A. oldfieldii* and *A. sessilispica*.



Map 6. Indicative distribution of *A. acuminata* discussed in text: 'typical' variant – green, 'narrow phyllode variant' – orange, *acuminata/burkittii* (variant 2) – yellow.

Distribution and habitat

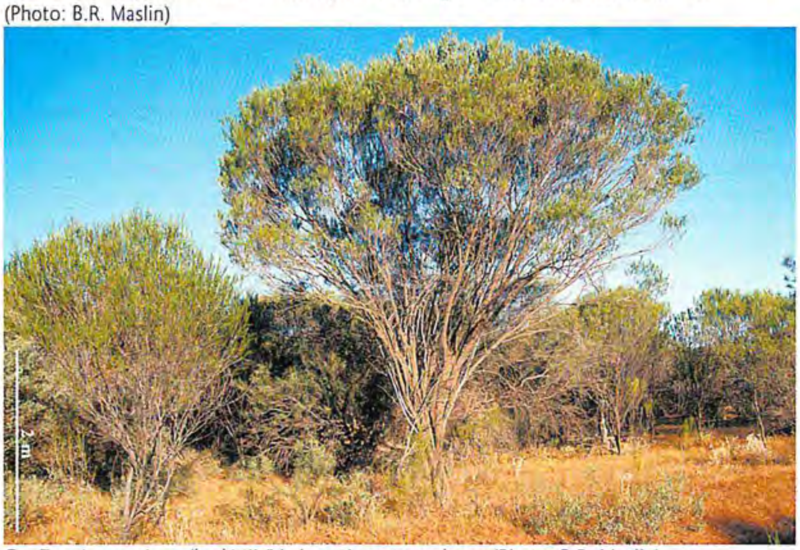
Acacia acuminata is confined to the wheatbelt region of southwest Western Australia, and its distribution is mostly within the target area. This species is quite common in the places where it occurs. Indicative distributions of the three variants included in this report are shown in Map 6 (see Maslin *et al.* 1999 for further details).

Typical variant. Occurs in the western part of the wheatbelt from near Mingenew south to Borden and Ravensthorpe with an apparent outlier from

Figure 2. *Acacia acuminata* (variants)

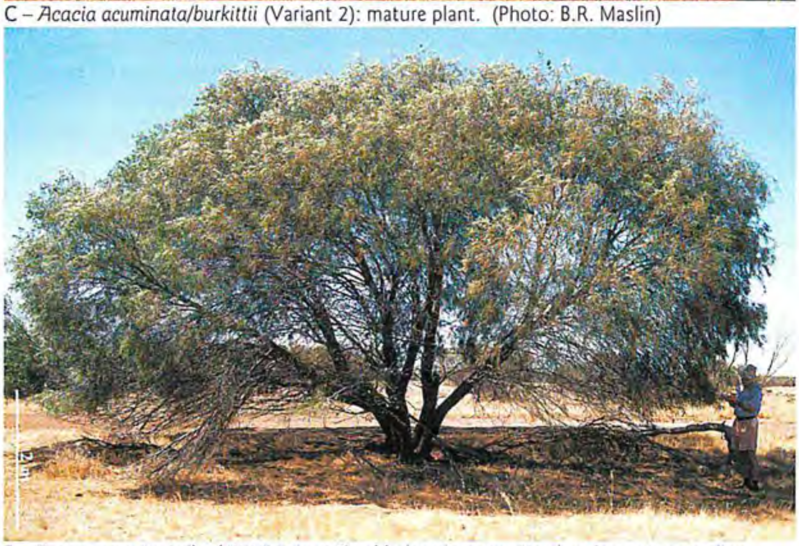
A – 'Narrow phyllode variant': mature plant showing characteristic obconic outline. (Photo: B.R. Maslin)

B – 'Narrow phyllode variant': multi-stemmed base. (Photo: B.R. Maslin)



C – *Acacia acuminata/burkittii* (Variant 2): mature plant. (Photo: B.R. Maslin)

D – 'Narrow phyllode variant': young branch showing very dark heartwood & pale sapwood. (Photo: B.R. Maslin)



E – *Acacia acuminata/burkittii* (Variant 2): old plant in open site showing very spreading growth habit. (Photo: B.R. Maslin)

F – 'Narrow phyllode variant': flowering branch showing sessile spikes & phyllodes characteristically fringed with minute hairs. (Photo: S. Armstrong)

Peak Charles, about 130 km due northeast of Ravensthorpe Most commonly occurs in brown loamy clay or sandy loam (pH 5.5–7) in lower parts of the landscape (often near water courses) or in low hilly country, in low eucalypt Woodland. Soil colour varies from dark brown, red-brown, pink-brown to grey-brown. It has also been recorded from shallow white sand over laterite near Corrigin, from clays and from around granite outcrops. At the northern extremity of its range this variant may occur on low sandy rises associated with salt lakes.

Narrow phyllode variant. Occurs in the northern, central and eastern wheatbelt region and extending just into the adjacent arid zone. It extends from near Morawa southeast to Balladonia with an outlier near Ravensthorpe. Commonly found on brown or red-brown loam or clay-loam flats (pH 6–7) in tall shrubland or open eucalypt woodland. It is also commonly found on sandy loam associated with granite rocks and commonly forms dense fringing communities around the base of these outcrops. It has also been recorded from low sand rises associated with salt lakes and appears slightly to moderately salt tolerant.

Acacia acuminata/burkittii (Variant 2). Common in the Northampton–Nabawa area but ranging south to Eradu (Greenough River) and Mt Fairfax, and north to Ajana on the Murchison River. Low hilly country in rich brown clay-loam (pH 6–7).

Comprehensive habitat details are provided for *A. acuminata* by Hall & Turnbull (1976), Boland *et al.* (1984) and Barrett (1995), but as these works were published prior to that of Maslin *et al.* (1999) the information presented is not aligned against the variants that are now known to exist within the species.

Flowering and fruiting

Typical variant. Flowers from September to October. Fruiting specimens with mature seeds have been collected mainly between mid-December and mid-January, infrequently in late November. This variant is somewhat variable in its fruiting. In some years pods may fail to develop completely, or only a proportion of the plants will set fruit.

Narrow phyllode variant. Flowers from late July to September, sometimes extending to October. Pods with mature seed have been collected mainly in late November and December. Not all trees in a population necessarily produce fruit and those that do commonly display considerable differences with regard to the amount of fruit set. It is not known what factors cause this variation but it is likely that the timing and/or intensity of rainfall events play a role.

Acacia acuminata/burkittii (Variant 2). Flowers from August to September. Mature seeds appear from late November to December.

Biological features

Moderately fast growth rate and moderately long-lived (perhaps in excess of 50 years). Coppicing ability absent or very low; unlikely to sucker. It is drought and frost tolerant but will not tolerate waterlogging (Barrett 1995). It is reported to be killed by fire (Hussey, pers. comm.), however, following a recent fire near Brookton most plants of the typical variant resprouted vigorously from the base of the burnt stems. Roughley (1987) noted that *A. acuminata* is a promiscuous host with nodulation by 75–100% of the 20 *Rhizobium* strains tested. An analysis of gum characteristics of *A. acuminata* is given in Anderson *et al.* (1980); under natural conditions plants of this species produce very little gum.

Genetics

The results of detailed chloroplast DNA and isozyme studies of genetic diversity and phylogeographic patterns of variation in *A. acuminata* are presented in Maslin *et al.* (1999), Broadhurst & Coates (2002) and Byrne *et al.* (2002).

Cultivation

A detailed review of germination techniques for *A. acuminata* is provided in Barrett (1995). As noted in Maslin *et al.* (1999) growth form of this species (in nature, and therefore probably also in cultivation) can vary depending upon spacing between plants (i.e. a more upright habit occurs when plants are closely spaced).

Trials

Assessment trials of *A. acuminata* were recently established in plots on farmland at various locations in south-western Australia by the "Search" project (see Acknowledgements). At age 10 months plants of the best performing provenance of 'typical' *A. acuminata* showed an average survival of 84% and an average height of 79 cm. The 'best' plot was located on a downslope site with heavy soil in the southern Avon Wheatbelt IBRA region, with plants averaging 133 cm high.

The 'narrow phyllode' variant of *A. acuminata* was also included in the 'Search' trials but did not perform as well as the 'typical' variant. At age 10 months plants of the best performing provenance of this variant showed an average survival of 54% and an average height of 49 cm. The two 'best' plots were located on a downslope site with light soil in the northern Avon Wheatbelt IBRA region and a saline seep site in the Mallee region, with plants averaging 60 cm high.

Pests and diseases

Plants of both the typical and narrow phyllode variants of *A. acuminata* sometimes show signs of light Gall Rust infection. In the Toodyay–York area in particular the typical variant is sometimes heavily infected with the aerial parasite, *Amyema*, as are some plants of *A. acuminata/burkittii* (Variant 2) from near Northampton.

As summarised by Barrett (1995) larvae of the Bag-Shelter Moth can cause severe defoliation, and eventually death; also, locusts, wingless grasshoppers, rabbits, and other native and feral animals can also cause severe grazing damage.

Weed potential

No records of weediness for this species. Does not display any weed tendencies in its natural habitat despite producing prolific quantities of seed.

Wood

Hard and durable with the odour of Raspberry Jam when freshly cut. The wood is finely textured with an attractive grain (often with fiddleback). The heartwood is dark chocolate brown and the sapwood pale yellowish. It has a basic density of 899 kg/m^3 (Ilic *et al.* 2000: note, the value 1171 kg/m^3 which also appears in this report for this species should have been listed under the air-dry density column). A basic density value of 1077 kg/m^3, based on analyses of a single wood sample is also reported by CALM's NHT-supported 'Search' project (unpublished data).

Utilisation

Wood

As summarised by Barrett (1995) the wood is used for craft and turning, fencing, specialty saw logs (however, only the typical variant would be suited to this purpose) and occasionally charcoal.

Land use and environmental

Acacia acuminata is generally considered well-suited for revegetation in the wheatbelt, particularly for well-drained loamy soils (see Wilcox *et al.* 1996 and Lefroy *et al.* 1991); it often regenerates well in previously cleared areas once grazing animals are excluded (amount of regeneration dependent upon how long the land has been under pasture). It provides good shelter and has been used for erosion control. It would be suited to amenity planting.

Sandalwood silviculture

The various forms of A. *acuminata* and its close relative A. *oldfieldii* are currently under trial in Western Australia to assess their suitability as Sandalwood (*Santalum spicatum*) host plants (Brand 2002, Woodall & Robinson 2002).

Fodder

Streets (1962) states that the phyllodes make excellent fodder but other authors place little value on the species for this purpose (Hall & Turnbull 1976).

Other uses

Acacia acuminata has sometimes been advocated as a human food because the seed is said to have a good 'nutty' flavour; however, it is not recommended for large-scale production of seed by Maslin *et al.* (1998) because of its annual variability in pod production.

Potential for crop development

Acacia acuminata is regarded as having only moderate prospects as a crop plant for high volume wood production. It is ranked a category 3 species (see Table 6) and current evidence suggests that it would be best suited to development as a long cycle crop for solid wood products. Its very dense wood lowers its attraction for use in reconstituted wood products. It has only a moderately fast growth rate and there are many other species (especially eucalypts) within its geographic area of occurrence that are likely to perform much better. Nevertheless, additional to its use in sandalwood silviculture A. *acuminata* is regarded as important in Western Australia because it is one of the few common, arborescent acacias that occur in the cropping zone of that State. Silviculturally jam has a number of desirable attributes: it is genetically diverse, has a reasonably wide ecological tolerance, is easy to germinate and apparently does not sucker. Although the variants of Jam discussed above produce reasonable quantities of woody biomass, their suitability as a fuel stock for bioenergy will depend upon them attaining acceptable growth rates under cultivation; other acacias such as A. *saligna*, A. *microbotrya* etc. are likely to do better in this regard. Any utilisation of Jam will need to take account of the taxonomic variation within this species in order that the appropriate variant/ provenance is used (special care should be taken if plants from the Geraldton area are used as there is much unresolved taxonomic complexity in that area).

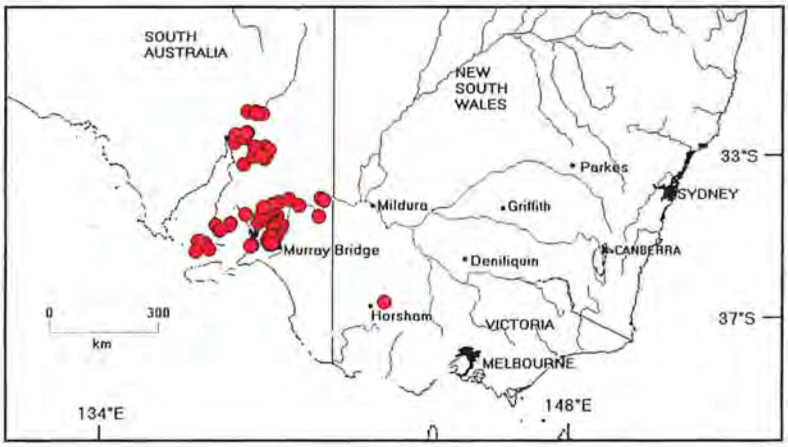
The area predicted to be climatically suited to the cultivation of A. *acuminata sens. lat.*, based on its natural climatic parameters, is shown in Map 5. This analysis indicates that A. *acuminata* is suited to the climatic conditions prevalent throughout the target area in Western Australia and much of the eastern target area. It predicts conditions suitable for growth well beyond its natural distribution in South Australia, Victoria and New South Wales. In the eastern target area, the 300 metre elevation contour appears to represent the limit of climatic conditions suitable for its cultivation. This suggests cold winters and low temperatures will be a limiting factor for its successful cultivation. This species has the potential to be cultivated on a wide range of loamy soil types.

Acacia argyrophylla Hook.

Common Name

Silver Mulga.

Habit



Map 7 Distribution of *A. argyrophylla*.

Erect, hardy shrubs 2–3 m high and often the same across, crowns dense, multistemmed or with a very short bole (to c. 0.3 m long), the stems sub-straight, ascending to erect stems and c. 6 cm dbh, however, on oldest plants the main stems may reach c. 11 cm dbh and become somewhat crooked. New shoots sericeous with bright greenish yellow hairs. Mature phyllodes silvery grey due to a layer of dense, appressed hairs. Flower heads golden yellow.

Botanical descriptions and illustrations/photographs are provided by Simmons (1988), Whibley & Symon (1992) and Maslin (2001 & 2001a).

Taxonomy

Acacia argyrophylla is referable to *Acacia* section *Phyllodineae*, a large, diverse and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Species of section *Phyllodineae* are widespread in Australia with the main centres of richness located in temperate and adjacent semiarid areas of eastern, southeastern and southwestern Australia; species numbers greatly decline in the arid zone and in northern tropical/subtropical areas (Hnatiuk & Maslin 1988 and Maslin & Pedley 1988).

As discussed by Maslin (2001) the taxonomic status of *A. argyrophylla* deserves further attention, in particular, its relationship to certain forms of the highly variable close relative *A. brachybotrya* (not detailed in this report). In some cases hybridity between the two species is suspected.

Map 8. Predicted area (blue) where *A. argyrophylla* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 7), see also Table 5. Target area shown in yellow.

Distribution and habitat

Occurs in South Australia from the Flinders Ranges near Hawker south to Monarto and the western Murray Mallee region, with isolated populations occurring on the Yorke Peninsula and Onkaparinga Gorge. This geographic range is contained mostly within the confines of the target area. It is reasonably common in the areas where it occurs but much of its native habitat has been cleared for agriculture so it is often found only along degraded road verges. An isolated occurrence from near Murtoa

Figure 3. *Acacia argyrophylla*

A – Adult plant showing dense crown & stem branching near base. (Photo: B.R. Maslin)

B (above) – Plants in 5 year old alley farming trial at Palmer, S.A.

C (above right) – Flowering branch showing characteristic silver-grey mature phyllodes & yellow new growth.

D (right) – Section of stem of mature plant; when first cut a clear gum exuded from interface of sapwood & heartwood. (Photos: B.R. Maslin) in Victoria is now presumed extinct (see Court 1973). Favours calcareous clay loams on low undulating hills.

Flowering and fruiting

Flowers from July to November (Whibley & Symon 1992) and pods with seed occur from December to February (some old seed is often retained in the pods throughout the year according to Martin O'Leary, pers. comm.). Seeds may mature in November in hot dry seasons (Bonney 1994).

Biological features

Growth rate moderately fast in cultivation (see below). Might reach c. 30 years old (M. O'Leary, pers. comm.). Has the ability to coppice if cut near ground level; unlikely to sucker; produces large quantities of seed.

Genetics

Possibly hybridizes with A. *retinodes* ('typical' variant): see under that taxon below for notes.

Cultivation

In a 5 year old alley farming trial at Palmer in S.A. (350 mm rainfall zone) the best plants reached 2–2.5 m tall and developed about 10 stems (2–3.5 cm dbh) following coppicing (unknown when coppicing occurred).

Weed potential

No records of weediness for this species. Does not display any weed tendencies in its natural habitat (which is predominantly located in a highly disturbed agricultural landscape) despite producing prolific quantities of seed.

Wood

Based on field observations from one plant, the wood was observed to be reasonably light weight relative to its volume. The sapwood was white and there was an extensive development of light brown heartwood. When first cut a clear gum was exuded at interface of sapwood and heartwood.

Utilisation

Land use and environmental

Useful as a low windbreak and because it usually has more breadth than height it could possibly be used as a weed suppressant (D. Kraehenbuehl, pers. comm.).

Other uses

Useful for ornamental and amenity plantings on account of its very attractive foliage (D. Kraehenbuehl, pers. comm.).

Potential for crop development

Acacia argyrophylla is not regarded as particularly prospective as a crop plant for high volume wood production. It is ranked as a category 3–4 species and current evidence suggests that it would be best suited to development as a phase crop (Table 6). It is a hardy species that produces a reasonable amount of woody biomass but the wood is contained in numerous, relatively small stems. The wood appears to be reasonably light weight. Although A. *argyrophylla* has a moderately fast growth rate in cultivation under quite dry conditions in its native environment, its potential to become a major wood crop is not high. Other South Australian prospects such as A. *retinodes* ('typical' variant) and A. *rivalis*, which occur in the same geographic area as A. *argyrophylla*, are likely to perform much better (i.e. grow faster and/or produce higher volumes of woody biomass).

The area prediced to be climatically suitable for the cultivation of A. *argyrophylla*, based on its natural climatic parameters, is shown in Map 8. This analysis indicates that A. *argyrophylla* is well suited to climatic conditions over large parts of both the eastern and western target areas. The parts projected as suitable in New South Wales, South Australia (Eyre Peninsula) and Western Australia, are well beyond the range of its natural distribution. This is a notable result given its relatively narrow natural distribution. The areas projected comprise the 250–500 mm rainfall zone of both target areas. Within this region A. *argyrophylla* would be best suited to sites with calcareous clay loams.

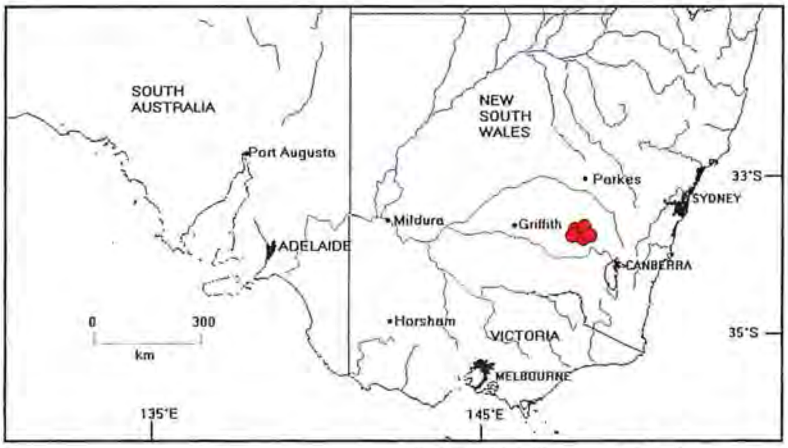
Acacia baileyana F. Muell.

Common Name

Cootamundra Wattle.

Habit

Large bushy shrubs or small trees commonly reaching 5–10 m high, typically freely branching from 1–2 m above the ground, less commonly with 2 or 3 main stems from ground level, plants in dense regrowth stands are somewhat spindly whereas in open sites they tend to be more robust with a more openly branched and spreading habit, main stems normally about 10–20 cm dbh (Maiden 1908b reports one exceptional tree as having a trunk diameter of about 60 cm!), boles and main stems straight to sub-straight; crown normally silvery blue-grey or blue-green in colour. Bark thin, smooth, grey or brown.



Map 9. Distribution of *A. baileyana*.

Cultivars with purple or yellow leaves, reddish new growth or prostrate form, are now available (Whibley & Symon 1992); these forms can be grown from cuttings (Simmons 1988).

Botanical descriptions and illustrations/photographs are provided by Maiden (1908b), Cunningham *et al.* (1981), Costermans (1981), Simmons (1988), Tame (1992), Whibley & Symon (1992), Tindale & Kodela (2001 & 2001a) and Kodela (2002).

Taxonomy

This species belongs to *Acacia* section *Botrycephalae*, a group of 44 mostly arborescent species characterized by having bipinnate adult foliage and flower heads normally arranged in elongated racemes (Orchard & Wilson 2001). These species predominate in temperate areas of eastern and southeastern Australia (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). There are seven species of *Botrycephalae* detailed in this report, namely, *A. baileyana, A. dealbata* subsp. *dealbata, A. decurrens, A. filicifolia, A. leucoclada* subsp. *leucoclada, A. mearnsii* and *A. parramattensis*. A number of recent studies have suggested that species of section *Botrycephalae* are most closely related to certain racemose species of section *Phyllodineae* (foliage phyllodinous) from eastern Australia, see Maslin & Stirton (1998) and Maslin *et al.* (2003) for reviews.

Of the phyllodinous species included in this report those having presumed closest affinities to species of *Botrycephalae* include *A. linearifolia, A. neriifolia* and *A. pycnantha*; members of the '*Acacia microbotrya* group' are not far removed from these species.

Acacia baileyana is known to hybridize with a number of its close relatives, especially *A. decurrens* (see **Genetics** below). A study by Tindale & Roux (1969) of flavonoid and condensed-tannin contents of the heartwood and bark of *Acacia* recognized four groups within section *Botrycephalae*; this study grouped *A. baileyana* and *A. dealbata* together.

Map 10. Predicted area (blue) where *A. baileyana* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 9), see also Table 5. Target area shown in yellow.

Figure 4. *Acacia baileyana*

A (above) – Adolescent plant in dense regrowth stand near Temora, N.S.W. B (top right) – Stem dividing above ground level. C (bottom right) – Stem dividing at ground level. (Photos: B.R. Maslin)

D (above) – Mature plant in natural stand near Cootamundra, N.S.W. (Photo: B.R. Maslin). E (top right) – Section of stem (mature plant) showing pale-coloured wood. (Photo: B.R. Maslin). F (bottom right) – Branch showing prolific flowering & bluish bipinnate leaves. (Photo: M. O'Leary)

Distribution and habitat

This species has a very restricted natural distribution and is confined to the target area in the Temora–Stockingbal–Cootamundra district, New South Wales, a distance of just 50 km (Tindale & Kodela 2001: 224-225; see also notes by Cootamundra Landcare at www.cootamundra.nsw.gov.au/wattle.html). However, *A. baileyana* has been extensively planted as an ornamental outside its natural range, both within Australia and abroad, and in some places it has become naturalized (see under **Weed potential** below). In its natural habitat, *A. baileyana* grows in open woodland, in stony, hilly country, on clay or clay loams derived from granites and porphyries. Detailed ecological information is given in Hall & Turnbull (1979).

Flowering and fruiting

Flowers mostly between June and early September with individual trees flowering for only a few weeks (Boden 1969); Whibley & Symon (1992) report observations by L. Pryor of both early and late flowering variants. Flowering commences when plants are two years old (Morgan *et al.* 2002). Experiments conducted under controlled conditions showed that plants of this species require warm temperatures for bud formation (at or above a mean maximum of 18°C and a minimum of 13°C), and cool temperatures for flowering (at or below a mean maximum of 16°C and a minimum of 9°C) (Morgan & Sedgley 2002). Pods mature from October to January (Tindale & Kodela 2001).

Biological features

A fast-growing, frost resistant, fairly hardy species that prefers cool, higher rainfall areas. It is not especially long-lived. For example, when planted on dry and otherwise unfavourable sites it may commence to deteriorate at 10–12 years (Boland *et al.* 1984), although on better sites it may live longer, but probably rarely more than 30–40 years (Hall & Turnbull 1979). Whibley and Symon (1992) report that plants cultivated at the Waite Arboretum in Adelaide lived from 10–26 years with an average of 17 years for six trees. This species does not coppice to any extent or root sucker.

Detailed life history studies of *A. baileyana* are provided by Newman (1933, 1934 & 1934a) in which ecological, vegetative and reproductive phases were examined.

Genetics

As noted by Tindale & Kodela (2001) *A. baileyana* commonly hybridises with *A. decurrens* and occasionally with *A. dealbata*, *A. oshanesii*, *A. pubescens*, *A. spectabilis* and *A. leucoclada*; specimen label information of the NSW Herbarium suggests that it also hybridises with *A. parramattensis*; it is also recorded as hybridizing with *A. mearnsii* in cultivation in South Africa (see *A. mearnsii* for references). The hybrid with *A. decurrens* is referred to as *A.* x *nabonnandii* Nash in Jacobs & Pickard (1981) and is discussed by Cheel (1935). A study of breeding systems and reproductive biology by Morgan *et al.* (2002) showed *A. baileyana* to be outcrossing and highly self-incompatible.

Chromosome number: n = 13 (Newman 1933).

Cultivation

Pre-sowing germination treatments are given in Aveyard (1968). It is not suited to growing in arid areas or on limestone soils (Simmons 1988).

There is very little trial information available for this species. Ryan & Bell (1989) incorporated one seedlot of *A. baileyana* in two trials near Gympie, Queensland. At age 3.4 years the plants in one trial were 4.37 m tall with stem diameter at ground level measuring 9.8 cm while at the other they were 3.09 m tall with a 7.4 cm ground level diameter. By contrast, *A. decurrens* under trial in this same region attained similar growth dimensions when only 18 months of age. We observed *A. baileyana* under cultivation at the Burrendong Arboretum where it performed well in the absence of supplementary watering; adolescent plants here (age unknown) were 5 m tall and developed single straight stems about 8 cm dbh. Burrendong Arboretum is located about 20 km due southeast of Wellington, just outside the target area near its north eastern corner (Wellington has a mean annual rainfall of 620 mm).

Pests and diseases

Whibley & Symon (1992) report that, based on records at the Adelaide Herbarium, the only mistletoe recorded on this species is *Amyema preissii*, a wire-leaved mistletoe which infests many species of *Acacia*.

Weed potential

Acacia baileyana is an environmental weed both within Australian and abroad. In certain areas, especially higher rainfall districts, the species has spread from garden plantings into surrounding areas. Within Australia invasive populations occur in parts of Western Australia, South Australia, Queensland, New South Wales and Victoria (Hall & Turnbull 1979; Tindale & Kodela 2001 provide maps of both the native and naturalized distributions); the species has also become naturalized in New Zealand (Webb *et al.* 1988) and South Africa (Henderson 2001, who provides a map of its distribution there). In South Africa *A. baileyana* is a Declared Invader (category 3) weed.

Morgan *et al.* (2002) showed that from a biological perspective, precocity and high flower numbers, resulting in high seed production, appear to be major factors for the weediness of *A. baileyana*. Under appropriate conditions seedlings establish in large numbers; fires and mechanical disturbance (e.g. along road verges and power lines, etc.) can increase the spread by stimulating mass germination. The dispersal of plants/seed by humans is an important factor in the weed success of this species.

Wood

Little information is available except that the wood is described by Hall & Turnbull (1979) as pale coloured, rather weak and not highly durable. Our limited field observations (one sample) show the wood to be pale coloured with an extensive development of white sapwood and a small amount of weakly coloured (light brownish) heartwood; this wood displayed substantial splitting upon drying due to shrinkage.

Utilisation

Wood

According to Anderson (1968) the wood of this species has little value other than possibly as a source of second-grade fuel. However, see under **Potential for crop development** below.

Land use and environmental

Grown in places as a wind break but its relatively short life span is regarded by Cunningham *et al.* (1981) as being a disadvantage when used for this purpose. It is regarded by Hall & Turnbull (1979) as useful for shade and shelter in suitable areas.

Fodder

Sheep and cattle are reported to eat the seedlings (Newman 1935), but it is not recognised as a species with any value as a source of fodder (Hall & Turnbull 1979).

Other uses

Acacia baileyana is extensively planted as an ornamental, both for its foliage and floral display. It is grown in temperate climates of New Zealand, South America, South Africa and southern Europe (Hall & Turnbull 1979). Experiments by Morgan & Sedgley (2002) suggest that temperature could be used to manipulate flowering for the commercial production of cut stems or pot plants at specific times of the year. This species produces an abundance of pollen and is a valuable source of pollen for bees in winter (Leigh, cited in Hall *et al.* 1972). All parts of the plant can be used to dye wool (Martin 1974).

Potential for crop development

Acacia baileyana is regarded as having only moderate prospects as a crop plant for high volume wood production It is ranked as a category 3 species (see Table 6). In appropriate environments Cootamundra Wattle is capable of producing fair quantities of woody biomass, the wood is pale coloured and is likely to have a low density (thus attractive for use in reconstituted wood products). In drier areas, however, it may not achieve acceptable levels of growth or wood production. Because the species is fast growing and neither coppices nor root suckers it would be suited for development as a phase crop. However, *A. baileyana* may flower and fruit from a very young age and this phenological precocity may result in the creation of a soil seed bank which could lead to it becoming a weed in adjacent or subsequent annual crops. An alternative management strategy might be to treat the young seedlings as a form of green manure.

The area predicted to be climatically suitable for the cultivation of *A. baileyana*, based on its natural climatic parameters, is shown in Map 10. This species has a very restricted natural distribution which extends over a distance of only about 50 km, within 536–610 mm/year rainfall zone (Hall *et al.* 1981). The bioclimatic analysis, however, suggests that within the target area *A. baileyana* would be capable of being cultivated on a wide range of upland sites in the 400–650 mm rainfall zone. The area projected by the bioclimatic analysis as having suitable growing conditions for *A. baileyana* is limited by the relatively low rainfall and short dry season experienced across its natural distribution. For example, the relatively large areas where the species is known in cultivation in South Australia and Western Australia have not been projected as suitable. This infers that *A. baileyana* is a good example of a species with high levels of climatic and ecological plasticity that enable it to grow in areas that differ from those of its restricted natural habitat.

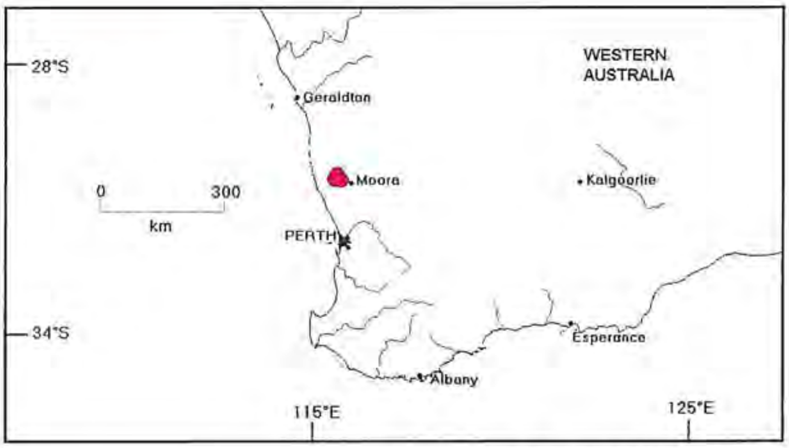
An issue associated with any development of *A. baileyana* as a crop is its potential weediness. This could be a problem particular to the wetter areas of the target zone. *Acacia baileyana* produces large quantities of seed and regardless of whether or not seedlings are treated as green manure in cultivation this species has the potential of becoming an environmental weed. Therefore, caution is needed if any wide-scale use of *A. baileyana* is undertaken, and such use must be accompanied by a thorough weed risk assessment (see also discussion on weed reduction strategies under **Weed potential of *Acacia* in target area** in the introduction to this report).

Acacia bartleana Maslin (MS name)

Common Name

Bartle's wattle.

Habit



Map 11. Distribution of *A. bartleana*.

Shapely trees 4–8 m tall but reaching 10–12 m on good sites, single-stemmed (boles straight and 2–3 m or more long) or with 2 stems from ground level, dividing at 0.5–2 m above the ground into 2–5, spreading-erect, stout, straight main branches (to 30–40 cm dbh), sometimes slight to moderate root suckering; crowns dense and spreading. Bark thin, hard, longitudinally fissured, grey.

Taxonomy

Acacia bartleana is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). More specifically this species is a Western Australian member of the Australia-wide '*Acacia microbotrya* group' (Maslin 1995). A number of other species from this group are detailed in this report, namely, *A. euthycarpa*, *A. microbotrya*, *A. retinodes*, *A. rivalis* and *A. wattsiana*.

Until now this species had been considered conspecific with *A. microbotrya* (Maslin 2001 & 2001a). However a review of this species (Maslin, unpublished) has shown that arborescent plants from west of Moora warrant recognition as a distinct species and these will soon be formally described as *A. bartleana*

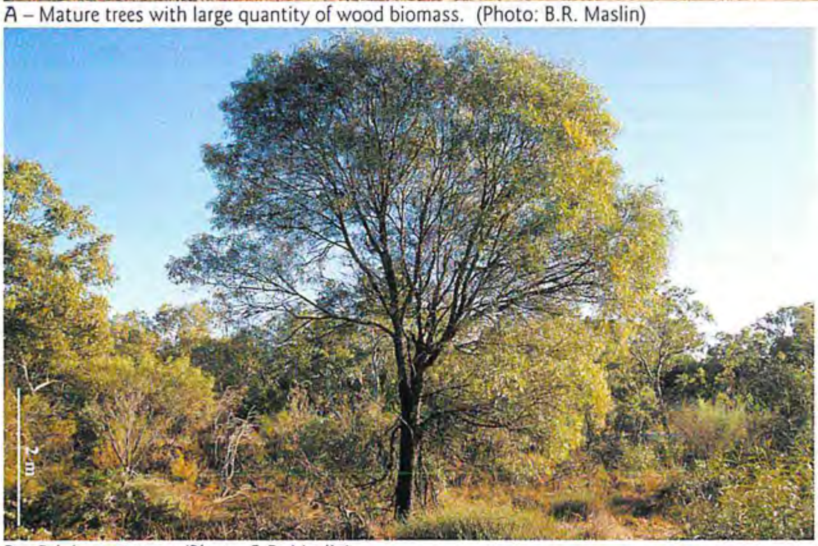
Map 12. Predicted area (blue) where *A. bartleana* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 11), see also Table 5. Target area shown in yellow.

Distribution and habitat

Current knowledge suggests that *A. bartleana* has a restricted distribution west of Moora, Western Australia (entirely within the target area), where it is known from a number of roadside populations. Grows in low hilly country on brown sandy loam (perhaps with clay at depth but this needs confirmation). It occurs both in the lower parts of the landscape near watercourses with *Eucalyptus camaldulensis* and also on hills with *E. todtiana*. One population occurs in a tall dense shrubland dominated by *Banksia* and *E. todtiana* but most other populations occur along highly degraded roadverges.

Figure 5. *Acacia bartleana*

A – Mature trees with large quantity of wood biomass. (Photo: B.R. Maslin)



B – Adolescent tree. (Photo: B.R. Maslin)

C – Section of stem showing moderately dense wood. (Photo: W. O'Sullivan)

D – Flowering branch, heads golden & phyllodes green. (Photo: B.R. Maslin)

E – 14 month old plant in trial at Esperance, W.A. (Photo: J. Carslake)

F – Fruiting branch, pods prolific & narrow. (Photo: B.R. Maslin)

Flowering and fruiting

Flowers in May and June (possibly extending to July but needs confirmation); mature seeds are present in late November and December. Prolific quantities of seed are produced by this species.

Biological features

Very little is known about this species but field observations of natural stands suggest that it probably has quite a fast growth rate and a low to moderate suckering propensity (seems to be less vigorous than *A. microbotrya* but this needs confirming). It is likely to coppice (but with what vigor and frequency is unknown) and probably lives for about 20–30 years (but this requires confirmation). Reasonable quantities of gum are exuded from fissures in the bark of some plants.

Cultivation

Pests and diseases

Wheatbelt trials in Western Australia show *A. bartleana* to be one of the few acacias that is apparently resistant to locust attack (J. Carslake, pers. comm.).

Weed potential

This species does not display weed tendencies in its natural habitat despite producing prolific quantities of seed and having some degree of suckering ability.

Wood

The basic density values range from 718 kg/m^3 to 959 kg/m^3 (mean 815 kg/m^3) based on analyses of 10 wood samples by CALM's NHT-supported 'Search' project (unpublished data). Note: This study preferentially sampled young and adolescent plants.

Utilisation

Nothing is recorded for utilisation of this species but it would be expected to have a similar potential to that of *A. microbotrya*. *Acacia bartleana* is currently being assessed for its suitability as a host for growing Sandalwood (*Santalum spicatum*).

Potential for crop development

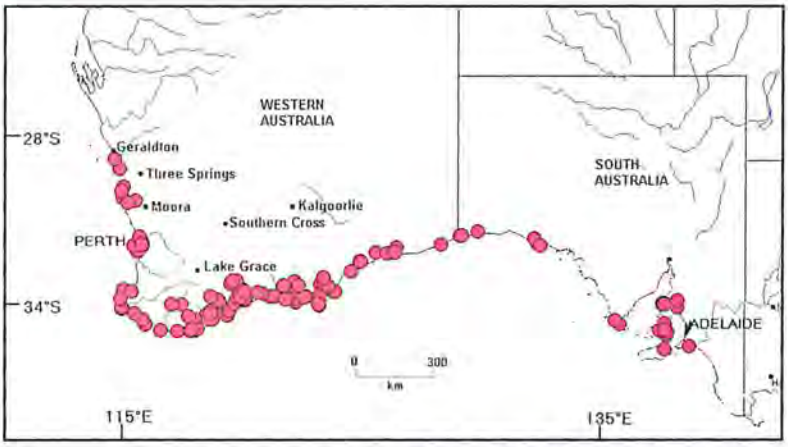
Acacia bartleana is a poorly known species but has a number of desirable features that render it prospective for development as a crop plant for high volume wood production. It is ranked as a category 2–3 species and seems best suited as a phase crop, although it may also have some prospects as a long cycle crop for solid wood products (Table 6). Although this species is likely to coppice details of its coppicing ability are unknown therefore its potential as a coppice crop cannot be assessed at present. Although *A. bartleana* displays root suckering in nature (but seems less vigorous than *A. microbotrya*) it is not known if this will present difficulties for management in cultivation. Because the species produces large quantities of seed it would be appropriate to harvest plants before they reach reproductive maturity to avoid creating a soil seed bank that may lead to weed problems in adjacent or subsequent annual crops. For this technique to be viable the plants will need to have produced acceptable quantities of wood prior to the first pod crops being set. An alternative might be to regard the seedling recruitment as a form of green manure. *Acacia bartleana* is similar to the 'typical' variant of *A. retinodes* from South Australia in displaying a very good growth form and producing excellent quantities of woody biomass. The wood, however, is moderately dense which lowers its attraction for use in reconstituted wood products.

The area predicted to be climatically suitable for the cultivation of A. *bartleana*, based on its natural climatic parameters, is shown in Map 12. Although A. *bartleana* has a very restricted natural distribution the analysis indicates that it might be expected to grow quite well under cultivation in areas outside its natural range. Judging from its natural habitat A. *bartleana* might be expected to grow on a fairly wide range of soil types and may tolerate moderately saline soils. If the species proves successful as a Sandalwood host then this would be an excellent accompaniment to it being used as a wood crop plant. Uncertainty about successful growth in rainfall zones that receive less than 450 mm appears to be a main limiting factor predicted by the bioclimatic analysis in both the eastern and western target areas. However, the ecological plasticity of A. *bartleana* is presently poorly known. Therefore trials to assess its performance in areas beyond the region predicted in the bioclimatic map may warrant consideration.

Acacia cyclops Cunn. ex Don

Common Names

Western Coastal Wattle, Rooikrans (South Africa).



Map 13. Distribution of *A. cyclops*.

Habit

Widely spreading shrubs 1–4 (–6) m or small trees (to 8 m high), single-stemmed to about 1 m or sparingly divided at ground level into a few sub-straight or rather crooked main stems (dbh often about 10–15 cm, rarely exceeding 20 cm), in windy coastal sites it forms hedges less than 0.5 m high (National Academy of Sciences 1980); crowns dense and bushy. Bark smooth except longitudinally fissured at base of main stems, grey.

Botanical descriptions and illustrations/photographs are provided by Costermans (1981), Simmons (1988), Whibley & Symon (1992) and Cowan & Maslin (2001 & 2001a).

Taxonomy

Acacia cyclops is referable to *Acacia* section *Plurinerves*, a diverse and probably artificial group of about 212 species (Maslin 2001) which are characterized by having plurinerved phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Species of section *Plurinerves* are widespread in Australia with the main centres of richness located in the inland areas of the southwest and southeast of the continent (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). Five species of section *Plurinerves* are detailed in this report, namely, *A. cyclops*, *A. implexa*, *A. melanoxylon*, *A. stenophylla* and *A.* aff. *redolens*.

Affinities unknown. Rather invariate.

Map 14. Predicted area (blue) where *A. cyclops* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 13), see also Table 5. Target area shown in yellow.

Distribution and habitat

Widespread and somewhat discontinuous in coastal and near-coastal areas ranging from Leeman, Western Australia, to the north western part of the Eyre Peninsula in South Australia. In South Australia there are populations from the eastern Eyre Peninsula, the Yorke and Fleurieu Peninsulas and Kangaroo Island but there is contention over whether some of these are indigenous or have spread from plantings (Virtue & Melland 2002). Much of the natural distribution of this species lies outside the target area only just reaching its southern edge in some regions. Acacia cyclops is one of only four species in this report that occur in both the eastern and westen target areas (the other three are *A. hakeoides*,

Figure 6. *Acacia cyclops*

A – Plant with erect growth form; in clay soil near Scaddan, W.A. (Photo: B.R. Maslin)

B – Pods with seeds encircled by large, bright red arils. (Photo: B.R. Maslin)

C – Plant with typical spreading growth form; in coastal sands. (Photo: B.R. Maslin)

D – Section of stem. (Photo: W. O'Sullivan)

E – 10 month old plants in trial at Narrogin, W.A. (Photo: J. Carslake)

A. murrayana and *A. victoriae*). This species is grown in a number of countries abroad (CAB International 2000) and in places, notably South Africa, it has become an invasive weed (see Weed potential below). *Acacia cyclops* is mostly found on well-drained calcareous coastal sands but around Scaddan and near Esperance in Western Australia it also occurs in water-logged clay soil. Fox (1985), Marcar *et al.* (1995) and CAB International (2000) provide details of the ecological tolerances and preferences for this species.

Flowering and fruiting

Flowers mainly between December and March. Pods with mature seeds are often present when plants are in flower. See Fox (1985) for additional phenological information. Pods (with seeds attached) are commonly retained on the plants for some time following dehiscence (see Gill 1979 & 1985 for details); seed can be collected by threshing technique, but sometimes they may be a little difficult to dislodge from the pods (may possibly depend upon age of seed).

Biological features

According to Marcar *et al.* (1995) this is a relatively slow-growing species, taking 7–10 years to reach harvestable size for fire wood in South Africa. These authors also report it as tolerating mild frosts, drought, sand blast and salinity (expect reduced growth at EC_e c. 10–15 dS/m with reduced survival above c. 20 dS/m). It is apparently sensitive to soil pH, preferring neutral to slightly alkaline soils (Fox 1985). It rarely coppices and seemingly does not root sucker. Fox (1985) provides additional biological details.

Cultivation

Information on silvicultural practice is summarised in CAB International (2000) and the following account is taken from that source (Fox 1985 provides additional information).

Establishment

To establish a stand, direct sowing of pretreated seed is required. Treatment of the seed can be done by abrasion, acid or hot water treatment (National Academy of Sciences 1980). The most effective pretreatment is chipping the seed coat (Youssef *et al.* 1991).

Trials

Assessment trials of this species were recently established in plots on farmland at various locations in south-western Australia by the "Search" project (see Acknowledgements). At age 10 months plants of the best performing provenance of *A. cyclops* showed an average survival of 85% and an average height of 96 cm. The 'best' plot was located on a downslope site with heavy soil in the Esperance Plains IBRA region, with plants averaging 140 cm high.

Studies in Pakistan showed that for 60 planted trees, survival after 6 months was 72% and after 16 months was 16%. Trees grew up to 0.24 m after 6 months and between 0.2–2.7 m after 16 months (Marcar *et al.* 1991).

Yield

For fuelwood purposes a harvestable size plant may be reached in around 7–10 years. At a sheltered site, trees with a 10 cm basal diameter yield about 12 kg dry mass, and at 15 cm basal diameter can yield up to 60 kg dry mass (National Academy of Sciences 1980). In South Africa, standing biomass of *A. cyclops* was around 131 MT/ha; of this, the litterfall represented 7.4% of the total biomass and 21.2% of the canopy mass (Duke 1983).

Pests and diseases

No significant pests have been recorded for this species, although members of the seed-predating genus *Zulubius* may be potential biocontrol agents in South Africa, where *A. cyclops* has become invasive (fide CAB International 2000). In trials in Western Australia *A. cyclops* is susceptible to locust attack (J. Carslake, pers. comm.). See Fox (1985) for additional information.

Weed potential

Acacia cyclops is a serious environmental weed in the Cape Province, South African (Ross 1975, Stirton 1980, Henderson 2001) where it may form dense, impenetrable stands invading and displacing indigenous flora. Once established over large areas the species is difficult to remove or replace. In South Africa *A. cyclops* is a Declared Invader (category 2) species and attempts to control it have included the use of both herbicides and biocontrol agents (Henderson 2001). The biocontrol agent being employed is the seed-feeding weevil, *Melanterius servulus* (type A) (see Olckers & Hill 1999 for review of the effectiveness of this program).Whibley & Symon (1992) provide a good summary of the weediness of this species in South Africa; Virtue & Melland (2002) regard *A. cyclops* as posing a significant weed risk in parts of the agricultural region of South Australia.

The seeds of *A. cyclops* possess a large, conspicuous red aril and are spread by birds, but once the seed has fallen on the ground ants appear to be the main dispersal agents. The species regenerates prolifically following fire from a huge seed store in the soil.

Wood

Basic density range is 780- 826 kg/m^3 (mean 802 kg/m^3) based on analyses of four wood samples by CALM's NHT-supported 'Search' project (unpublished data). This study preferentially sampled young and adolescent plants. Anecdotal field observations show the wood to comprise darkish brown or pale greyish brown heartwood (which may occupy up to about half the stem diameter) surrounded by pale coloured sapwood; the proportion of heartwood to sapwood, and the extent of the heartwood varied significantly between the two samples examined.

Utilisation

Wood

It produces a dense, high quality firewood according to Ayensu *et al.* (1980).

Land use and environmental

As this species tolerates salt spray, soil salinity and sand blast it is a very useful species for coastal dune stabilization (Marcar *et al.* 1995).

Fodder

According to Craig *et al.* (1991), *A. cyclops* has some potential as a perennial fodder shrub for use in saline areas; however, (Le Houerou 2000) considers it to be of poor forage value in north Africa.

Other uses

Details of utilisation are summarised in CAB International (2000).

Potential for crop development

Acacia cyclops is not regarded as particularly prospective as a crop plant for high volume wood production. It is ranked as a category 4 species and would seem best suited as a phase crop (see Table 6). *Acacia cyclops* generally does not possess a particularly good growth form (plants are commonly rather wide-spreading with a much-branched habit and somewhat crooked stems and branches), its growth rate appears not to be especially fast and its wood density is higher than the optimum for reconstituted wood products. Nevertheless, this is a salt tolerant species which does produce a reasonable amount of woody biomass. Although *A. cyclops* commonly grows in deep sandy soil, around Esperance in Western Australia it may also occur in water logged clays (an atypical habitat for the species) where it may develop an erect (rather than spreading) growth form. These latter provenances in particular may be worth including in trials (perhaps for growing in association with *A. saligna*).

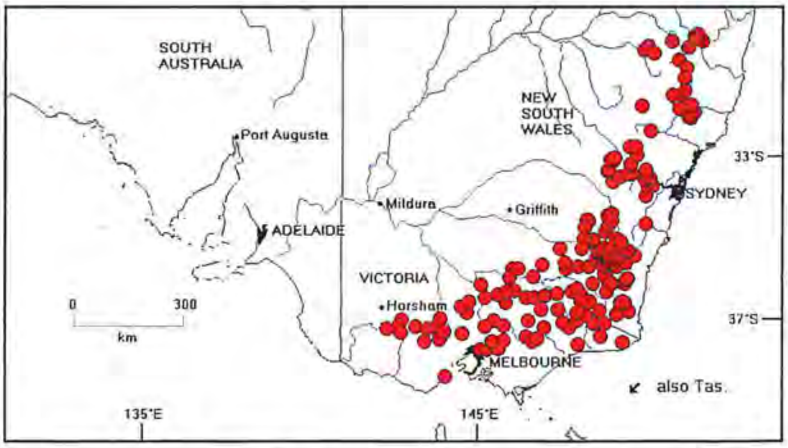
The area predicted to be climatically suitable for the cultivation of *A. cyclops*, based on its natural climatic parameters, is shown in Map 14. This analysis indicates that *A. cyclops* is well-suited to climatic conditions well beyond its natural distribution. The prediction suggests that it has the potential to be cultivated throughout the target area in Western Australia and most of the eastern target area (excluding the region which coincides approximately with the 300 metre elevation contour). This latter area incorporates vast areas of South Australia, Victoria and New South Wales. Within these areas *A. cyclops* has the potential to be cultivated on both sandy and clay soils subject to waterlogging. Trials are warranted to ascertain if provenances of *A. cyclops* display edaphic specificity.

Because of its weed potential caution is needed if any wide-scale use of this species is undertaken, and such use must be accompanied by a thorough weed risk assessment. Because of this issue it may be deemed inappropriate to cultivate *A. cyclops* in areas outside its natural geographic range (see also discussion on other possible weed reduction strategies under **Weed potential of *Acacia* in target area** in the introduction to this report).

Acacia dealbata Link subsp. *dealbata*

Common Name

Silver Wattle (Standard Trade Name).



Map 15. Distribution of *A. dealbata* subsp. *dealbata*.

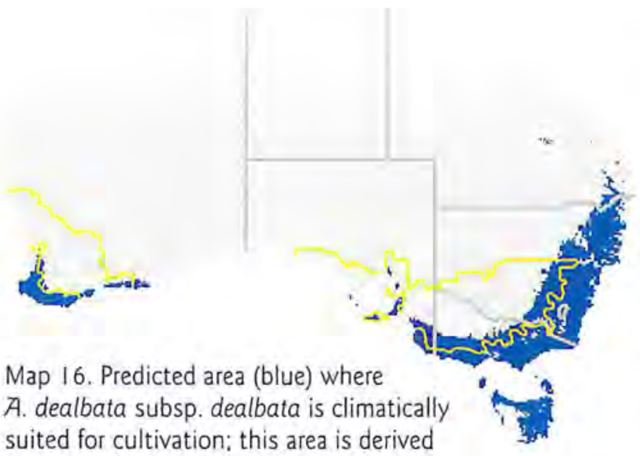
Habit

Shrubs or trees 2–15 m tall but attaining 30 m in wetter parts of Tasmania and Victoria, becoming shrubby on drier sites (Entwistle 1996), it develops an erect main stem and, wherever there is sufficient space, a well-developed conical or rounded crown, root suckers freely. Bark smooth but becoming deeply corrugated with age, brown or grey to almost black, often mottled white (due to lichen growth).

Botanical descriptions and illustrations/photographs are provided by Maiden (1907), Cunningham *et al.* (1981), Costermans (1981), Boland *et al.* (1984), Simmons (1988), Whibley & Symon (1992), Tame (1992), Entwistle (1996), Tindale & Kodela (2001 and 2001a) and Kodela (2002).

Taxonomy

This species belongs to *Acacia* section *Botrycephalae*, a group of 44 mostly arborescent species characterized by having bipinnate adult foliage and flower heads normally arranged in elongated racemes (Orchard & Wilson 2001). These species predominate in temperate areas of eastern and southeastern Australia (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). There are seven species of *Botrycephalae* detailed in this report, namely, *A. baileyana*, *A. dealbata* subsp. *dealbata*, *A. decurrens*, *A. filicifolia*, *A. leucoclada* subsp. *leucoclada*, *A. mearnsii* and *A. parramattensis*. A number of recent studies have suggested that species of section *Botrycephalae* are most closely related to certain racemose species of section *Phyllodineae* (foliage phyllodinous) from eastern Australia, see Maslin & Stirton (1998) and Maslin *et al.* (2003) for reviews. Of the phyllodinous species included in this report those having presumed closest affinities to species of *Botrycephalae* include *A. linearifolia*, *A. neriifolia* and *A. pycnantha*; members of the '*Acacia microbotrya* group' are not far removed from these species.



Map 16. Predicted area (blue) where *A. dealbata* subsp. *dealbata* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 15), see also Table 5. Target area shown in yellow.

A study by Tindale and Roux (1969) of flavonoid and condensed-tannin contents of the heartwood and bark of *Acacia* recognized four groups within section *Botrycephalae*; that study grouped *A. baileyana* and *A. dealbata* together. *Acacia dealbata* is similar to *A. nano-dealbata* and, according to Doran and Turnbull (1997) is sometimes confused with *A. leucoclada*, *A. mearnsii* and *A. silvestris*.

Acacia dealbata comprises two subspecies, subsp. *dealbata* and subsp. *subalpina*. Subspecies *subalpina* (which is not detailed in this report) is distinguished by its generally smaller

Figure 7. *Acacia dealbata* subsp. *dealbata*

A – Excellent growth form at Christmas Creek, Victoria. (Photo: M.W. McDonald)

B – Plants in open sites near Glen Innes, N.S.W. (Photo: B.R. Maslin)

C – Stem base variation, single-stemmed (left) & stem branching at ground level (right). (Photos: B.R. Maslin)

D – Spreading growth form in open site at Ben Lomond, N.S.W. (Photo: J. Williams)

E – Wood core from 7.5 year old plant. (Photo: P. Macdonnell)

F – Branch showing racemose inflorescences & greyish bipinnate leaves (Photo: B.R. Maslin) leaves and smaller stature, it occurs outside the target area at higher altitudes from near Canberra to northeast Victoria. Intermediates occur between the subspecies (Kodela 2002).

Distribution and habitat

Acacia dealbata subsp. *dealbata* occurs on the Great Divide (mainly tablelands and foothills) from the Ben Lomond Range in northern New South Wales to the Grampians in western Victoria; it is also common in Tasmania. The main area of occurrence of this subspecies is to the south and east of the target area but it reaches the temperate periphery of the region in New South Wales and Victoria. *Acacia dealbata* is naturalized in parts of southwest Western Australia and southern South Australia (in the Adelaide Hills and around Penola, fide Whibley & Symon 1992). Tindale & Kodela (2001) provide maps of both the native and naturalized distributions of this subspecies. *Acacia dealbata* has been introduced into many countries abroad including Chile, China, France (and other parts of southern Europe), Ethiopia, India, Japan, Kenya, Nepal, New Zealand, North Africa, South Africa, Sri Lanka, Uganda, West Africa, Zambia and Zimbabwe (see CAB International 2000 for further details) and in some of these regions has become naturalized (see **Weed potential** below).

In western New South Wales subsp. *dealbata* occurs as scattered plants or in small clonal clumps in river red gum forests fringing the Murray River, usually on the higher levels of clay banks (Cunningham *et al.* 1981).

As summarised by Boland *et al.* (1984) and Doran & Turnbull (1997), *A. dealbata* occurs in topography ranging from high plateaus to deep mountain valleys where it grows in hilly country, often on steep slopes and along stream banks, usually in dry sclerophyll forest or woodland. It is found on a variety of substrates (including basalt, granite and sandstone) and its soils range from deep and fertile forest podsolics, clays and gravelly clays of moderate drainage to well-drained stony slopes, volcanic brown earths and lateritic krasnozems. Along the Great Divide subsp. *dealbata* occurs between 350–1000 m elevation while in Tasmania it grows between 50–600 m. It generally occurs at higher elevations than *A. mearnsii* and *A. decurrens* (Anderson 1968). Further details of its ecology are given in Boland *et al.* (1984), Doran & Turnbull (1997) and CAB International (2000).

Flowering and fruiting

Flowers mainly from August to October (but can extend from July to November) and mature seeds are produced mostly between November and January (or sometimes to March). It takes 5–6 months from flowering for seeds to mature (Boland 1987); the seed drops soon after maturity. According to Stelling (1998) *A. dealbata* produces large seed crops every 2–3 years and the plants mature early with seed set at 4–5 years of age. Upon shedding the seed remains viable in the ground for many years.

Biological features

A fast growing and frost hardy species (Simmons 1988) that root suckers freely and can coppice from cut stumps (Campbell *et al.* 1990). It regenerates readily following fire and often forms fire-induced thickets by prolific root suckering. According to Doran & Turnbull (1997) this species grows best in cool climates with annual rainfall in the range 750–1000 mm. See below under **Cultivation** for further details. *Acacia dealbata* has a lifespan of up to several decades (Stelling 1998).

Genetics

Chromosome number: $2n = 26$ (B. Briggs in Tindale & Kodela 2001).

Acacia dealbata occasionally hybridizes with *A. baileyana* (Tindale & Kodela 2001) and possibly also with *A. pataczekii* (Maslin 2001); it is also recorded as hybridizing with *A. mearnsii* in cultivation in South Africa (see *A. mearnsii* for references). A European garden hybrid involving *A. dealbata* and *A. podalyriifolia* has been described as *A.* x *hanburyana* (Maslin 2001).

Cultivation

The following information on the establishment, management and yield of this species is taken from Doran & Turnbull (1997) and CAB International (2000).

Establishment

There are no standard nursery practices for *A. dealbata*. A number of trials have been established in Australia and overseas but all differed in their nursery practise, details of which can be found in Midgley & Vivekanandan (1987), Fangqiu *et al.* (1998), Thinh *et al.* (1998), Mitchell (1998), Bird *et al.* (1998) and Searle *et al.* (1998).

Propagation is by seed previously immersed in boiling water for 1 minute to break seed-coat dormancy. Germination rate averages about 75% and there are about 50-55,000 viable seeds/kg. The seed are then either directly sown into containers or into beds to produce bare rooted seedlings. It is common practice to sow two seeds per container which are later thinned out or transplanted into another container, depending on germination success. According to Stelling (1998) *A. dealbata* establishes well when direct-seeded.

Kube & Brown (1996) established that the ideal height for seedling establishment in the field in Tasmania is around 30 cm with a collar diameter of 7 mm. These larger plants had a greater survival, less foliage loss and better form than smaller seedlings. Topping the seedlings in the nursery appears to accentuate form problems and therefore should be avoided. Seedlings take 4–5 months before being large enough for planting. Containerized stock probably need to be grown in large pots (250 cubic centimetres) as Ryan *et al.* (1987) found for other *Acacia* species.

In Sri Lanka, rapid root development is a problem in the nursery as acacias are sensitive to root wrenching. High nursery mortality was recorded where a single heavy wrenching was given rather than several lighter root prunings (Midgley & Vivekanandan 1987). Most *Acacia* species, including *A. dealbata*, appear to be quite sensitive to transport damage (associated with root damage) and the use of planting boxes is recommended.

Due to the susceptibility of its foliage to desiccation, leading to poor growth and survival, *A. dealbata* should be established during wetter months to avoid dry periods (Kube & Brown 1996). Large seedlings which retained all their foliage had a high survival and growth rate and developed a single stem. However, seedlings with more than 66% foliage loss had poor survival and growth and often developed multiple stems (Kube & Brown 1996). Initial stocking rates should be high if survival problems are anticipated.

When introducing *A. dealbata* to new areas seedlings will benefit from inoculation with appropriate rhizobia and mycorrhizal strains (Hopmans *et al.* 1983, Roughley 1987, Reddell & Warren 1987). Roughley (1987) found that 75–100% of rhizobium strains will nodulate *A. dealbata*. New introductions to Sri Lanka demonstrated good nodulation (Midgley & Vivekanandan 1987) and Fangqiu *et al.* (1998) note that seedlings grown for trials in China produced root nodules within three months. Inoculation techniques in the nursery are described by Doran (1997).

Although *A. dealbata* can fix atmospheric nitrogen, application of fertilizer will increase growth rate, especially on marginal sites. Many nurseries have a general purpose fertilizer in the soil mix as well as adding to the plants in the nursery. Seedlings should also be fertilized in the field with a general N:P:K fertilizer but caution should be taken as most *Acacia* species grow in infertile soils and high levels of nutrients may reach toxic levels (Tame 1992). Examples of the use of fertilizer with acacias are given by Midgley & Vivekanandan (1987), Doran (1997) and Bird *et al.* (1998).

Form pruning is required 1–2 years after planting (2–3m height) (Kube *et al.* 1997). This is particularly important if foliage loss has occurred after planting as it can often cause loss of apical dominance and consequently seedlings produce numerous shoots from the base of the seedling. These shoots often persist and, without form pruning, are likely to produce trees with multiple leaders making the timber unmerchantable.

An important aspect of silviculture for this species is weed control (Doran 1997). Better survival and growth rates were attained when competition, especially with weeds, was eliminated (Midgley & Vivekanandan 1987, May 1999).

Yield

Acacia dealbata produces wood suitable for high quality pulp (Logan 1987). Batchelor *et al.* (1970) found that pulpwood rotations of 15–20 years were feasible on suitable sites in Australia, but *A. dealbata* had a limited life span of 20–40 years on harsher sites. Although *A. dealbata* is known to grow fast in native forests, wood yields are highly variable (Brooks & Brown 1996). Best annual growth rates recorded in Tasmania were 23 cubic metres per hectare at age 10 years (Kube *et al.* 1997). In New Zealand, a stand gave an estimated annual volume growth (under bark) of 46 cubic metres per hectare and averaged 16 m in height at age 8 years (Frederick *et al.* 1985). In China, the annual biomass production was estimated to be 15–20 tonnes/ha dry matter at age 5 years; in a species trial in subtropical Guangdong, *A. dealbata* provenances averaged 5 m in height at 18 months (Yang *et al.* 1991). The annual net production in a 4-year-old stand in Japan was 17–30 tonnes per hectare (Takashi & Ikuo 1973).

Trials in Western Australia by Barbour (2000) that included 12 bipinnate acacias showed substantial provenance differences in survival and growth. At Darkan (650 mm mean annual rainfall) 2 year old plants of *A. dealbata* were ranked, in terms of height attained, sixth (Errinundra provenance) and twenty fifth (Captains Flat provenance) overall; 5-year-old plants of this species were ranked eleventh and were amongst the poorest performers. Provenance differences among populations of *A. dealbata* were not as marked at two other more mesic trial sites (Busselton, Mt Barker) discussed in this same report. In these trials *A. dealbata* was out-performed by *A. decurrens*, *A. fulva* and *A. mearnsii* across all sites.

In trials involving 16 acacias at two site in Victoria, *A. dealbata* was amongst the best performiong species (Bird *et al.* 1998). At age 34 months, the mean height of the best provenance was 4.9 m with a mean diameter of 79 cm. The mean annual rainfall at these sites was 700 mm.

Provenance

Although there is interest from many countries there are no large scale commercial plantations of *A. dealbata* (Neilsen *et al.* 1998) and consequently there has been little research carried out on provenance variation or breeding.

Given the wide range of environments in which *A. dealbata* occurs, it is likely that genetic variation will be important in the utilisation of this species (Kube *et al.* 1996), and that provenance research and tree breeding will make economic gains for growth rates, wood properties, tree form and resistance to the fireblight beetle; this could increase the plantation potential of *A. dealbata* (Kube *et al.* 1996, Neilsen *et al.* 1998).

Recently trials by Kube *et al.* (1996) and Neilsen *et al.* (1998) have been established in Tasmania and although conclusive recommendations cannot yet be made preliminary results indicate that there may be important variation both between and within provenances. Neilsen *et al.* (1998) found variation in growth at regional, provenance and family level with the majority of variation for growth rate occurring at the family level. Kube *et al.* (1996) found a heritability of 0.21 for height growth of *A. dealbata* at age 16 months.

Pests and diseases

Lee (1993) provides a summary list of diseases recorded on *A. dealbata* in several parts of the world. Various fungi have been reported as causing serious losses to *A. dealbata* stock in the nursery (Ito &

Shibukawa 1956 and Terashita 1962). The species is subject to fireblight beetle (*Pyrgoides orphana*) in Australia (Simpfendorfer 1992), a defoliator which limits its use as a plantation species. The sapwood is susceptible to *Lyctus* attack. The above information is taken from Doran & Turnbull (1997); see CAB International (2000) for further details.

Weed potential

Within Australia *A. dealbata* has become naturalized in parts of southwest Western Australia and southern South Australia and overseas in parts of South Africa (Ross 1975 and Henderson 2001), New Zealand (Pollock *et al.* 1986) and India (Troup 1921). In South Africa it is a Declared Weed in the West Cape Province and a Declared Invader (category 2) elsewhere in the country. Attempts at control of *A. dealbata* in South Africa have included the use of herbicides; also, a seed-feeding weevil, *Melanterius* sp., is currently under investigation as a biocontrol agent of this species (see Dennill *et al.* 1999). On account of its strong suckering propensity *A. dealbata* is frequently difficult to eradicate when clearing (Anderson 1968). It is often seen in dense stands on recently disturbed land (Simmons 1988).

Wood

The heartwood varies from light-brown to pinkish (Boland *et al.* 1984). Green density of the wood is about 800 kg/m^3 while air-dry density ranges from 540 to 720 kg/m^3 (Bootle 1983). The basic density is given as 570 kg/m^3 by Ilic *et al.* (2000) and 553 kg/m^3 by Clark *et al.* (1994).

Utilisation

The following information on the utilisation is taken largely from the summaries provided in Doran & Turnbull (1997) and CAB International (2000).

Wood

Acacia dealbata is recognised as a very good quality pulpwood in Tasmania (Batchelor *et al.* 1970, Logan 1987). Its kraft pulping and papermaking properties make it suitable for a range of paper and paperboard products such as linerboards, bag and wrapping papers, white boards and writing and printing paper. It has the levels of brightness required for some high grade papers (Clark *et al.* 1994), and it has lower alkali requirements than most eucalypts (Phillips *et al.* 1991). The wood has good glueing properties and has minor usage for clothes pegs, shoe heels and wood wool; it provides a satisfactory fuelwood but compared with many other Acacias is rather poor in this regard (Boland *et al.* 1984):

In Tasmania, *A. dealbata* is not a valuable commercial species but it is harvested from natural stands as a minor species (Kube & Brown 1996). ANM Newsprint Mill at Boyer uses about 12,000 tonnes of *A. dealbata* wood annually and about 500 cubic metres/year are sold as sawlogs and craftwood.

Land use and environmental

Acacia dealbata has been used to control soil erosion and its prolific seeding and root suckering facilitates its use in this regard. In New Zealand this was one of the drought tolerant *Acacia* species used for hillside stabilisation, gully erosion control and for windbreaks (Sheppard *et al.* 1984, Sheppard 1987, Pollock *et al.* 1986). It has also been used to stabilise eroded hill slopes in the Nilgiri Hills in India (Troup 1921, Streets 1962) and in Sri Lanka for afforestation of marginal upland areas (Midgley & Vivekanandan 1987). However, due to its invasiveness *A. dealbata* has now become a weed in some of these regions.

Various studies show that nitrogen levels in the soil are increased where *A. dealbata* is planted. Chau *et al.* (1985) noted that in its area of occurrence the nitrogen fixation carried out by *A. dealbata* played an important role in the nutrient cycling of the forest. Frederick *et al.* (1985) showed that the top 40 cm of soil of an A. *dealbata* stand contained over 60% more nitrogen than under *Pinus radiata* and 40% more than under *Eucalyptus regnans*. Furthermore the nitrogen cycling through the litterfall was more than twice as large in the A. *dealbata* leaf litter compared with the other species. It was found that the net annual accumulation of nitrogen for the A. *dealbata* was 280 kg/ha, thus improving the nitrogen status of the soil considerably. Stelling (1998) also reports that A. *dealbata* is an ideal 'nurse crop' for use with slow growing eucalypts or other long-lived species in mixed woodlots.

Tannin

It yields 16–36% tannin but is regarded as inferior to both A. *mearnsii* and A. *decurrens* as a source of tanning bark (Anderson 1968).

Gum

It produces a gum arabic substitute (Doran & Turnbull 1997); details of gum properties are given in Anderson *et al.* (1973).

Fodder

The species is not especially known in Australia for its animal fodder value, although it is reportedly used for this purpose in the Nilgiri Hills of southern India (Doran & Turnbull 1997).

Wildlife value

Acacia dealbata is an important source of winter carbohydrate for petaurid arboreal marsupials including Leadbeater's possum (*Gymnobelideus leadbeateri*), the sugar glider (*Petaurus breviceps*), the squirrel glider (*Petaurus norfolcensis*), the mahogany glider (*Petaurus norfolcensis*) and the yellow-bellied glider (*Petaurus australis*) (Smith 1982, Henry 1985, Menkhorst *et al.* 1988). Smith & Lindenmayer (1992) found that Acacia gum may contribute up to 80% of the Leadbeater's possum's daily energy requirements. Lindenmayer *et al.* (1994) showed that the sugar content of A. *dealbata* gum was 48.6%. *Acacia dealbata* is a valuable source of pollen for bees (Clemson 1985).

Other uses

Acacia dealbata is widely grown as an ornamental within Australia and overseas on account of its attractive silvery foliage and its prolific flowers (but suckering may cause problems in cultivation). The cultivar, 'Kambah Karpet', is a prostrate ground cover (Tame 1992). In southern Europe A. *dealbata* is known as 'mimosa', and here it is also used commercially in the cut flower trade (Boland *et al.* 1984). The flowers are used for perfume production and French manufacturers recognise the extract for its ability as a blender and 'smoothing agent' for synthetics and as a fixative in high grade perfume (Poucher 1984, Boland 1987). Details of the industry are given by Guenther (1952). Wool may be dyed with A. *dealbata* leaves to yellow-fawn or green depending on the mordants used (Martin 1974). Aborigines reputedly used this species for making boomerangs, as a food (the gum) and for medicinal purposes (bark infusions in hot water as a remedy for indigestion) (Stelling 1998). The gum is highly soluble in water and was reputedly dissolved in boiling milk and taken for dysentery and diarrhoea, with good results, by European settlers (Stelling 1998).

Potential for crop development

Acacia dealbata subsp. *dealbata* is regarded as having moderate prospects as a crop plant for high volume wood production in the area covered by this study especially cooler, moister regions. Subspecies *dealbata* is a vigorous, long-lived taxon which typically shows very fast early growth. It is ranked as category 2–3 and has potential for development as a phase crop and possibly also as a long cycle crop (see Table 6). It develops good to reasonable quantities of woody biomass but plant form can be variable (see below). The wood is pale coloured, of low density and has been shown to be suitable for producing high quality pulp. The propensity for A. *dealbata* to vigorously root-sucker in nature may or may not be advantageous in cultivation, it depends whether or not this attribute is required (or expressed) for the system in which it is placed. A possible constraint in developing *A. dealbata*, at least as a phase crop, is its reported ability to set prolific quantities of seed at a relatively early age. Such phenological precocity will lead to the creation of a soil seed bank that may cause weed problems in adjacent or subsequent annual crops. (Alternatively young seedlings may possibly be treated as a form of green manure.) One way of avoiding soil seed build up is to harvest plants prior to them producing appreciable quantities of pods, but this would also require that sufficient woody biomass had been produced by that time. Perhaps the successful crop development of this subspecies will depend upon locating non- (or low-propensity) suckering forms or those which commence fruiting from a later age, >5-6 years. Although *A. dealbata* is reported to coppice from cut stumps it is probable that growth would be insufficiently frequent or vigorous to sustain the species as a coppice crop. For example, trials in Western Australia by Barbour (2000) showed that 62 month old plants of *A. dealbata* showed no sign of coppicing (or root suckering) 12 months after harvest.

Acacia dealbata displays a somewhat variable growth habit (excellent on wetter sites but can become shrubby in drier sites). Provenance variation in growth form and, based on existing trial results, in survival and growth rates, can be expected to be substantial for plants grown in the target area. Also, as *A. dealbata* is subject to defoliation by fireblight beetles this is likely to limit its use as a plantation species. Inoculation of seedlings with appropriate symbionts should be undertaken when introducing the species to new areas.

Attempts should be made to harvest this species for biomass production on five to ten year rotations as vigour and wood quality are likely to decline beyond this period based on ornamental trees cultivated in the Canberra area. To achieve this the spacing of plants may be a critical factor and therefore trials are warranted to investigate this effect.

Acacia dealbata has demonstrable weed potential, both within Australia and abroad. However, it is not known if this will be a major problem in the drier environments of the present target area. Nevertheless, caution is needed if any wide-scale use of this species is undertaken, and such use must be accompanied by a thorough weed risk assessment (see also discussion on possible weed reduction strategies under **Weed potential of *Acacia* in target area** in the introduction to this report).

The area predicted to be climatically suitable for the cultivation of *A. dealbata*, based on its natural climatic parameters, is shown on Map 16. This analysis indicates that subsp. *dealbata* is not well-suited for cultivation in drier parts of either the eastern or western target areas. It predicts that climatic conditions in the higher rainfall zones on the periphery of the target area in New South Wales, Victoria, South Australia and Western Australia are well-suited to its growth. Within the eastern area, valley soils on upland sites that receive greater than 500 mm mean annual rainfall should be targeted for this species. It may be advantageous to cultivate subsp. *dealbata* on run-on sites in these areas to supplement rainfall. *Acacia dealbata* should tolerate a relatively wide range of soil types and frosty conditions within this zone. Provenance variation in this species for survival and growth will be substantial based on results of previous trials.

Acacia decurrens Willd.

Common Names

Green Wattle (Standard Trade Name), Early Black Wattle, Wattah (aboriginal name, *fide* Maiden 1889).

Habit

Shapely erect trees 5–10 (–15) m tall but sometimes attaining 20–22 m tall under favourable conditions (Boland 1987, Pryor & Banks 1991), commonly with single, straight to almost straight main stems, strong, shallow lateral roots are developed. Bark smooth but may become fissured on main trunks of mature plants, dark grey to almost black.

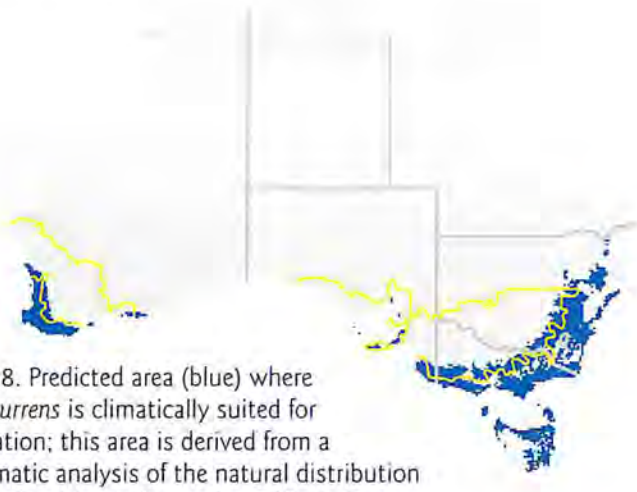
Map 17. Distribution of *A. decurrens.*

Botanical descriptions and illustrations/photographs are provided by Maiden (1907), Costermans (1981), Simmons (1987), Fairley & Moore (1989), Tame (1992), Whibley & Symon (1992), Tindale & Kodela (2001 and 2001a) and Kodela (2002)

Taxonomy

This species belongs to *Acacia* section *Botrycephalae*, a group of 44 mostly arborescent species characterized by having bipinnate adult foliage and flower heads normally arranged in elongated racemes (Orchard & Wilson 2001). These species predominate in temperate areas of eastern and southeastern Australia (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). There are seven species of *Botrycephalae* detailed in this report, namely, *A. baileyana, A. dealbata* subsp. *dealbata, A. decurrens, A. filicifolia, A. leucoclada* subsp. *leucoclada, A. mearnsii* and *A. parramattensis*. A number of recent studies have suggested that species of section *Botrycephalae* are most closely related to certain racemose species of section *Phyllodineae* (foliage phyllodinous) from eastern Australia, see Maslin & Stirton (1998) and Maslin *et al.* (2003) for reviews. Of the phyllodinous species included in this report those having presumed closest affinities to species of *Botrycephalae* include *A. linearifolia, A. neriifolia* and *A. pycnantha*; members of the '*Acacia microbotrya* group' are not far removed from these species.

Acacia decurrens is related to *A. dangarensis* and is similar to *A. parramattensis* and *A. filicifolia* but is readily distinguished from all these taxa by its branchlets which are prominently angled by conspicuous winged ridges. The species commonly hybridizes with *A. baileyana* (see under **Genetics** below). A study by Tindale and Roux (1969) of flavonoid and condensed-tannin contents of the heartwood and bark of *Acacia* recognized four groups within section *Botrycephalae*; this study placed *A. decurrens* in a group containing *A. constablei, A. irrorata subsp. velutinella, A. mearnsii, A. parramattensis* and



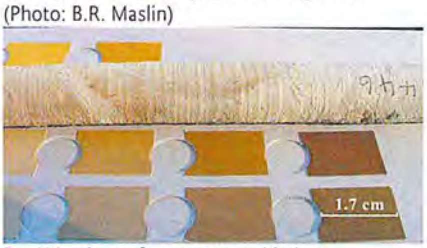
Map 18. Predicted area (blue) where *A. decurrens* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 17), see also Table 5. Target area shown in yellow.

Figure 8. *Acacia decurrens*

A – Adult trees with insert of stem base. (Photo: B.R. Maslin)

B – Juvenile stand (regrowth from seed). (Photo: B.R. Maslin)

C – Upturned mature plant showing roots. (Photo: B.R. Maslin)



D – Wood core from 10 year old plant. (Photo: P. Macdonnell)

E – Mature stand. (Photo: B.R. Maslin)

F – Branch showing racemose inflorescences & dark green bipinnate leaves. (Photo: B.R. Maslin)

A. *trachyphloia*. *Acacia parramattensis* is probably often mistakenly grown as A. *decurrens* according to Tame (1992).

Distribution and habitat

Endemic in New South Wales where it occurs chiefly on the coast and tablelands from the Hunter Valley south to the Australian Capital Territory. This distribution is outside the target area but not far from its eastern border. *Acacia decurrens* has been widely cultivated as an ornamental and has become naturalized in many areas, both within Australia and abroad (see below under **Cultivation** and **Weed potential**). In Australia naturalized populations occur in southwest Western Australia, southeast South Australia (see Whibley & Symon 1992), southeast Queensland (see Pedley 1980), parts of New South Wales, the Australian Capital Territory, Victoria (see Entwistle 1996) and Tasmania. Tindale & Kodela (2001) provide maps of both the 'natural' and naturalized distributions. As noted by Burbidge & Gray (1970) in parts of New South Wales distinguishing between 'natural' and naturalized occurrences is difficult. *Acacia decurrens* grows in open forest or woodland, on hillsides or gullies, on clays and clay loams usually derived from shale. Comprehensive summaries of habitat characteristics are given in CAB International (2000).

Flowering and fruiting

Flowers mostly between July and early September, but this may vary with seasonal conditions, locality and particularly altitude (Clemson 1985). Kodela (2002) indicates that flowering can extend to November. The time between flowering and pod maturation is 5–6 months (Boland 1987) with seeds being present from November to January, but pods are not produced every year (Pryor & Banks 1991).

Biological features

A relatively short-lived species which declines in vigour after 10–15 years (Pryor & Banks 1991). Boland (1987) considered it to have moderate frost tolerance. The species is reported as having the ability to coppice and root sucker (Ruskin 1983), however, the accuracy of this report requires further investigation (see also under **Yield** below). In our experience this species has at best only weak root suckering and coppicing ability. For example, 32 month old plants under trial near Canberra did not display any suckering (Searle *et al.* 1998). Similarly, 62 month old plants under trial in Western Australia showed no evidence of root suckers or coppicing 12 months after harvest (Barbour 2000).

Genetics

As noted by Tindale & Kodela (2001) A. *decurrens* commonly hybridises with A. *baileyana*; these hybrids are referred to as A. x *nabonnandii* Nash in Jacobs & Pickard (1981) and are discussed by Cheel (1935). The hybrids appear to be more susceptible to insect galls than either parent species (Burbidge & Gray 1970).

Philp & Sherry (1946 & 1949) reviewed the hybridity between A. *decurrens* and A. *mearnsii* in cultivation in South Africa with a view to improving forestry stock. Features of the hybrids are discussed by Moffett (1965a & b) and Moffett & Nixon (1958). Moran *et al.* (1989) included A. *decurrens* in an allozyme study to estimate overall genetic diversity in a range of *Acacia* species. Based on plants from the Goulburn population, A. *decurrens* had similar levels of expected heterozygosity ($H_E = 0.156$) relative to the other *Acacia* species assayed (H_E mean of eight species = 0.147). The above summary is taken from CAB International (2000).

A study of the breeding behaviour of A. *decurrens* and A. *mearnsii* by Moffett & Nixon (1974) showed that self-fertilization in both these species leads to a decrease in fertility and general vigour.

Chromosome number: $2n = 26$ (Ghimpu 1929).

Cultivation

Acacia decurrens has been grown in the following countries abroad: Argentina, Bolivia, Brazil, Chile, China, Colombia, Congo, Ecuador, Ethiopia, Haiti, Honduras, India, Indonesia, Japan, Kenya, Mexico, Morocco, Myanmar, Nepal, New Zealand, Papua New Guinea, Philippines, Russia, Rwanda, South Africa, Sri Lanka, Swaziland, Taiwan, Tanzania, Turkey, United States of America, Uruguay, Vietnam, Zaire, Zimbabwe (CAB International 2000 based on records of the Australian Tree Seed Centre, CSIRO, Forestry and Forestry Products). The species has also been trialled in Australia, e.g. near Canberra (Searle *et al.* 1998) and southwest Western Australia (Barbour 1995).

CAB International (2000) provides a comprehensive summary of the silvicultural characteristics, practice and management of A. *decurrens*, and the following information is taken directly from this source.

Establishment

Acacia decurrens can be easily propagated from seed but, as with most acacias, the seed must be pre-treated to induce germination. The best method is to boil the seeds at 100°C for 1 minute in a relatively large volume of water (ATSC 1998). The seeds should then be allowed to cool and imbibe water for 24 hours; seeds that float to the surface are normally not viable and should be discarded; viable seeds should become swollen and sink. The seeds can also be scarified (Wrigley & Fagg 1996); mechanical nicking of the seed coat is also an option. The average viability of A. *decurrens* seeds, based on laboratory tests of 12 provenances, is 57, 000 seeds per kilogram and the recommended temperature for optimum germination is 25°C; germination commences after five days and all viable seeds normally germinate within 25 days (ATSC 1998). More than 60% of seed stored for 17 years has been shown to germinate (Smith 1930).

Acacia decurrens can also be propagated by vegetative means. Darus (1992) provides a summary of important factors to consider for successful vegetative propagation of acacias using cuttings and tissue culture techniques. These include: age of stock plants; rooting medium, basal medium and type and concentration levels of rooting hormones and growth hormones used.

In the nursery, direct sowing of pre-treated seed into germination trays and subsequent transplanting of vigourous germinants into tubes at the two-phyllode stage is an effective method for raising seedlings (Ryan *et al.* 1987). Alternatively, pre-treated seeds can be sown directly into pots. A mix of 1 part peat moss and 2 parts vermiculite is an appropriate potting medium. A slow-release fertiliser should be added to the sowing mix at the nursery phase. Foliar applications of fertiliser are not advisable due to the difficulty of adding sufficient nutrients at low concentrations to avoid foliage burn and to an increased susceptibility of plants to pathogens (Ryan *et al.* 1987). At the 4–6 phyllode stage, seedlings can be removed from the greenhouse and kept under 50% shade for 3–4 days before exposure to full sun.

Seedlings from nursery-grown stock are normally used to establish industrial plantations, however, in Swaziland woodlots of A. *decurrens* were established by direct sowing (Allen *et al.* 1988). Plantations for chipwood, pulpwood or firewood are not usually thinned or pruned but clear-felled at age 6–15 years.

Midgley and Vivekanandan (1987) provide silvicultural methods for establishing acacias in Sri Lanka which included A. *decurrens*. These authors emphasise that appropriate levels of weed control and fertiliser application are essential components in the silviculture of A. *decurrens* if optimum yields are to be obtained.

Ectomychorrhizal associations improve growth by enhancing absorption of nutrients from the soil (Reddell & Warren 1987). *Acacia decurrens* is a relatively promiscuous host for Rhizobia as 75–100% of Rhizobium strains tested successfully nodulated (Roughley 1987). Growth is improved by the application of NPK fertiliser and frequent weeding ensures optimal growing conditions (Midgley & Vivekanandan 1987, Searle *et al.* 1998).

Acacia decurrens has the potential to produce clear, straight stems when close-grown and it regenerates via seedling recruitment (Ruskin 1983). Light fire will promote profuse seedling regeneration (Midgley & Vivekanandan 1987) with 32 000 seedlings/ha, up to 3–4 m in height, having been recorded after two years (Weeraratne 1964). Protection from livestock and other browsing animals is important during the establishment phase.

Yield

Acacia decurrens was represented at two sites in fuelwood trials near Canberra, A.C.T. (CSIRO 2001). The sites at Kowen and Uriarra had a mean annual rainfall of 630 mm and 824 mm respectively. In the two best performing provenances (Goulburn and Mittagong), variation was evident for biomass production based on assessments made at 2.6 years. However, there were negligible differences between provenances for biomass at 5.2 years of age. Interestingly, there were also only marginal differences for growth between these two provenances at either site despite the higher rainfall at Uriarra. At age 5.2 years mean heights ranged from 6.1–6.4 m and dbh ranged from 9.2–9.6 cm at both sites. These data suggest this species has excellent potential to be cultivated in short phase cropping rotations at suitable sites.

In trials involving 12 bipinnate acacias at three sites in Western Australia, Barbour (2000) ranked *A. decurrens* second to *A. mearnsii* for wood production across all three sites when assessed at 5.5 years of age. In these trials, *A. decurrens* was one of only three species identified as having potential to be developed commercially for its bark tannin (for wood adhesives) and for fuelwood, in Western Australia. Some marked differences in performance between provenances, however, were evident in these trials. For example, of the two provenances tested the Picton-Mittagong provenance out-ranked the Goulburn provenance at all three sites, based on assessments at two years of age. There were negligible differences in biomass production for *A. decurrens* at two sites (Busselton and Mt Barker). In these trials, the performance of plants at the Mt Barker and Darkan sites are of most interest to the present study as these sites both receive 650 mm mean annual rainfall. The report highlighted the fact that high evaporation and high summer temperatures at the Darkan site were too severe for the successful establishment of bipinnate acacias.

Ryan & Bell (1989) tested one seedlot of *A. decurrens* in two trials near Gympie, Queensland. At 18 months the plants in one trial were 3.2 m tall with stem diameter at ground level measuring 6.2 cm while at the other they were 4.3 m tall with a 7.5 cm ground level diameter. In these trials, coppicing in *A. decurrens* was poor for all three treatments when cut at 0.1, 0.5 and 1.0 m above ground level. Interestingly, root suckering was a focus of these trials and none was noted for this species.

In Sri Lanka, the Goulburn provenance of *A. decurrens* that had been used by Searle *et al.* (1998) in the Canberra trials recorded moderate growth of 3.1 m in height and 2.6 cm dbh at age 2.5 years; the trial site was 1160 m in altitude and had 1580 mm mean annual rainfall (Weerawardane & Vivekanandan 1991). Elsewhere in Sri Lanka, *A. decurrens* was one of the best species for diameter growth of all fuelwood and timber species tested (Weerawardane & Phillips 1991), averaging 25m^3 per ha per year according to Ruskin (1983).

In the Natal Midlands, South Africa, 14-year-old commercial stands of *A. decurrens* and *A. mearnsii* were assessed for bark yield and pole yield by Coetzee (1986). *Acacia decurrens* yielded 30% more bark than *A. mearnsii*, but as its bark is of inferior quality for tanning, this result was not considered to have commercial significance.

In trials involving 15 acacias at two sites in Victoria, *A. decurrens* was amongst the best performing species (Bird *et al.* 1998). At age 34 months, the mean height of *A. decurrens* was 2.5 - 4.8 m, while mean diamaters ranged from 64-78 cm. The mean annual rainfall at the trial sites was 700 mm.

Pests and diseases

The following information is taken largely from CAB International (2000).

Diseases known to attack *A. decurrens* are a canker, *Corticum salmonicolor*, in Malaysia (Singh 1973); gummosis (*Ceratocystis fimbriata*) in Brasil (Ribeiro *et al.* 1988); and root rot caused by *Ganoderma lucidum* in Madhya Pradesh, India (Harsh *et al.* 1993).

A minor pest is *Trichilogaster trilineata* which lays eggs in flower buds of *A. decurrens* and other bipinnate acacias. The plant then produces spherical galls around each egg and these may replace most of the flowers on a tree (New 1984). In New Zealand seeds of *A. decurrens* were heavily infested with the phytophagous chalcid, *Eurytoma acaciae* (Cameron 1910) and in Hawaii the species is attacked by four species of native Cerambycidae (Davis 1953). 127 beetle `morphospecies' belonging to the Coleoptera were recorded on *A. decurrens* by New (1979). Ruskin (1983) notes that *A. decurrens* is susceptible to the defoliator *Acanthopsyche junode* and the rust fungus *Uromycladium*. In Australia, the wood of *A. decurrens* is susceptible to Lyctid borer attack which reduces its longevity (Wrigley & Fagg 1996, Pryor & Banks 1991).

Weed potential

Due primarily to its prolific seeding *A. decurrens* can become an environmental weed under certain favourable conditions. It has been widely cultivated as an ornamental and has become naturalized in many areas, including Hawaii, New Zealand, South Africa, Mediterranean Europe and elsewhere. In South Africa it is a Declared Invader (category 2) species (Henderson 2001). Attempts at control of *A. decurrens* in South Africa include the use of herbicides; also, seed-feeding weevils are currently under investigation as a biocontrol agent of this species.

Wood

The wood of *A. decurrens* is light, tough and strong, the sapwood is white and the heartwood pinkish; it has an air-dry density of about 720 kg/m^3 (Bootle 1983) and a basic density of 457 kg/m^3 (Hannah *et al.* 1977). Ilic *et al.* (2000) provides an estimated basic density from air-dry (12%) MC as 520 kg/m^3.

Utilisation

The following information is taken largely from the comprehensive summary of utilisation provided by CAB International (2000).

Wood

Acacia decurrens has the potential to provide an excellent source of fuelwood. Maiden (1889) noted that the wood provides an excellent fuel even in its green state. Ruskin (1983) reports that the wood has a calorific potential of 3 530–3 949 kcal per kg. Individual farm woodlots of both *A. decurrens* and *A. mearnsii* are an important source of woody biomass production in Swaziland (Allen *et al.* 1988, Allen 1990).

The wood of *A. decurrens* has been used for building poles, mine props, fence posts and hardboard production (Ruskin 1983) but according to this author it is not suitable for sawn timber production due to its small dimension. In India it has been considered a valuable timber species (Gamble 1972) and, according to Maiden (1889), it was grown at Coonoor (New South Wales) on a somewhat extensive scale. *Acacia decurrens* was noted a good pole producer in South Africa as it developed only fine lateral branches (Boland 1987).

This species is one of several temperate species reported by Clark *et al.* (1994) as having kraft pulp yields within the range of commercial pulpwoods. Kraft pulping and bleaching studies of plantation-grown eucalypts and acacias, which included *A. decurrens*, pulped to relatively high yields (50–56%) and their pulps bleached readily to high brightness (Hannah *et al.* 1977). *Acacia decurrens* was amongst the species that showed low bulk, high bursting strength and high breaking length and was considered suitable for fine paper furnishes. Pulp from *A. decurrens* was readily bleached to high brightness levels and the bleached pulp properties would be suitable for end products such as writing and printing papers (Logan & Balodis 1982).

Tannin

In the past, *A. decurrens* was used in Australia for the tanning of hides when the industry was locally viable (Clemson 1985), however, its bark is much thinner and inferior in quality to *A. mearnsii* (Maiden 1889). The bark of *A. decurrens* yields 35–40% of good quality tannin but contains an excessively red-coloured tannin extract (Ruskin 1983, Luyt *et al.* 1987). Thus, its tannin is considered to reduce the value of leather and tannin from species such as *A. mearnsii* is preferred. Ruskin (1983), however, notes that this problem with tannin from *A. decurrens* could be overcome by changing the tanning process or by the addition of additives. *Acacia decurrens* is still the main tannin producing species exploited in Indonesia (Prayitno 1982), where the addition of 5–10% of tannin-formaldehyde, made from the tannin from *A. decurrens* bark, is used to manufacture fibreboard from mixed wood species (Silitonga *et al.* 1974). Tannin-formaldehyde from *A. decurrens* significantly improves the strength, water-absorption and thickness-swelling properties of the boards and the cost of its production is reduced by the addition of urea to the tannin (Santoso & Sutigno 1995).

Gum

Acacia decurrens is also known for the production of wattle gum. According to Maiden (1889), the tree yields copious gum during the summer months and was used to make jelly-like confection; its gum has also been used as a substitute for gum arabic (Macmillan *et al.* 1991).

Land use and environmental

Acacia decurrens is a moderately deep rooted, drought-tolerant, nitrogen-fixing tree, widely planted to shade crops (Macmillan *et al.* 1991). It has been used for windbreaks, shelterbelts, as a shade crop and for stabilisation of ash spoil. In Sri Lanka, it was introduced by tea planters around the 1870s and widely-used above an altitude of 1000 m for hedges, shelterbelts and windbreaks, shade trees, green manure and fuelwood production (Midgley & Vivekanandan 1987). It was a major component in the Sri Lankan government fuelwood plantations until 1936 (Streets 1962, Champion 1935) and is used in ornamental plantings (Midgley & Vivekanandan 1987, Clemson 1985).

Acacia decurrens was included in an investigation of stabilisation techniques to control wind erosion of an ash disposal site at Port Kembla, Australia where salinity of the ash, exposure to winds, and high erodibility were particular problems (Junor 1978). It established and grew well and along with various methods of a bituminous emulsion seal, grass sowing, strip sodding and addition of an earth layer, enabled the site to be developed as a recreational area.

Acacia decurrens also competes well with weeds (Ruskin 1983). If established in dense stands, the accumulation of shed foliage from *A. decurrens* forms a thick ground cover which, over time, eliminates the growth or establishment of other vegetation at the site.

Fodder

Acacia decurrens is not known for its fodder value in Australia.

Other uses

Other known uses of *A. decurrens* include the following: medium to abundant quantities of pollen are produced during good flowering seasons and which is a potential source of forage to sustain bee hives (Clemson 1985); according to Subba Rao (1959) the seeds have a high oil content with potential for use as a `drying oil'; it has been used for green manure production (Webb *et al.* 1984); and dyes extracted from the leaves of *A. decurrens* have been used to colour wool yellow or green depending on the mordant used (Martin 1974).

This species is well known as an ornamental.

Potential for crop development

Acacia decurrens is regarded as having reasonably good prospects as a crop plant for high volume wood production. *Acacia decurrens* is ranked a category 2 species and would be best suited to development as a phase crop (see Table 6). Available evidence suggests that this species would not be suited as a coppice crop. Vegetative regrowth is seemingly poor, however, coppicing trials could be undertaken to ascertain if two or more rotations can be produced from the original planting stock. Provenance variation for coppicing ability and seasonal timing of pollarding may be factor in this species.

Acacia decurrens develops an excellent growth with the potential to produce clear, straight stems and produces good quantities of woody biomass. The wood is pale coloured of low density (457–520 kg/m^3) and is within the range needed for reconstituted wood products, commercial pulpwoods and other wood products (see under **Utilisation** above). Additional important end-product possibilities for this species could include gum and tannin. *Acacia decurrens* has potential to be harvested for wood on five (or less than five) year rotations (vigour and wood quality are likely to decline beyond this period). Trees around this age should attain a dbh in the range of 10–15 cm. To achieve this, spacing of plants may be a critical factor and therefore trials are warranted to investigate this effect. (Judging from our field observations of natural stands we would expect that, under cultivation, plants could be grown reasonably close together without detrimental effect to growth form or the quantity of woody biomass produced.)

Root suckering is unlikely to pose problems in the management of this species as a phase crop. However, *A. decurrens* produces prolific quantities of seed which would result in the creation of a soil seed bank that could lead to weed problems in adjacent or subsequent annual crops. (Alternatively young seedlings may possibly be treated as a form of green manure.) Harvesting plants before they reach biological maturity is one way of preventing seed set; however, plants would need to have developed sufficient wood biomass by that time for such a technique to be viable.

The area predicted to be climatically suitable for the cultivation of *A. decurrens*, based on its natural climatic parameters, is shown in Map 18. This analysis indicates that *A. decurrens* has the potential to be cultivated in regions well beyond its natural distribution, extending into the greater than 600 mm rainfall zones of Victoria, Tasmania, South Australia and Western Australia. However, within the both the eastern and western target zones the best results will probably be achieved on valley soils on upland sites that receive a minimum of 500 mm mean annual rainfall. The species should also tolerate frosty winter conditions fairly well so sites at higher altitudes should be targeted. However, provenance variation is likely to affect its success in cultivation, particularly for growth and drought tolerance. The species is susceptible to borer attack and control of insects and fungal pathogens could be important silvicultural issues.

Acacia decurrens has environmental weed potential, particularly in high rainfall areas. It is not known, however, if it would be a problem in the drier environment of the target area. Nevertheless, any wide-scale use of this species should be accompanied by a thorough weed risk assessment.

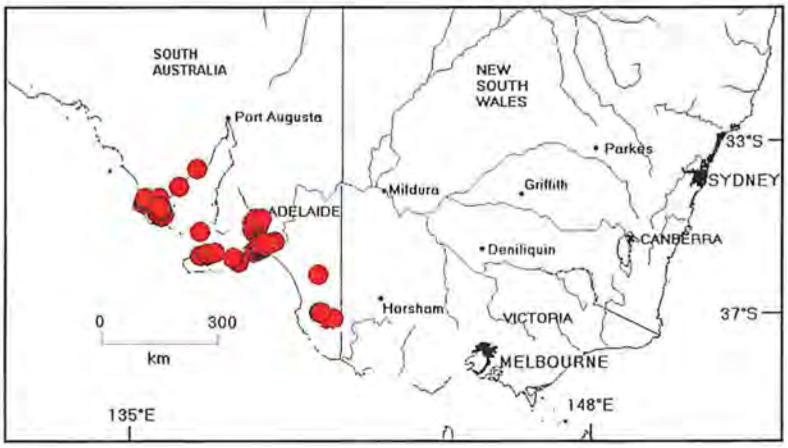
Acacia dodonaeifolia (Pers.) Balb.

Common Names

Sticky Wattle, Hop-leaved Wattle.

Habit

Erect, bushy or open, much-branched, viscid shrubs or small trees 2–6 m tall, dividing near ground level into a number of main stems, the main stems to 20 cm dbh and not especially straight on old plants, typically with a spreading canopy.



Map 19. Distribution of *A. dodonaeifolia*.

Botanical descriptions and illustrations/photographs are provided by Simmons (1988), Tame (1992), Whibley & Symon (1992) and Maslin (2001 & 2001a).

Taxonomy

Acacia dodonaeifolia is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Species of section *Phyllodineae* are widespread in Australia with the main centres of richness located in temperate and adjacent semiarid areas of eastern, southeastern and southwestern Australia; species number greatly decline in the arid zone and in northern tropical/subtropical areas (Hnatiuk & Maslin 1988 and Maslin & Pedley 1988).

Acacia dodonaeifolia is taxonomically quite far removed from other members of section *Phyllodineae* that are discussed in this report. It is a member of the *A. verniciflua* group of species.

Map 20. Predicted area (blue) where *A. dodonaeifolia* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 19), see also Table 5. Target area shown in yellow.

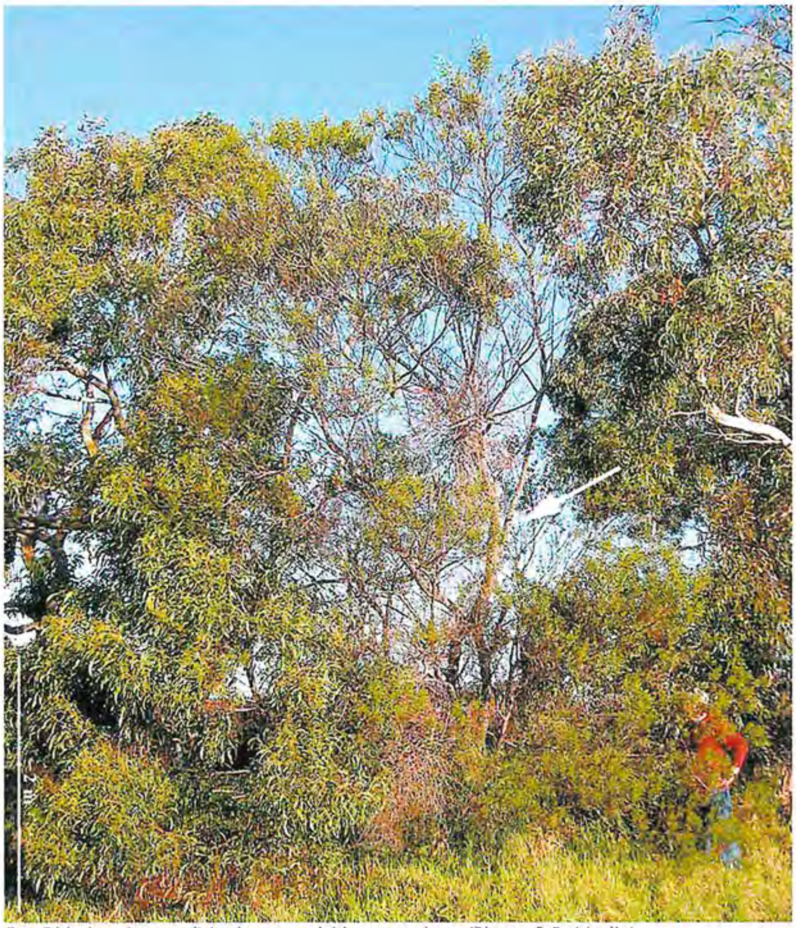
Conservation status

This species is listed as Rare on the South Australian National Parks and Wildlife Schedule. Collection of seed from wild populations will require a permit and because of its conservation rating more stringent conditions apply than would to a non-listed species.

Distribution and habitat

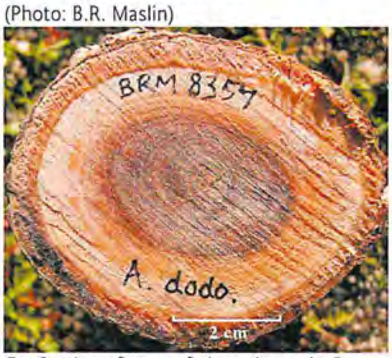
Seemingly endemic in South Australia where it has a scattered distribution, mainly in near-coastal, regions. It is unknown if the species occurs naturally in Victoria (see **Weed potential** below). In South Australia the two main areas of occurrence are the southern part of the Eyre Peninsula and the southern Lofty region; it is locally common in some places on the southern Eyre

Figure 9. *Acacia dodonaeifolia*



A – Old plant (arrowed) in dense roadside vegetation. (Photo: B.R. Maslin)

B – Base plant shown in A. (Photo: B.R. Maslin)



C – Section of stem of plant shown in A. (Photo: B.R. Maslin)

D – Adolescent plant showing dense rounded habit. (Photo: B.R. Maslin)

E – Branchlet showing round heads & sticky phyllodes. (Photo: J. Simmons)

Peninsula but not common elsewhere. There are minor occurrences on the southern Yorke Peninsula, Kangaroo Island and few scattered localities in the southeast of the State around Naracoorte and Keith.- The distribution of A. *dodonaeifolia* is largely confined to the target area. Usually grows on undulating hills on clay loams or sandy clay loams, in eucalypt woodland and open forest (not in Mallee communities according to P. Lang, pers. comm.). It is tolerant of calcareous soils.

Flowering and fruiting

Flowers from July to November and fruits usually from December to January (Bonney 1994).

Biological features

Likely to coppice and only occasionally suckers. It is reputed to be fast growing (according to M. O'Leary, pers. comm., it can reach 4–5 m quickly with main stems 6–8 cm diam.). It is estimated that plants live for about 20 years.

Genetics

Possible natural hybrids between A. *dodonaeifolia* and A. *paradoxa* are recorded from the Eyre Peninsula, South Australia (see Whibley & Symon 1992); in WATTLE (Maslin 2001a) this putative hybrid is keyed and described separately, as A. *dodonaeifolia x paradoxa*.

Cultivation

In South Australia A. *dodonaeifolia* has been cultivated in rows as a hedge plant (M. O'Leary pers. comm) and is used in roadside plantings in Victoria (see below). However, it is not common in cultivation. It is likely to grow best on well-drained soils; lime tolerant. Seed should be sown from mid- to late-spring (Bonney 1994).

Weed potential

This species has at least moderate weed potential in wetter areas (for example, some plants found in the Adelaide Hill may be garden escapes). Also, according to Entwistle *et al.* (1996), the species is naturalized and spreading in western Victoria, usually escaping from roadside plantings. These authors note that it is not possible to determine with certainty whether herbarium records of A. *dodonaeifolia* from the early 1900's, from around localities such as Nhil and Kerang, are plantings or naturalized.

Wood

Based on our limited field sampling, the wood is reasonably lightweight relative to its volume (hence probably of moderately low density); the sapwood is white and was present in a similar ratio to the light brown heartwood. Splits occurred due to shrinkage during drying of our field wood samples.

Utilisation

Suitable for ornamental and amenity planting.

Potential for crop development

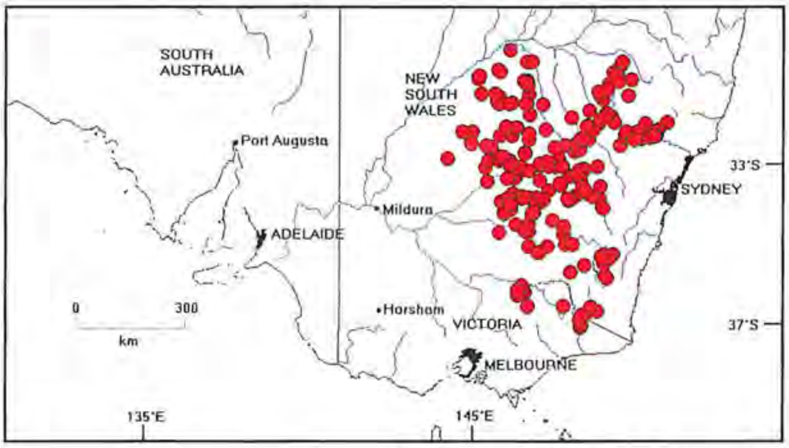
Because of a paucity of relevant information it is difficult to accurately assess the crop potential of *A. dodonaeifolia*. Nevertheless, based on current evidence it is not considered particularly prospective as a crop plant for high volume wood production. It is ranked as a category 4 species and would seem best suited as a phase crop (Table 6). It is expected that the coppicing ability of *A. dodonaeifolia* would be insufficient to warrant its consideration as a coppice crop. This species is reputed to have a very fast grow rate and, in wetter areas at least, develops a moderate amount of woody biomass (wood seemingly has a moderately low density). However, it is not known if this species is capable of producing acceptably high volumes of wood; in drier sites in particular it may well have difficulties meeting biomass requirements. Because *A. dodonaeifolia* is taxonomically distinct from other species detailed in this report it may possess unique, desirable attributes; it is therefore worth undertaking further study to assess these possibilities.

The area predicted to be climatically suitable for the cultivation of *A. dodonaeifolia*, based on its natural climatic parameters, is shown in Map 20. This analysis suggests that *A. dodonaeifolia* is suited for cultivation on exposed sites in the 300–450 mm rainfall zone of the target area. However, we would expect it to perform even better in higher rainfall areas (which is where it may possibly be prone to some degree of weediness). This may be a difficult species to mechanically harvest due to its often "busy" multiple branching from ground level.

Acacia doratoxylon A. Cunn.

Common Names

Brown Lancewood (Standard Trade Name), Lancewood, Currawang, Spearwood, and more (see Cunningham *et al.* 1981).



Map 21. Distribution of *A. doratoxylon*

Habit

Normally shapely tall shrubs or trees 3–12 m high, with a single trunk (bole 1–6 m long and 15–35 cm dbh) or sometimes dividing into a few main branches from near ground level, the bole and main branches straight to sub-straight, its form apparently deteriorates (becomes more twisted) as the species approaches coastal districts (*fide* Maiden and Boorman specimen NSW 378864), branch wood brittle; crowns dense, not overly spreading and occupying about ¼–½ of the total plant height. Bark dark brown, longitudinally fissured and tightly held.

Botanical descriptions and illustrations/photographs are provided by Maiden (1910), Cunningham *et al.* (1981), Costermans (1981), Simmons (1987), Tame (1992), NSW (2001 & 2001a) and Kodela (2002).

Taxonomy

Acacia doratoxylon is referable to *Acacia* section *Juliflorae* a diverse, and probably artificial, group of about 235 species (Maslin 2001) which are characterized by having plurinerved phyllodes and flowers arranged in cylindrical spikes (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Section *Juliflorae* is widespread in Australia with the main centres of species richness occurring in the north, northwest and southwest of the continent and secondary centres of richness located along the Great Dividing Range in eastern Australia; although plants of this group often form a conspicuous element of the Arid Zone flora, species numbers in these areas are generally not great (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). Only three species of section *Juliflorae* are detailed in this report, namely, *A. acuminata*, *A. doratoxylon* and *A. lasiocalyx*.

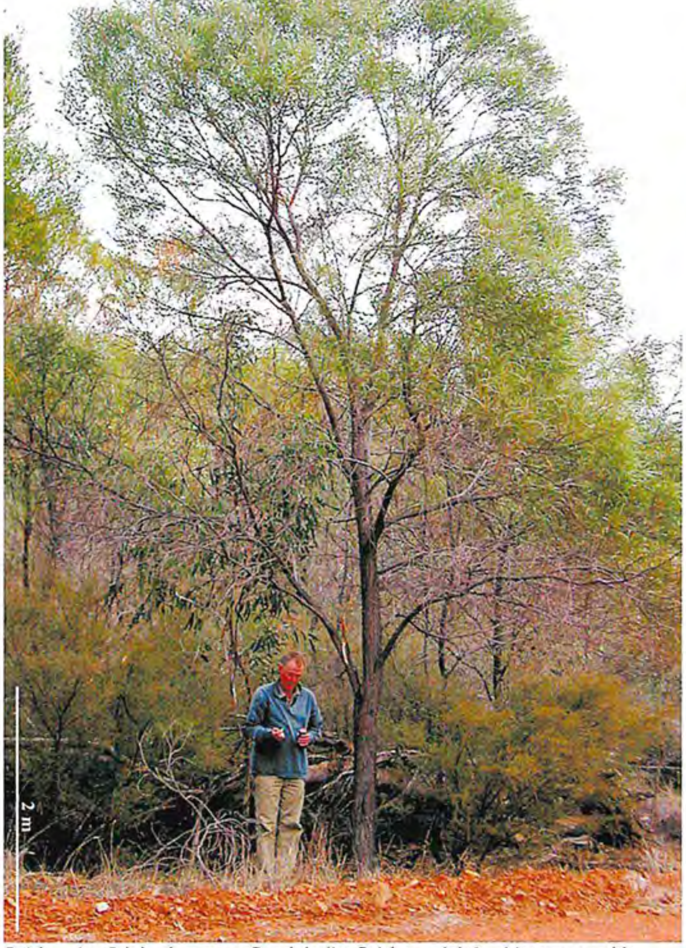
Closely related to *A. caroleae* (not included in this report as it occurs north of the target area and seemingly lacks suitable woody biomass). It also has some affinities with *A. lasiocalyx* from Western Australia (see below).

Map 22. Predicted area (blue) where *A. doratoxylon* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 21), see also Table 5. Target area shown in yellow.

Distribution and Habitat

Widespread and common on the western slopes and plains of New South Wales south 30°S, extending to the southern tablelands of New South Wales and Australian

Figure 10. *Acacia doratoxylon*



A (above) – Adult plant near Condobolin; B (above right) – Mature stand in sclerophyl forest near Sandy Hollow;
C (right) – Stem section (of plant shown in A) showing dark heartwood.
(Photos: B.R. Maslin)

D (far left) – Single stem at base (normal for the species); E (left) – Multistemmed (not common); F (above) – Flowering branch showing spikes on short racemes. (Photos: D & E by B.R. Maslin; F by J.M. Baldwin)

Capital Territory and also the Barambogie Range near Beechworth and the Suggan Buggan area in northeastern Victoria (Entwistle 1996, NSW 2001). This species is common in parts of the target area in New South Wales but its distribution extends beyond the boundary of the region. It is often common in the areas where it occurs and often forms relatively dense, almost monospecific communities. It commonly volunteers along roadsides from seed introduced in road gravel (Cunningham *et al.* 1981). *Acacia doratoxylon* occurs mainly on well-drained, skeletal soils (which include coarse and gravelly sands and lithosols) on rocky ridges or hillsides (often granite), and on flat or undulating land on red earths.

Flowering and fruiting

Flowers from late August to late September in the north of its range and mid-September to November in the south.

Biological features

A drought- and frost-tolerant species that requires well-drained soils (Doran and Turnbull 1997). Does not sucker; coppicing/pollarding ability unknown. In dense populations the species undergoes a natural thinning process in the wild, whereby some plants (which are perhaps 20–30 years old) die off. When this happens the dying plants are clearly visible on account of their yellowish foliage. Our anecdotal field observations suggest that this is a rather slow growing species (plants from around Condobolin perhaps attaining 5–6 cm dbh in about 20 years); however, Doran & Turnbull (1997) report a reasonably fast growth rate of 2.6 m/year. This matter requires further investigation. It is long-lived (Stelling 1998).

Toxicity

Phyllodes contain moderate amounts of cyanogenic glycoside (Maslin *et al.* 1987) but do not contain an endogenous enzyme necessary to hydrolize this into hydrogen cyanide. *Acacia doratoxylon* has not been incriminated in stock losses due to cyanide poisoning.

The splinters of the wood are believed to be quite poisonous (Webb 1948).

Cultivation

Can be grown from both cuttings and seed according to Simmons (1987). Under cultivation it would be expected that, on account of its relatively narrow crowns and by observation of how it behaves in nature, this species could be planted rather close together without deleterious effect to its stem form or biomass production.

Weed potential

No records of weediness for this species despite the fact that its natural distribution is within the cleared, agricultural zone.

Wood

Hard and close-grained, perfumed (when freshly cut), tough, heavy and durable; it is dark brown, with a small amount of yellow sapwood Maiden (1910). The estimated basic density from air-dry (12%) MC is given as 720 kg/m^3 by Ilic *et al.* (2000). The wood develops minor end fractures upon drying.

Utilisation

Wood

In the past wood of this species has been used for gates, buggy poles, turnery, furniture, etc. and by the aboriginies for boomerangs, spears and waddies (Maiden 1889). The wood is an excellent fuel, producing a hot fire (Stelling 1998). Stelling reports that the wood resembles that of blackwood (*A. melanoxylon*) but is heavier and less-grained and, although it tends to split, it is still valuable for furniture manufacture.

Land use and environmental

Useful as a low windbreak and produces good growth in rocky erodible soil in recharge areas; it is a good habitat for wildlife (Stelling 1998).

Fodder

Although Cunningham *et al.* (1981) report this species as having been eaten by stock (both cattle and sheep) it is not rated highly in this regard (see Maiden 1910).

Other uses

A shapely small tree suitable for ornamental and amenity planting. A prolific pollen producer (Doran & Turnbull 1997).

Potential for crop development

Acacia doratoxylon is regarded as having only moderate prospects as a crop plant for high volume wood production. It is ranked as a category 3 species and current evidence suggests that it would be best suited to development as a long cycle crop for solid wood products (Table 6). The plants have an excellent growth form (commonly forming clean, straight boles 2m or more in length) and would be amenable to mechanical harvesting. The species develops a good amount of woody biomass, however, the wood is moderately dense which lowers its attraction for use in reconstituted wood products. Growth rates require further investigation but they appear to be only moderately fast and are unlikely to match the more prospective species such as *A. linearifolia*, *A. leucoclada*, etc. which occur in the same geographic area as this species. Growth rate will probably be slowest in the drier, inland parts of its range. *Acacia doratoxylon* could, nevertheless, be a useful inclusion for diversifying planting systems, for long-term prospects for timber production and for growing on recharge sites in light soils. It is one of the very few plurinerved species of section *Juliflorae* that possess characteristics which have enabled its inclusion in this report.

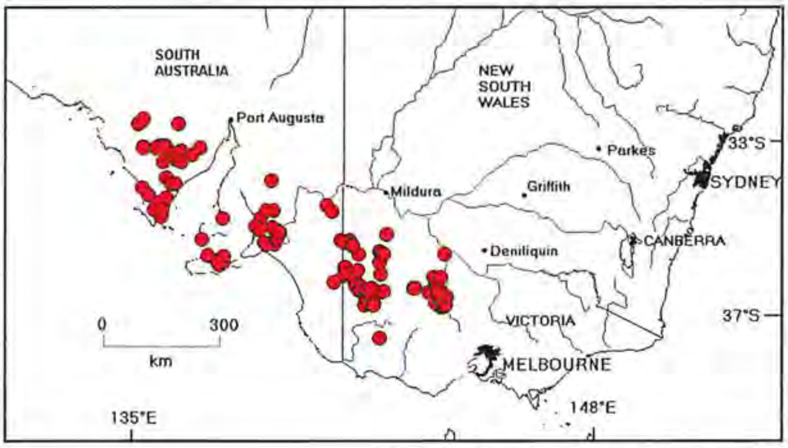
The area predicted to be climatically suitable for the cultivation of *A. doratoxylon*, based on its natural climatic parameters, is shown in Map 22. This analysis indicates that within the eastern target area *A. doratoxylon* has the potential to be cultivated in areas of Victoria and South Australia, well beyond its natural distribution. The analysis also predicts that climatic conditions throughout much of the western target area are also suitable for its growth. Areas for cultivation should include exposed sites in the 300–450 mm rainfall zone. Upland sites that receive some supplementary water from run-on rainfall effects should be targeted. This species could prove particularly useful on steep hilly landforms. *Acacia doratoxylon* is not suited to heavy clay soils. Provenance variation in this species for attributes such as frost tolerance is likely to be substantial.

Acacia euthycarpa (J. Black) J. Black

Common Name

None known.

Habit



Map 23. Distribution of *A. euthycarpa*.

Obconic shrubs 2–6 m tall, reputed to attain small tree stature to c. 10 m high but such plants have not been seen by the authors (see discussion under Variants below), with 3–6 main stems from near ground level, the main stems sub-straight to somewhat crooked, 7–10 cm dbh and becoming much divided into many twiggy, ascending to erect terminal branches (pendulous on plants from the Gawler Range, S.A.), the crown sub-dense and occupying ¼–½ total plant height, develops strong lateral roots. Bark smooth, thin, grey.

Botanical descriptions and illustrations/photographs are provided by Maslin & O'Leary (2001).

Taxonomy

Acacia euthycarpa is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). More specifically this species is a South Australian member of the Australia-wide '*Acacia microbotrya* group' (Maslin 1995) and has until recently been treated as conspecific with its very close relative, *A. calamifolia* (see Maslin & O'Leary 2001 for discussion). *Acacia calamifolia* is not regarded as a prospective species for development as a woody crop plant on account of its low wood biomass production. However, a number of other species from the '*Acacia microbotrya* group' are detailed in the present report, namely, *A. bartleana*, *A. microbotrya*, *A. retinodes*, *A. rivalis* and *A. wattsiana*. Species of section *Phyllodineae* are widespread in Australia with the main centres of richness located in temperate and adjacent semiarid areas of eastern, southeastern and southwestern Australia; species numbers greatly decline in the arid zone and in northern tropical/subtropical areas (Hnatiuk & Maslin 1988 and Maslin & Pedley 1988).

Map 24. Predicted area (blue) where *A. euthycarpa* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 23), see also Table 5. Target area shown in yellow.

As discussed by Maslin & O'Leary (2001) *A. euthycarpa* exhibits a wide range of variation and further study is needed to elucidate this complexity. The species normally grows as a shrub 2–4 m tall, however, under the name of *A. calamifolia*. Court (1973) reports *A. euthycarpa* from the Wedderburn–Wychitella district in Victoria to occur as substantial trees reaching 10 m high and with a stem diameter of c. 20 cm. Despite having briefly visited this area we have not been able to locate these plants. Tall shrub forms (to 6 m high)

Figure 11. *Acacia euthycarpa*

A – Old plant at Saunders Creek, S.A. (note sub-straight main stems & terminal crown). (Photo: B.R. Maslin)

B – Stem branching near base. (Photo: B.R. Maslin)

C – Section of stem of plant in A (wood dense). (Photo: B.R. Maslin)

D – Adolescent plant at Saunders Creek showing typical obconic growth form. (Photo: B.R. Maslin)

E – Flowering branch showing heads (in very short racemes) & short phyllodes. (Photo: M. O'Leary) occur near Saunders Creek in South Australia and it is these plants that form the basis of the above description.

Distribution and habitat

Occurs in South Australia from Mt Finke, Gawler Ranges, Eyre Peninsula, Kangaroo Island, the Barossa Range south to Goolwa, and eastwards through the Murray Mallee to north-western and western Victoria (including Mt Arapiles). This distribution is largely confined to the target area. Occurs on plains or gently undulating terrain on deep sand or alluvial loams derived from granite.

Flowering and fruiting

Flowers from August to October and pods with mature seeds occur between December and January (Martin O'Leary, pers. comm.).

Biological features

No experimental data available, however, based on field observations of the Saunders Creek population it is probable that this species would be only moderately fast growing (it may take around 10 years to produce stems c. 3 cm dbh), its coppicing ability is unknown but it is unlikely to sucker. It is probably moderately long-lived (around 30 years, D. Kraehenbuehl pers. comm.)

Cultivation

Not known in cultivation. However, it would be best suited to light-textured, well-drained soils.

Weed potential

No records of weediness for this species despite the fact that its natural distribution is within the cleared, agricultural zone.

Wood

Based on field observations from one plant from Saunders Creek the wood is dense and had an extensive development of medium brown heartwood.

Utilisation

Land use and environmental

Suited to low windbreaks on account of the porous crowns.

Potential for crop development

Because of a paucity of relevant information it is difficult to accurately assess the crop potential of this poorly known species. Nevertheless, based on current evidence it is not regarded as particularly prospective as a crop plant for high volume wood production. It is ranked as a category 4 species and would seem best suited as a phase crop (Table 6). Judging from our observation of a natural population at Saunders Creek, South Australia, *A. euthycarpa* develops quite a good growth form but does not produce excessively large amounts of woody biomass (the upper branches are very twiggy). Furthermore, it is probably not overly fast growing and the wood appears to be rather dense (therefore lowering its attraction for use in reconstituted wood products). However, *A. euthycarpa* is a member of the '*Acacia microbotrya* group' which contains a number of species considered prospective in this report. It may therefore be worth further investigating *A. euthycarpa* and in particular trying to locate and assess the reported arborescent form that is reported to occur near Wedderburn in Victoria.

The area predicted to be climatically suitable for the cultivation of A. *euthycarpa*, based on its natural climatic parameters, is shown in Map 24. This analysis indicates that A. *euthycarpa* is a good match for climatic conditions throughout the less than 500 mm rainfall zone of the eastern and western target areas. This prediction suggests it cultivation could be extended beyond its natural distribution into large areas of New South Wales and Western Australia. The potential for cultivation on appropriate soils types throughout much of the target areas is a possibility.

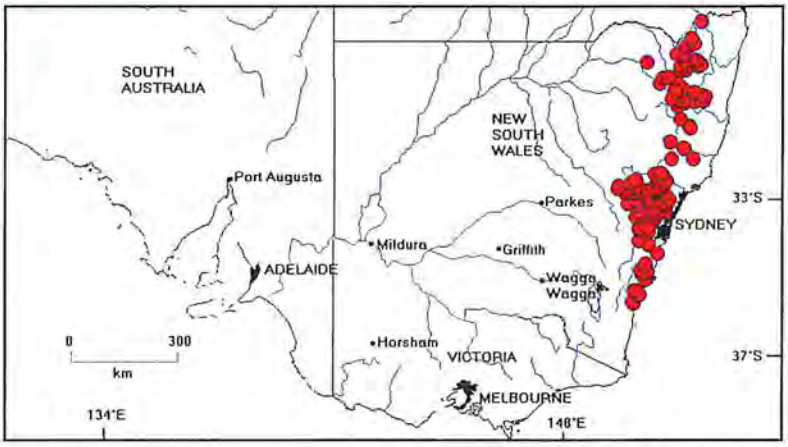
Acacia filicifolia Cheel & M.B.Welch

Common Name

Fern-leaved Wattle.

Habit

Erect shrubs or trees 3–14 m high, multi-stemmed at ground level (with up to 5 main stems) or single-stemmed to 0.5–1.5 m before branching, main stems straight to sub-straight (we measured stems 11–14 cm dbh but they undoubtedly get larger). Bark thin, smooth but with age becoming fissured near base of main stems, black or dark brown. Note: this description is based on very limited field knowledge of the species.



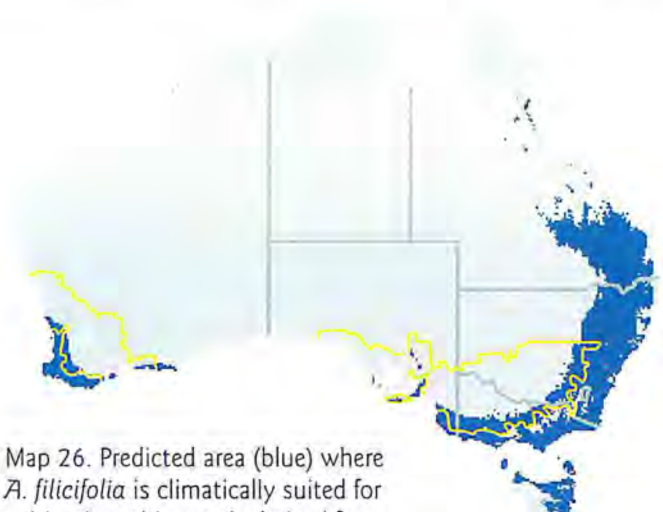
Map 25. Distribution of *A. filicifolia*

Botanical descriptions and illustrations are provided by Costermans (1981), Fairley & Moore (1989), Tindale & Kodela (2001) and Kodela (2002); a description is also provided by Pedley (1980).

Taxonomy

This species belongs to *Acacia* section *Botrycephalae*, a group of 44 mostly arborescent species characterized by having bipinnate adult foliage and flower heads normally arranged in elongated racemes (Orchard & Wilson 2001). These species predominate in temperate areas of eastern and southeastern Australia (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). There are seven species of *Botrycephalae* detailed in this report, namely, *A. baileyana, A. dealbata* subsp. *dealbata, A. decurrens, A. filicifolia, A. leucoclada* subsp. *leucoclada, A. mearnsii* and *A. parramattensis*. A number of recent studies have suggested that species of section *Botrycephalae* are most closely related to certain racemose species of section *Phyllodineae* (foliage phyllodinous) from eastern Australia, see Maslin & Stirton (1998) and Maslin *et al.* (2003) for reviews. Of the phyllodinous species included in this report those having presumed closest affinities to species of *Botrycephalae* include *A. linearifolia, A. neriifolia* and *A. pycnantha*; members of the '*Acacia microbotrya* group' are not far removed from these species.

Acacia filicifolia is closely related to *A. storyi* and *A. parvipinnula* (Tindale & Kodela 2001). A study by Tindale & Roux (1969) of flavonoid and condensed-tannin contents of the heartwood and bark of *Acacia* recognized four groups within section *Botrycephalae*; this study placed *A. filicifolia* in a group with *A. irrorata* and *A. silvestris*.


Map 26. Predicted area (blue) where *A. filicifolia* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 25), see also Table 5. Target area shown in yellow.

Distribution and habitat

Occurs from Stanthorpe, southeast Queensland, to Bateman's Bay on the south coast of New South Wales (Tindale & Kodela 2001). In the latter State it occurs in the North and South Coast regions, as well as the Northern and

Figure 12. *Acacia filicifolia*

A – Young plant. (Photo: J. Simmons)

B – 3 years old plant in trial at Kowan, Australian Capital Territory. (Photo: S. Searle)

C – Base of stems showing variation in number of branches. (Photos: B.R. Maslin)

D – Stem core showing pale coloured wood. (Photo: P. Macdonnell)

E – Flowering branch showing heads in racemes & leaves bipinnate. (Photo: J. Simmons)

Central Tablelands, and the North and Central Western Slopes. It is common within its geographic range. Although the natural distribution of A. *filicifolia* is outside the target area it occurs close to the northeastern border in New South Wales. Grows in open forest, eucalypt scrub-woodland and savannah, on valley slopes or alluvial flats, often near streams, often on granite but also on various strata (Tindale & Kodela 2001). Soils range from sands to gravelly clays.

Flowering and fruiting

Flowers from late July to October and fruits chiefly from November to January (but sometimes in October).

Genetics

Chromosome number: $2n = 26$ (Tindale & Kodela 2001).

Biological features

Our field observations at one site near Glen Innes suggest that the species may have some suckering potential (but this is not likely to be vigorous). Under trial conditions near Canberra plants of A. *filicifolia* did not develop root suckers (Searle *et al.* 1998). In these same trials this species was shown not to be especially frost sensitive. It is unlikely to coppice. Five year old plants under trial in Western Australia showed no evidence of coppicing (or root suckering) 12 months after harvest (Barbour 2000). An analysis of gum characteristics is given in Anderson *et al.* (1971).

Cultivation

Yield

Acacia filicifolia was represented at two sites in fuelwood trials near Canberra, A.C.T. (CSIRO 2001). The sites at Kowen and Uriarra had a mean annual rainfall of 630 mm and 824 mm respectively. Differences in performance between the Yadboro Flat and Singleton provenances at each trial site were not great. At age 2.6 years mean heights ranged from 4.7–5.2 m tall and dbh ranged from 4.7–5.1 cm. The mean height and dbh incremental increase was around 2 m and 2 cm per year respectively. At 5.2 years some differences in growth between provenances had become evident. At Kowen the mean height of the Singleton provenance was 6.8 m and mean dbh of 8 cm, while the Yadboro Flat provenance attained 5.3 m in height with a 6.3 cm mean dbh.

Acacia filicifolia was included by Barbour (2000) in trials involving 12 bipinnate acacias at three sites in Western Australia (Busselton, Darkan and Mt Barker). The species was ranked among the top five for growth, form and volume yield per hectare at age 5 years. Of the two provenances represented, Yadboro Flat out-performed the Singleton provenance. Survival and ranking of A. *filicifolia* was best at the cooler Mt Barker site. At the Busselton and Mt Barker trial sites A. *filicifolia* produced around twice the biomass compared to the Darkan site. In these trials the performance of plants at the Mt Barker and Darkan sites are of most interest to the present study because these areas both receive 650 mm mean annual rainfall. Barbour's report highlighted the fact that high evaporation and high summer temperatures at the Darkan site were too severe for the successful establishment of bipinnate acacias. These trial results suggest provenance variation will be a significant factor in the domestication of A. *filicifolia*. They also demonstrate that this species has some potential for successful cultivation in areas receiving at least 650 mm rainfall in the target area.

Acacia filicifolia was represented by two provenances in trials involving 16 temperate acacias at two sites in Victoria (Bird *et al.* 1998). The Yadbora Flat provenance performed well attaining 4.7 m in mean height with a 6.5 cm mean diameter at age 34 months.

Pests and diseases

African Black Beetle can cause severe damage in cultivation trials in W.A. (Barbour 1995). Birds are reported to have caused damage to plants under trial near Canberra (Searle *et al.* 1998).

Weed potential

There are no reported serious weed problems involving this species. However, in its natural area of occurrence it frequently colonises disturbed sites and hence, probably has some weed potential, especially in areas outside its natural range (Terry Tame, pers. comm.).

Wood

No specific information known except wood is pale coloured (it is likely to be of low density).

Utilisation

The timber of this species, according to Anderson (1968), has been used for fuel and minor purposes; the bark is inferior to that of A. *meansii* for tanning purposes, yielding about 25–32% tannin.

Potential for crop development

This poorly known species is provisionally ranked as category 3 (Table 6). Current evidence suggests that A. *filicifolia* is moderately fast growing and does not root sucker (or suckers only weakly) and therefore would be most suited for development as a phase crop. However, like many other species included in this report A. *filicifolia* has the capacity to produce large quantities of seed and this would lead to the creation of a soil seed bank that may lead to weed problems in adjacent or subsequent annual crops (on the other hand seedling regeneration may possibly be treated as a form of green manure). Harvesting plants prior to them reaching biological maturity is one way of avoiding soil seed build up, however, it is not known at what age A. *filicifolia* first sets appreciable pod crops. This species is capable of producing good quantities of woody biomass, at least in the wetter parts of its range (which occur outside the target area). Although nothing is known of its wood characters they are likely to be similar to those found in other Botrycephalae species, namely, pale coloured and of low density (thus attractive for use in reconstituted wood products).

The area predicted to be climatically suitable for the cultivation of A. *filicifolia*, based on its natural climatical parameters, is shown in Map 26. This analysis indicates that A. *filicifolia* is well suited to climatic conditions beyond its natural range into Victoria, Tasmania and the higher rainfall zones of South Australia and Western Australia. Within the eastern target area best growth is predicted to be mainly along the south-eastern fringes but site selection will be critical to achieving best results for biomass production. Wherever it is cultivated in the target areas A. *filicifolia* can be expected to perform best in the 550–650 mm rainfall zone and in valley soils on upland sites. Areas where frosts are a problem could be targeted as this species does not appear to be especially frost sensitive. Provenance variation is also likely to be substantial, particularly for desirable attributes such as form and biomass production. Comprehensive trials are therefore warranted to investigate this effect.

Depending on site conditions data from the few existing trials suggest that A. *filicifolia* may be out-performed by two other species of *Botrycephalae* that are detailed in the present report, namely, A. *decurrens* and A. *mearnsii*.

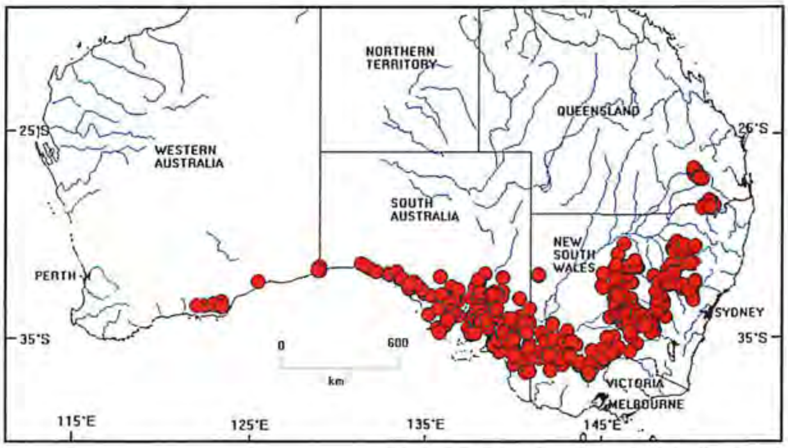
Acacia hakeoides Cunn. ex Benth.

Common Names

Western Black Wattle, Hakea Wattle.

Habit

Bushy, multi-stemmed (2 to many stems) shrubs or small trees to 1–4 (–6) m high, rarely single-stemmed, reported as 'occasionally up to 40 feet' by Anderson (1968), but this is undoubtedly an error, main stems normally straight to sub-straight, commonly 4–9 cm dbh and moderately branched, it suckers freely and commonly forms thickets; crowns rather spreading. Bark smooth, thin.



Map 27. Distribution of *A. hakeoides*

Botanical descriptions and illustrations/photographs are provided by Cunningham *et al.* (1981), Costermans (1981), Simmons (1987), Fairley & Moore (1989), Whibley & Symon (1992), Tame (1992), Maslin *et al.* (1998) Maslin (2001 & 2001a) and Kodela (2002).

Taxonomy

Acacia hakeoides is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Species of section *Phyllodineae* are widespread in Australia with the main centres of richness located in temperate and adjacent semiarid areas of eastern, southeastern and southwestern Australia; species number greatly decline in the arid zone and in northern tropical/subtropical areas (Hnatiuk & Maslin 1988 and Maslin & Pedley 1988).

Acacia hakeoides is related to *A. williamsonii* and *A. difformis* (not included in this report) and not far removed taxonomically from *A. pycnantha* (see species profile below). Other species detailed in this report which are not far removed taxonomically from *A. hakeoides* include *A. linearifolia* and *A. neriifolia*; members of the '*Acacia microbotrya* group' are related to these taxa.

As discussed by Maslin (2001) the phyllodes of *A. hakeoides* are somewhat variable in shape and size; specimens with narrow linear phyllodes are scattered throughout the range of the species. Also, a long phyllode variant occurs near Eaglehawk in the Bendigo 'Whipstick' forest, Victoria (Court 1973); these plants superficially resemble hybrids between *A. pycnantha* and *A. williamsonii* which also occur in the 'Whipstick'.

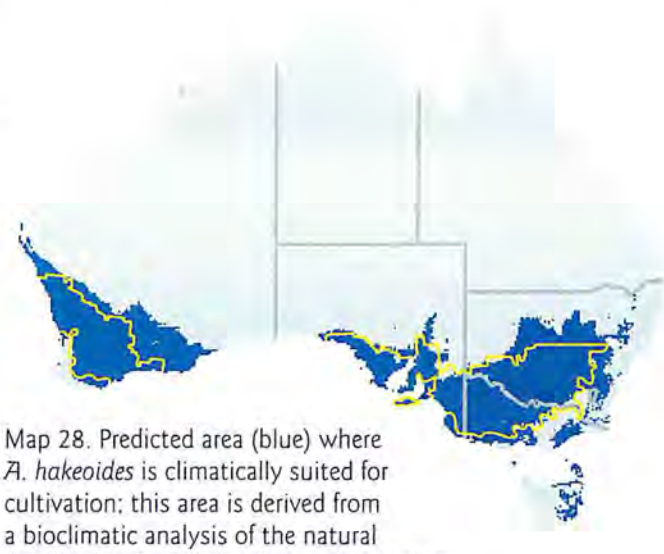

Map 28. Predicted area (blue) where *A. hakeoides* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 27), see also Table 5. Target area shown in yellow.

Figure 13. *Acacia hakeoides*

A – Adult multi-stemmed plant in roadside suckering population. (Photo: B.R. Maslin)

B – Adult single-stemmed (rare) plant in same population as A. (Photo: B.R. Maslin)

C – Adult plant showing dense crown. (Photo: B.R. Maslin)


D – Branch showing prolific flowering (heads in racemes). (Photo: comm. I.B. Armitage)


E – 4 year old plant in on-farm revegetation trial near Wagga Wagga. (Photo: B.R. Maslin)


F – Section of stem (of plant in A) showing dense, pale wood. (Photo: B.R. Maslin)

Distribution and habitat

Widespread but scattered in southern Australia where it extends from near Esperance, Western Australia, eastwards through South Australia (southern regions) and western Victoria, north on the Great Divide, it occurs on inland slopes and adjacent plains in New South Wales to the Tara area in southeast Queensland; there is an occurrence near Broken Hill, New South Wales. *Acacia hakeoides* is often locally common in the places where it occurs (often due to its aggressive suckering habit). This species is common in the easatern target area but rare in the west. It is one of only four species in this report that occur in both the eastern and westen target areas (the other three are *A. cyclops*, *A. murrayana* and *A. victoriae*).Grows mainly on gently undulating plains in a variety of soils but commonly in sand or loam, often in mallee communities. In South Australia it grows mainly on brown calcareous earths (Whibley & Symon 1992) while in New South Wales it sometimes occurs on rocky ranges (Costermans 1981).

Flowering and fruiting

Main flowering period is July to September but individual plants may flower as early as June or as late as October (Maslin *et al.* 1998) or November (Stelling 1998). Mature pods occur in December and January in South Australia (Bonney 1994) or February in Queensland (Pedley 1980). It flowers heavily in most years and regularly sets moderate to heavy seed crops (Maslin *et al.* 1998).

Biological features

Moderate to fast growth rate (Whibley & Symon 1992, Stelling 1998), drought resistant and moderately frost tolerant (Simmons 1987). Although *A. hakeoides* has a strong propensity to sucker and form clumps (Anderson 1968) it can also occur as scattered, individual plants (eg. in western New South Wales, fide Cunningham *et al.* 1981). It has a moderate life-span (up to several decades according to Stelling 1998); its coppicing ability is unknown.

Cultivation

It can be grown from both cuttings and seeds (Simmons 1987). It establishes readily when direct seeded (Stelling 1998).

There is no field trial data available for this species (Maslin *et al.* 1998), however, we did inspect *A. hakeoides* in cultivation (for on-farm revegetation work near Wagga Wagga) during this project. The site was located within the 450 mm rainfall zone and experienced occasional frosts; the land was ripped and controlled for weeds prior to planting. Plants were direct seeded and in 4 years had attained 2 m in height; they divided just above ground level into a number of straight to sub-straight, rather branched main stems about 1 cm dbh. *Acacia pycnantha* in this same plot showed better performance.

Pests and diseases

There are no major pests or diseases known for this species (Maslin *et al.* 1998).

Weed potential

Suckers freely, especially if roots are disturbed, and frequently forms dense thickets which are often difficult to clear (Anderson 1968). The species also produces large quantity of seed which could also contribute to its weed potential. The species is not far removed taxonomically from *A. pycnantha*, a known environmental weed in some areas.

Wood

Our anecdotal field observations show the wood to be reasonably dense and pale coloured with no dark heartwood developed. Upon drying the wood developed a pinkish tone and split due to shrinkage.

Utilisation

Wood

According to Anderson (1968) the timber is of little use except in a minor way for fuel (however, see **Potential for crop development** below).

Land use and environmental

Suitable for low shelter belts and for roadside planting (Whibley & Symon 1992). Useful for broadacre sowing to help arrest erosion of coastal soils and sand dunes; sow in mid-winter (Bonney 1994).

Fodder

Not known to be eaten by stock in western New South Wales (Cunningham *et al.* 1981).

Human food

Regarded by Maslin *et al.* (1998) as a lesser known species that is worth considering as a source of seed for human consumption.

Other uses

An attractive shrub suitable for ornamental uses (Cunningham *et al.* 1981). Provides a good habitat and food source for insects and birds (Stelling 1998).

Potential for crop development

Acacia hakeoides is regarded as having only moderate prospects as a crop plant for high volume wood production. It is ranked as a category 3 species and its growth characteristics suggest that it has some potential for development as a phase crop (Table 6). Although there are no records of it coppicing we expect that it may regenerate if cut close to the ground. Its vigour from coppicing is not known so its potential as a coppice crop cannot be assessed. These hardy shrubs lend themselves well to direct seeding which is an attractive attribute for a phase crop plant. However, because of its prolific seed set *A. hakeoides* is likely to develop a significant soil seed bank that may lead to weed problems in adjacent or subsequent annual crops (on the other hand seedling regeneration may possibly be treated as a form of green manure). One way of avoiding soil seed build up is to harvest plants before they fruit; however, it is not know at what age fruits are first set or whether sufficient woody biomass will have been produced by that time. The propensity for *A. hakeoides* to vigorously root-sucker in nature may or may not be advantageous in cultivation, it depends whether or not this attribute is required (or expressed) for the system in which it is placed. However, successful development of this species as a phase crop may depend upon locating non-suckering provenances, if they exist. Although *A. hakeoides* is reported to have a fast growth rate it is not known how well it would perform in cultivation as soil profiles dry out.

Acacia hakeoides is typically multistemmed and although the stems are not overly thick a reasonable amount of woody biomass is produced (similar to a small mallee eucalypt). The wood is pale coloured but its density is unknown, although it may possibly be similar to, or slightly greater than, *A. microbotrya* (that is taxonomically not far removed from *A. hakeoides*) which averages about 830 kg/m^3, and if so it lowers the species attraction for use in reconstituted wood products.

Acacia hakeoides has a wide natural distribution, occurring throughout much of the target area in eastern Australia, but it is uncommon in Western Australia. The area predicted to be climatically suitable for the cultivation of *A. hakeoides*, based on its natural climatic parameters, is shown in

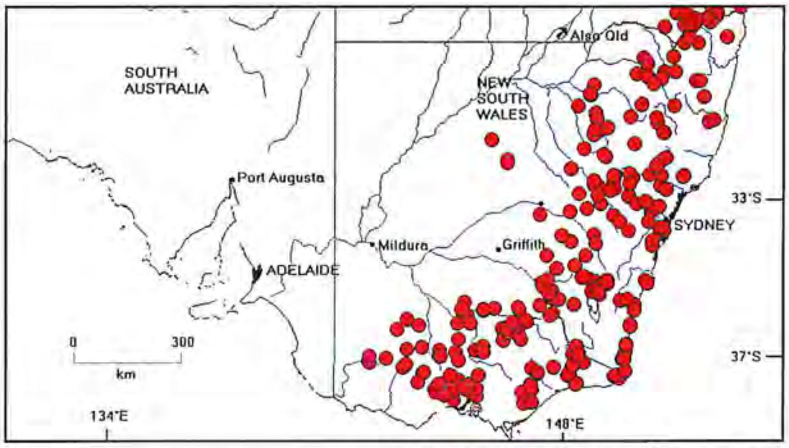
Map 28. This analysis indicates that climatic conditions suitable for the cultivation of A. *hakeoides* occur in both the eastern and western target areas. Within these regions it would be best suited to calcareous sandy loams. However, its tolerance of a range of soil types is unknown and assessment trials are warranted. *Acacia hakeoides* is likely to be unsuited to heavy clay soils such as those of the Riverina region. In Western Australia the bioclimatic analysis indicates that it would grow well beyond its natural distribution to encompass all of the target area in that State.

This species has at least a moderate potential as an environmental weed on account of its prolific seeding and vigorous suckering. Therefore, caution is needed if any wide-scale use of A. *hakeoides* is undertaken, and such use must be accompanied by a thorough weed risk assessment.

Acacia implexa Benth.

Common Names

Lightwood (Standard Trade Name), Hickory Wattle, and more (see Cunningham *et al.* 1981).



Map 29. Distribution of *A. implexa*.

Habit

Erect trees 5–12(–15) m tall, single-stemmed or dividing near ground level into 2 or 3 main stems, sometimes bifurcating into two main branches at about 2 m above ground but more usually branching higher up, commonly with clean straight to sub-straight boles to about 15–30 cm dbh (but on good sites can reach 60 cm dbh on oldest plants), crowns bushy and terminal, often gregarious due to suckering from the roots; bipinnate leaves may persist on young plants. Bark rough and unevenly tessellated, becoming longitudinally fissured with age, grey.

Botanical descriptions and illustrations/photographs are provided by Maiden (1910a), Burbidge & Gray (1970), Lebler (1981), Cunningham *et al.* (1981), Costermans (1981), Simmons (1987), Fairley & Moore (1989), Tame (1992), Cowan (1996), Cowan & Maslin (2001 & 2001a) and Kodela (2002); see also description in Pedley (1978).

Taxonomy

Acacia implexa is referable to *Acacia* section *Plurinerves* a diverse, and probably artificial, group of about 212 species (Maslin 2001) which are characterized by having plurinerved phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Species of section *Plurinerves* are widespread in Australia with the main centres of richness located in the inland areas of the southwest and southeast of the continent (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). Five species of section *Plurinerves* are detailed in this report, namely, *A. cyclops*, *A. implexa*, *A. melanoxylon*, *A. stenophylla* and *A.* aff. *redolens*.

Acacia implexa superficially resembles *A. melanoxylon* and is frequently confused with it but differs in its commonly pruinose branchlets, its drooping, sickle-shaped phyllodes that have a more elongated reticulum and its white (not red) funicle/aril which does encircle the seed.

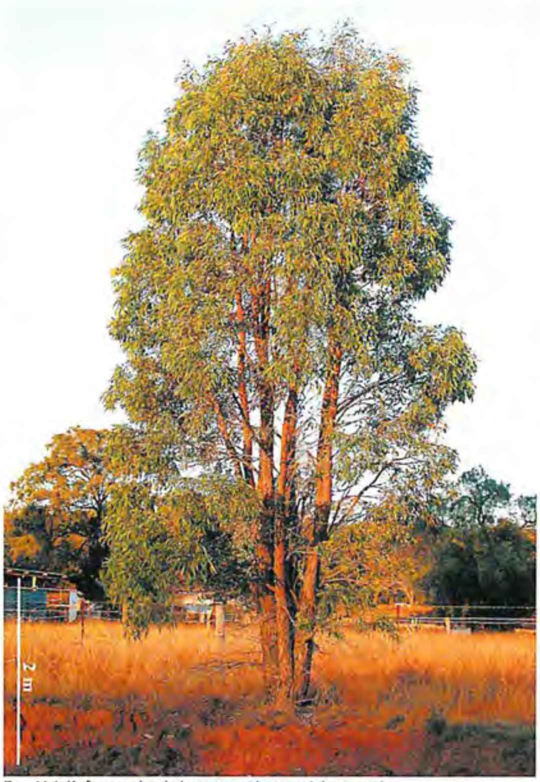

Map 30. Predicted area (blue) where *A. implexa* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 29), see also Table 5. Target area shown in yellow.

Distribution and habitat

Widespread and sometimes common in eastern Australia, mainly in higher rainfall zones, where it occurs in Queensland on the Atherton Tableland and then from Shoalwater Bay, Queensland, south along the coast and tablelands through eastern New South Wales and east to the Grampians in Victoria; also on King Island, Tasmania. The main area of occurrence of this species is to the south and east of the target area but it reaches

Figure 14. *Acacia implexa*

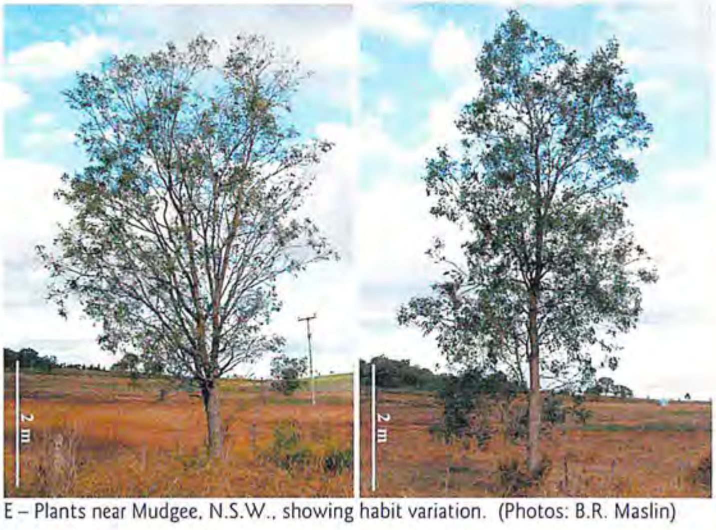
A – Old tree with insert showing bark.
(Photo: B.R. Maslin, tree; J. Simmons, bark)



B – Well-formed adolescent plant with 3 main stems.
(Photo: B.R. Maslin)

C – Roadside stand of young suckering plants. (Photo: B.R. Maslin)

D – Section of stem showing dark brown heartwood.
(Photo: B.R. Maslin)



E – Plants near Mudgee, N.S.W., showing habit variation. (Photos: B.R. Maslin)

F – Branch showing pale coloured-heads (in racemes) & multinerved phyllodes. (Photo: J. Simmons) the temperate periphery of the region in New South Wales and Victoria. It is uncommon or absent in the drier inland areas of the target zone of New South Wales and Victoria. In its natural habitat *A. implexa* grows in a variety of situations but often in shallow, well-drained soil in hilly country in woodlands or open forest. In western New South Wales it occurs on shallow red earths or skeletal soils on rocky hillsides and also well-drained sites in river red gum communities (Cunningham *et al.* 1981).

Flowering and fruiting

Flowers occur usually between December and March/April but sometimes also at other times of the year. Seeds mature about 11 months following flowering (Stelling 1998).

Biological features

A vigorous, long-lived, fast to moderately fast growing species that coppices well. Root suckering is common, particularly if the main stems are cut back severely or if the roots are disturbed. Thirty-two month old plants are reported by Searle *et al.* (1998) to have developed root suckers in trials near Canberra. In southern New South Wales the species is reported to tolerate fire, most droughts and strong wind (although its form may be affected) (Stelling 1998). It is frost resistant (Simmons 1987) although in trials near Canberra its growth and survival were seriously affected by frosts with minimum temperatures falling to -6^0 C (Searle *et al.* 1998).

Genetics

Cowan & Maslin (2001) report a putative hybrid between *A. implexa* and *A. trinervata* in New South Wales.

Toxicity

Webb (1948) notes that stock deaths are reported to have been caused by unripe pods. Bark contains much tannin (and saponin) which in the past was used by aboriginals to poison fish (Maiden 1910a).

Cultivation

Establishment

Can be grown from cuttings or from seeds (Simmons 1987) and lends itself well to direct seeding (Latarni McDonald, pers. comm.). Seed pretreatment techniques include scarfication (Stelling 1998 reports about 28 viable seeds per gram using this technique) and also pouring boiling water over the seed and soaking for several hours before drying and sowing.

Yield

Little is known regarding *A. implexa* in cultivation. Three provenances of the species were represented at two sites in fuelwood trials near Canberra, A.C.T. (CSIRO 2001). The sites at Kowen and Uriarra had a mean annual rainfall of 630 mm and 824 mm respectively. Variation among provenances was evident for survival and growth based on assessments at 2.6 and 5.2 years of age. Survival and growth was poorest for all provenances at the drier Kowen site. The Swansea provenance was clearly the poorest performer for growth at both sites. The most striking aspect of the overall performance of *A. implexa* in these trials was the relatively slight difference in growth at age 2.6 compared with age 5.2 years (best growth was for the Sofala provenance at Uriarra which attained 3.1 m in height and a dbh of 3.8 cm at 2.6 years, and 4.2 m tall with a dbh of 4.4 cm at 5.2 years). This same rapid early growth rate displayed by *A. implexa* was also observed in the results of Boxshall & Jenkyn (2001). In terms of mean stem volume, two provenances of *A. implexa* were amongst the worst performers in trials involving 16 temperate acacias at two sites in Victoria (Bird *et al.* 1998).

Boxshall & Jenkyn (2001) regarded the drought tolerance and the potential of *A. implexa* to grow to medium-sized trees on shallow impoverished soils favourable attributes. Its strong apical dominance and tendency to produce a central leading stem were also considered important characters based on observations of natural stands. Harvest rotation estimates were not given by Boxshall and Jenkyn but they suggested a stocking rate of 830 trees per hectare (at 4 x 3 m spacings) at a cost estimate of $1230 per hectare. They estimated that larger diameter logs may be worth $1000–1200 per tonne.

Pests and diseases

Susceptible to borer attack (Tame 1992). Wasps cause galls on flower buds in some areas, conspicuous woody galls are also caused by a fungus and young plants are susceptible to snails (Stelling 1998).

Weed potential

Not recorded as a major weed in Australia but, as discussed in Henderson (2001) it is a Declared Weed species in South Africa. Its strong root suckering propensity may render it problematic to eradicate if introduced into an area.

Wood

Hard, close-grained, dark brown with pale stripes and resembling *A. melanoxylon* to some extent (Anderson 1968), but of inferior quality to that species according to Maiden (1905). We observed the wood to be rather light relative to its volume (but not as light as either *A. leucoclada* or *A. retinodes* 'swamp variant') and it split due to shrinkage upon drying; the sapwood was pale brown and the heartwood dark brown. The basic density is given as 583–640 kg/m^3 by Ilic *et al.* (2000)*. A few aspects of wood anatomy are described in Shirley & Lambert (1922).

Utilisation

Wood

Wood can be used for turnery work and other purposes where tenacity and strength is required, furniture-making [e.g. plants from Candelo, SE coastal areas of N.S.W.] and for fuel (Anderson 1968). Boxshall & Jenkyn (2001) considered *A. implexa* to have potential as a plantation species for producing high value timber mainly for furniture and parquetry.

Tannin

Bark contains much tannin. Maiden (1910) reports on two bark analyses, one giving 7.82% of tannic acid and 20.54% of extract and the other 14.16% of tannic acid and 33.51% of extract.

Land use and environmental

Moderately useful for shelter purposes (Anderson 1968) and is occasionally planted in windbreaks and for shade on slopes and tablelands in temperate areas (Simmons 1987). This species is resistant to debarking by stock (Stelling 1998). In southern New South Wales it is reported to provide excellent recharge control on rocky hills and erosion control through its spreading root system (Stelling 1998).

Fodder

Phyllodes are eaten by cattle to some extent (Anderson 1968) but, as already noted, the unripe pods are reported to be toxic.

Other uses

Plants of this species provide a good wildlife habitat (Stelling 1998). An attractive summer flowering ornamental and shade for gardens and rockeries (Stelling 1998). Leaves produce a yellow dye with alum, and brown dye when copper is used as mordant (Stelling 1998).

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* The density range cited here represents a compilation of the Basic Density and the Estimated Basic Density from Air-dry (12%) MC values that are cited in Ilic *et al.* (2000).

Potential for crop development

Acacia implexa is regarded as having only moderate prospects as a crop plant for high volume wood production. This long-lived species is ranked as a categröy 3 species and would appear to have its best potential as a long cycle crop (Table 6). Despite having an ability to display rapid early growth rates, this species is unlikely to develop sufficient woody biomass within the short timeframe necessary for phase crops, particularly when cultivated in lower rainfall zones of the target areas. *Acacia implexa* is reported to coppice well but it is not known if this growth is sufficiently vigorous to sustain the species as a coppice crop. The propensity for A. *implexa* to vigorously root-sucker in nature may or may not be advantageous in cultivation, it depends whether or not this attribute is required (or expressed) for the system in which it is placed. *Acacia implexa* typically develops a good growth form (boles well-defined, rather straight and sparingly branched) that would be amenable to mechanical harvesting. It produces a good volume of moderately low density wood that is within the range of being attractive for reconstituted wood products, it could also be used for fuel and in high value solid wood products such as furniture and parquetry. *Acacia implexa* is susceptible to attack by borers and gall rust and these organisms are likely to cause problems in cultivation.

The area predicted to be climatically suitable for the cultivation of A.*implexa*, based on its natural climatic parameters, is shown in Map 30. This analysis indicates that A. *implexa* is not particularly well-suited to climatic conditions beyond its natural distribution, apart from the higher rainfall zones (greater than 500 mm isohyet) of South Australia and Western Australia. The critical climatic parameter limiting its wider cultivation in the target areas appears to be the mean annual rainfall range of its natural distribution. In the eastern target area A. *implexa* appears best suited for cultivation on upland areas that receive greater than 500 mm annual rainfall. Within this region the species could be cultivated on a range of relatively poor soil types but it is not suited to waterlogged soil conditions.

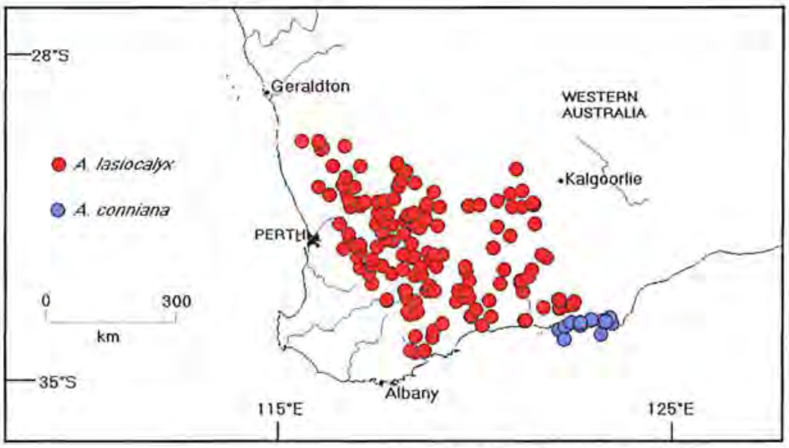
Although A. *implexa* is fairly common in eastern parts of the southeastern target area other species such as A. *leucoclada* and A. *linearifolia* offer better prospects.

Acacia lasiocalyx C.R.P. Andrews

Common Name

None known.

Habit



Map 31. Distribution of *A. lasiocalyx*.

Spreading tall shrubs or trees commonly 2–5 m high with dbh 13–15 cm, however, around the base of granite rocks it normally grows as erect trees to 10–15 m. These granite rock plants are single-stemmed or have few main stems from the base, the boles are straight to sub-straight with a maximum dbh of 30–50 cm. Bark longitudinally fissured and often peeling on main stems, smooth on upper branches, white to pruinose on young plants.

Botanical descriptions and illustrations/photographs are provided by Simmons (1988) and NSW (2001 & 2001a).

Taxonomy

Acacia lasiocalyx is referable to *Acacia* section *Juliflorae* a diverse, and probably artificial, group of about 235 species (Maslin 2001) which are characterized by having plurinerved phyllodes and flowers arranged in cylindrical spikes (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Section *Juliflorae* is widespread in Australia with the main centres of species richness occurring in the north, northwest and southwest of the continent and secondary centres of richness located along the Great Dividing Range in eastern Australia; although plants of this group often form a conspicuous element of the arid zone flora, species numbers in these areas are generally not great (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). Only three species of section *Juliflorae* are detailed in this report, namely, *A. acuminata*, *A. doratoxylon* and *A. lasiocalyx*.

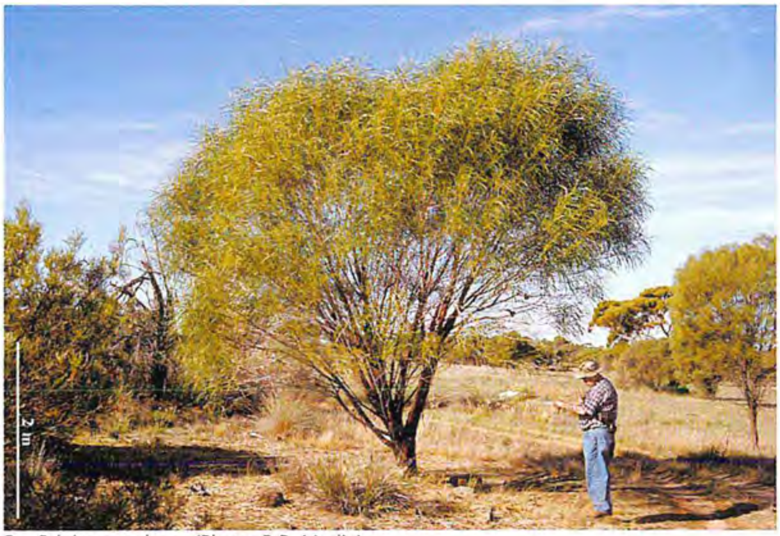
When plants grow close together (as they often do around the base of granite rocks) they tend to have an erect habit with relatively straight stems, but in open sites way from the larger outcrops plants are often smaller, possess a more spreading habit and their trunks are often less straight. The largest plants are found in the northern and central parts of the species range; growth form appears to deteriorate in more southerly areas (e.g. Mt Ridley) where the plants become quite small and spindly.

Map 32. Predicted area (blue) where *A. lasiocalyx* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 31), see also Table 5. Target area shown in yellow.

Most closely related to *A. conniana* which has a generally smaller, more spreading growth form and is distinguished from *A. lasiocalyx* by its non-pruinose branchlets, larger seed areoles and shorter, broader phyllodes. *Acacia conniana* occurs on the south coast of

Figure 15. *Acacia lasiocalyx*

A – Stand of mature plants at base of Muntadgin Rock, W.A. (Photo: B.R. Maslin)



B – Adolescent plant. (Photo: B.R. Maslin)

C – Branchlet showing spicate inflorescences & long, strap-like phyllodes. (Photo: B.R. Maslin)

D – Dense seedling regrowth stand of young plants. (Photo: B.R. Maslin)

E – Section of stem showing pale-coloured wood. (Photo: B.R. Maslin)

Western Australia east of Esperance, at the southern end of the distribution of A. *lasiocalyx* (see Map 29). *Acacia lasiocalyx* is also related to A. *longiphyllodinea* and A. *yorkrakinensis* subsp. *acrita*. Field observations suggest that near Bendering and Hyden A. *lasiocalyx* may hybridize with A. *inophloia* but this needs confirmation. None of the above relatives are detailed in the report, however, most are discussed in Maslin (2001b). *Acacia lasiocalyx* also has some affinities with A. *doratoxylon* from eastern Australia (see above).

Distribution and habitat

Acacia lasiocalyx endemic in Western Australia where it is widely distributed from near Eneabba east to near Kalgoorlie and south to near Bremer Bay and Mt Heywood (northeast of Esperance). The distribution of A. *lasiocalyx* is largely confined to the target area. Grows in sand, gravelly sand, loamy sand, clayey sand and loam, normally associated with granite hills or outcrops (it commonly forms dense populations around the base of granite rocks in the wheatbelt).

Flowering and fruiting

Flowers mostly in July to October. Mature pods occur from November to January.

Biological features

There is little definitive information available for this species. However, it appears to be moderately fast growing and has a life-span of perhaps 20–40 years. It is unlikely to sucker; it's coppicing/pollarding ability is unknown but is probably unlikely. Quite large numbers of pods are produced on the plants and these are easily collected by hand (threshing/shaking) although the height of the plants often makes them difficult to reach. The phyllodes of A. *lasiocalyx* contain relatively high concentrations of cyanogenic glucoside; however, they do not appear to possess an endogenous enzyme that is needed to hydrolyse this into hydrogen cyanide (Maslin *et al.* 1987); there are no reported cases of stock losses involving this species. In species trials in Western Australia A. *lasiocalyx* has been shown to be susceptible to locust attack (J. Carslake, pers. comm.).

Cultivation

Acacia lasiocalyx is unknown in cultivation, however, it was recently included in wheatbelt trials in Western Australia.

Trials

Assessment trials of this species were recently established in plots on farmland at various locations in south-western Australia by the "Search" project (see Acknowledgements). At age 10 months plants of the best performing provenance of A. *lasiocalyx* showed an average survival of 73% and an average height of 100 cm. The 'best' plot was located on a downslope site with heavy soil in the Esperance Plains IBRA region, with plants averaging 173 cm high.

Weed potential

No records of weediness for this species. Although this species is known to set large quantities of seed there are no records of it having become invasive despite the fact that its natural distribution is within the cleared, agricultural zone.

Wood

Field observations of a few plants show the wood to be moderately dense with heartwood yellowish (young branches) or pale brown. *Acacia lasiocalyx* and A. *conniana* are the only section *Juliflorae* species encountered in this survey that had pale-coloured heartwood (*Juliflorae* species such as A. *acuminata* and A. *doratoxylon* possess dark coloured heartwood). The basic density values range from 593 kg/m^3 to 912 kg/m^3 (mean 732 kg/m^3) based on analyses of 27 wood samples by CALM's NHT-supported

'Search' project (unpublished data). Note: This study preferentially sampled young and adolescent plants. Ilic *et al.* (2000) gives the air-dry density before reconditioning as 795 kg/m^3 (note: this value was erroneously listed in the basic density column in this work).

Utilisation

Wood

Plants with straight, undivided trunks may be worth examining as a potential source of small poles and other timber products.

Land use and environmental

Its growth form is suited to amenity planting and for providing windbreaks and visual screens, as well as shade and shelter for both stock and wildlife.

Potential for crop development

Acacia lasiocalyx is regarded as having reasonably good prospects for development as a crop plant for high volume wood production. It is ranked as a category 2 species and current evidence suggests that it would be suited to development as a phase crop and possibly also as a long cycle crop for solid wood products (Table 6). *Acacia lasiocalyx* is perhaps the largest Western Australian species included in the report. It produces a large amount of pale-coloured woody biomass. Although its density varies some plants have values close to the range of acceptability for use in reconstituted wood products. Plants of *A. lasiocalyx* commonly have a good growth form (i.e. clean, +/- straight boles 2 m or more in length) that would be amenable to mechanical harvesting. However, under natural conditions form does vary depending upon site, it is therefore recommended that seed for trial purposes be collected from plants growing around the base of large granite rocks where the best forms occur. Under cultivation plants of *A. lasiocalyx* could be spaced rather closely to promote good form, but if too close then the crowding effect may well lead to a reduction in stem biomass production. *Acacia lasiocalyx* appears to have a reasonably fast growth rate, however, its long-term performance under cultivation is yet to be determined. Its natural site of occurrence indicates that it prefers access to a good supply of soil moisture and it remains to be seen how well they will grow as water becomes limiting in cultivation. This species sets quite large quantities of seed. By harvesting plants prior to them reaching biological maturity it will avert creating a soil seed bank that may lead to weed problems in adjacent or subsequent annual crops (on the other hand seedling regeneration may possibly be treated as a form of green manure). It is not know at what age the plants first set seed.

The area predicted to be climatically suitable for the cultivation of *A. lasiocalyx*, based on its natural climatic parameters, is sown in Map 32. This analysis indicates that *A. lasiocalyx* is well-suited to the climatic conditions throughout the majority of the western and eastern target areas. Providing it is cultivated on appropriate soil types (sands, loamy sand, clayey sand and loam) that have adequate ground water, the climate match indicates that this species is a good prospect for widespread cultivation for this project

Acacia conniana is likely to have similar silvicultural requirements to *A. lasiocalyx* and may be better suited for growing in south coastal regions.

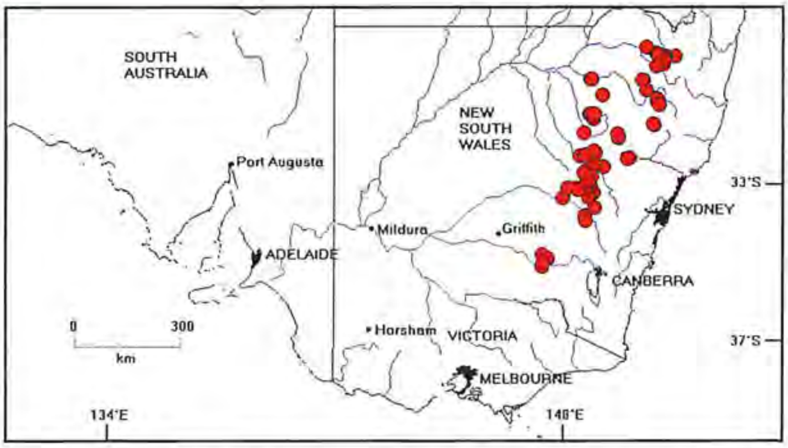
Acacia leucoclada Tindale subsp. *leucoclada*

Common Name

Northern Silver Wattle.

Habit

Trees or sometimes shrubs 4–9 (–15) m high, the single trunk bifurcating into 2 main branches at about 2–7 m above the ground, boles straight to sub-straight, 15–45 cm dbh and with relatively few short lateral branches, infrequently with 2–3 trunks from ground level, in dense regrowth stands or in shady situations the plants develop a rather spindly growth habit (with stems straight and erect), often freely suckering and forming pure stands; crowns not overly spreading (to about 6 m), sub-dense terminal (occupying about 1/3 of the total plant height). Bark smooth and grey on upper branches, rough, corrugated, grey or brown to black on lower trunk.

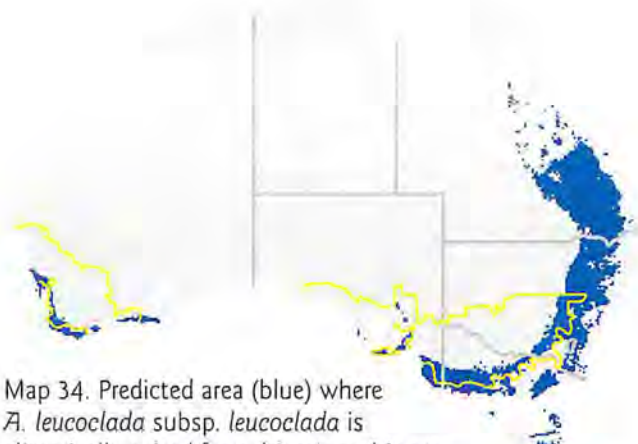


Map 33. Distribution of *A. leucoclada* subsp. *leucoclada*.

Botanical illustrations/photographs are provided by Costermans (1981), Tame (1992), Doran & Turnbull (1997) Tindale & Kodela (2001 and 2001a) and Kodela (2002).

Taxonomy

This species belongs to *Acacia* section *Botrycephalae*, a group of 44 mostly arborescent species characterized by having bipinnate adult foliage and flower heads normally arranged in elongated racemes (Orchard & Wilson 2001). These species predominate in temperate areas of eastern and southeastern Australia (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). There are seven species of *Botrycephalae* detailed in this report, namely, *A. baileyana*, *A. dealbata* subsp. *dealbata*, *A. decurrens*, *A. filicifolia*, *A. leucoclada* subsp. *leucoclada*, *A. mearnsii* and *A. parramattensis*. A number of recent studies have suggested that species of section *Botrycephalae* are most closely related to certain racemose species of section *Phyllodineae* (foliage phyllodinous) from eastern Australia, see Maslin & Stirton (1998) and Maslin *et al.* (2003) for reviews. Of the phyllodinous species included in this report those having presumed closest affinities to species of *Botrycephalae* include *A. linearifolia*, *A. neriifolia* and *A. pycnantha*; members of the '*Acacia microbotrya* group' are not far removed from these species.


Map 34. Predicted area (blue) where *A. leucoclada* subsp. *leucoclada* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 33), see also Table 5. Target area shown in yellow.

Acacia leucoclada has in the past been confused with *A. dealbata*, but differs in its more open growth habit, often inconspicuous glands and the presence of interjugary glands on the rachises between at least some pairs of pinnae. A study by Tindale & Roux (1969) of flavonoid and condensed-tannin contents of the heartwood and bark of *Acacia* recognized four groups within section *Botrycephalae*;

Figure 16. *Acacia leucoclada* subsp. *leucoclada*


A – Adult plant in open site with young sucker regrowth. (Photo: B.R. Maslin)


B – Mature roadside stand. (Photo: B.R. Maslin)


C – Stem base showing variation in branching. (Photo: B.R. Maslin)


D – Old plant in open site. (Photo: B.R. Maslin)

E – Section of stem showing pale-coloured wood. (Photo: B.R. Maslin)


F – Branch showing pale-coloured bipinnate leaves. (Photo: B.R. Maslin)

this study placed *A. leucoclada* (subsp. *argentifolia*) in a group containing *A. cardiophylla*, *A. chrysotricha* and *A. oshanesii*.

Acacia leucoclada comprises two subspecies, subsp. *leucoclada* and subsp. *argentifolia*. The latter grows to a tree 20 m tall and occurs in south-eastern Queensland on the north coast of New South Wales, it has fewer and less conspicuous glands on the leaves than in subsp. *leucoclada*; intermediates between the two subspecies occur (see Tindale & Kodela 2001 for further discussion).

Distribution and habitat

Occurs in New South Wales on the western slopes from Warialda south to Wagga Wagga, common in the Pilliga Scrub, also rarely on the Northern and Southern Tablelands, in the Hunter River valley and at Howes Mountain. Subspecies *leucoclada* is not uncommon in some of the drier north eastern region of the target area in New South Wales. It grows in open forest or woodland, usually in association with eucalypts and *Callitris* spp., in poor sandy or gravelly clay soils, red loams or acid granite sands (Doran & Turnbull 1997, Anderson 1968). Subspecies *leucoclada* has wide ecological tolerance and is suitable for growing on drier sites (Lex Thomson, pers. comm.). It is common in the places where it occurs and often forms pure stands (which appear to be produced from both seedling regeneration and from sucker regrowth). Further details of the ecological preferences of this subspecies are given in Doran & Turnbull (1997).

Flowering and fruiting

Flowers from late July to September/October with seeds present approximately 5 months after flowering (November to January). The seed is dropped soon after maturity (Stelling 1998).

Biological features

Very little information is available but based on our field observations this subspecies appears to have a fast growth rate (under good growing conditions it would probably attain trunks 10–15 cm dbh in about 10 years), it freely suckers but is unlikely to coppice (or has weak coppicing ability). Its life-span is unknown but is probably several decades and similar to *A. dealbata*.

Genetics

Chromosome number: $2n = 26$ (Briggs in Tindale 1966).

Occasionally hybridizes with *A. baileyana* (Tindale & Kodela 2001).

Cultivation

Acacia leucoclada is an adaptable, fast-growing species that prefers well-drained soils; little is known regarding its cultivation. According to Doran & Turnbull (1997) it should be possible to select seed sources for both drought and frost tolerance.

Yield

There have been favourable reports in terms of survival, biomass production and form for the cultivation of *A. leucoclada* at a number of trial sites in China and Vietnam (Fanggiu *et al.* 1998; Thinh *et al.* 1998). In these trials it was ranked amongst the best species, out-performing a range of other temmperate *Acacia* species.

The performance of *A. leucoclada* was most impressive in a trial at Calliope, Queensland (John Doran, pers. comm.). In this trial, in the 600 mm rainfall zone, *A. leucoclada* showed good form, attained 5.6 m in height and 7.2 cm in diameter, at age 30 months.

Establishment

There are 51 600 viable seeds/kg and immersion in boiling water for 1 minute is required to break seedcoat dormancy. Nursery and silvicultural techniques used for A. *dealbata* are likely to be applicable to this subspecies.

Weed potential

Acacia leucoclada is not normally recorded as having weed potential, however, according to Doran & Turnbull (1997) subsp. *argentifolia* frequently invades cleared farmland within its distribution. It is reasonable to assume that subsp. *leucoclada* could behave in a similar way.

Wood

Our field observations show the wood to be of low density, the sapwood is white with a small core of pale brown heartwood. According to Clark *et al.* (1994) A. *leucoclada* (subspecies not indicated) wood has a basic density of 626 kg/m^3. They reported that the species had a good pulp yield, excellent pulpwood productivity, moderate tear index and good tensile index when tested in a laboratory scale using a simulated Kraft process. However the level of brightness achieved in the test conditions was below standard. This species produces an exceptionally lightweight hardwood relative to its volume.

Utilisation

Wood

According to Doran & Turnbull (1997) A. *leucoclada* is a potential source of small round timbers for use as posts, poles or rails, and its wood characteristics indicate that it may be a useful source of firewood or charcoal, and possibly of pulpwood. Although this species produces pulp yields within the range of commercial pulpwoods its level of brightness (upon bleaching) is below standard. Doran & Turnbull (1997) note that further tests are required to see whether different wood samples give different properties and whether different bleaching sequences and higher chemical charges can overcome the brightness problem.

Land use and environmental

A useful windbreak species and provides excellent gully erosion control on account of its fast growth rate, vigorous suckering habit and proopensity to form thickets (Stelling 1998). Stelling also reports that A. *leucoclada* is an ideal 'nurse crop' for use with slow growing eucalypts or other long-lived species in mixed woodlots.

Stelling (1998) regards A. *leucoclada* as providing an excellent habitat for wildlife.

Potential for crop development

Acacia leucoclada subsp. *leucoclada* is regarded as having good prospects as a crop plant for high volume wood production. It is ranked as category 1–2 and would seem best suited for development as a phase crop but it may also have some prospects as a long cycle crop (Table 6). However, this species is currently not known in cultivation and there is very little relevant information available for it. Subspecies *leucoclada* is seemingly a fast-growing adaptable taxon and is common in northeastern parts of the target area in New South Wales. It has an excellent growth form and develops good quantities of woody biomass (we estimate that under good growing conditions this subspecies would probably attain trunks 10–15 cm dbh in about 10 years). The wood is pale coloured and has a low basic density (626 kg/m^3), thus within the range of being suitable for reconstituted wood products, and may possibly have potential as a pulpwood. Because of its apparent shade intolerance subsp. *leucoclada* is likely to do best if cultivated plants are widely spaced and grown in open sites. According to Doran & Turnbull (1997) it should be possible to select seed sources for both drought and frost tolerance.

The propensity for subsp. *leucoclada* to vigorously root-sucker in nature may or may not be advantageous in cultivation, it depends whether or not this attribute is required (or expressed) for the system in which it is placed. However, successful development of this species as a phase crop may depend upon locating non-suckering provenances, if they exist. As with other species of section Botrycephalae subsp. *leucoclada* would be expected to set prolific quantities of seed and this may possibly be produced from a relatively early age. Such phenological precocity will lead to the creation of a soil seed bank that may cause weed problems in adjacent or subsequent annual crops (on the other hand seedling regeneration may possibly be treated as a form of green manure). One way of avoiding soil seed build up is to harvest prior to pods being produced, but this would also require that sufficient woody biomass had been produced by that time. Perhaps the successful crop development of this subspecies will depend upon locating non- (or low-propensity) suckering or late-fruiting provenances, if they exist. These are important areas for future study if this subspecies is to be progressed as a crop plant.

The area predicted to be climatically suitable for the cultivation of A. *leucoclada*, based on its natural climatic parameters, is shown in Map 34. This analysis indicates that subsp. *leucoclada* has the potential to be cultivated well to the south and west of its natural distribution, including some parts of South Australia and Western Australia, mainly in areas that receive greater than 500 mm mean annual rainfall. As it is a poorly known taxon, many fundamental aspects of its successful cultivation need to be ascertained. For example, extent of variation among and within provenance for growth rate and form, drought and frost tolerance, optimal plantation stocking rates and pollarding response. As indicated by its excellent wood and growth characteristics this species warrants intensive silvicultural assessment over a range of sites and soil types throughout much of the target area.

Comprehensive range-wide seed collections are recommended for A. *leucoclada* so that representative assessment trials can be conducted. To assess the extent of within provenance variation (which is likely to be substantial) individual family seedlots should be maintained wherever possible.

The weed potential of subsp. *leucoclada* is likely to be low; however, if it behaves like subsp. *argentifolia* it may cause some problems by regenerating in agricultural lands. It is advisable therefore that any wide-scale use of subsp. *leucoclada* be accompanied by a weed risk assessment.

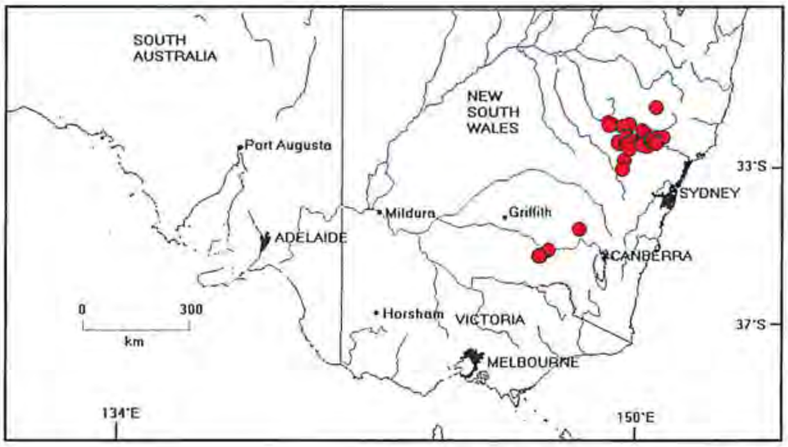
Acacia linearifolia Maiden and Blakely

Common Names

Stringybark Wattle, Narrow-leaved Wattle.

Habit

Tall shrubs or trees commonly 5–10 m tall with boles 15–45 cm dbh but may reach 14 m with boles 40 cm diam. in favourable sites, often with a single, straight to sub-straight, erect, sparingly branched trunk and a dense, terminal, somewhat narrow crown, however, in open sites plants may become widely branched from reasonably low down, may divide into two main trunks near the ground and their crowns may become quite spreading; strong, shallow lateral roots are developed; juvenile bipinnate foliage may persist on lower branches. Bark thin, smooth on young stems but aging longitudinally fissured, grey-brown.



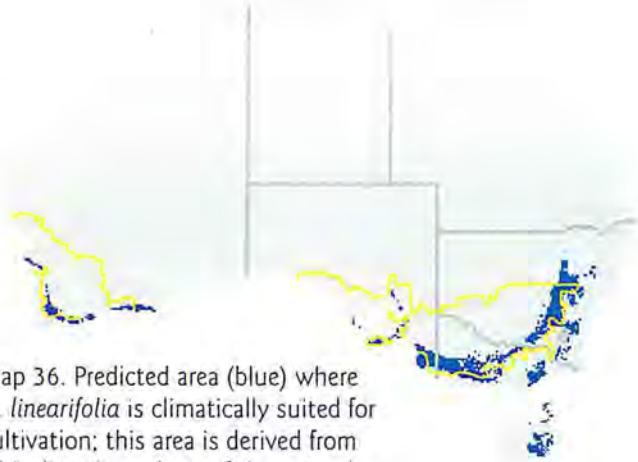
Map 35. Distribution of *A. linearifolia*.

Botanical descriptions and illustrations/photographs are provided by Tame (1992), Maslin (2001 & 2001a) and Kodela (2002).

Taxonomy

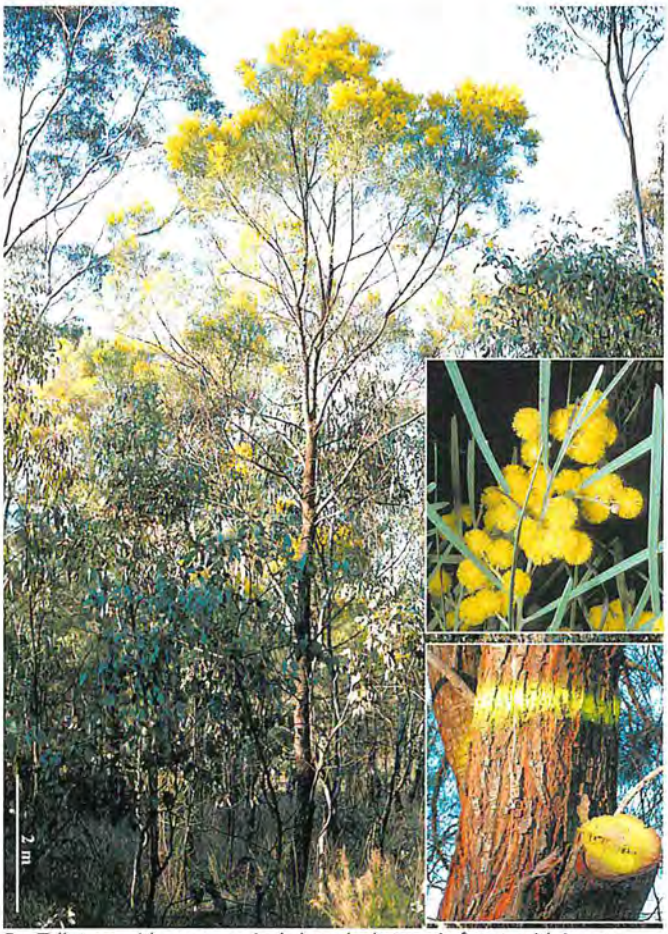
Acacia linearifolia is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Species of section *Phyllodineae* are widespread in Australia with the main centres of richness located in temperate and adjacent semiarid areas of eastern, southeastern and southwestern Australia; species number greatly decline in the arid zone and in northern tropical/subtropical areas (Hnatiuk & Maslin 1988 and Maslin & Pedley 1988).

As noted by Maslin (2001) *A. linearifolia* appears to be very closely related to *A. pustula* and further study is needed to determine the degree of difference between these two taxa. *Acacia linearifolia* is distinguished from *A. pustula* by its commonly narrower phyllodes, less prominent glands, fewer and less densely congested flowers in the heads and broader pods which are not or scarcely constricted between the seeds. *Acacia pustula* occurs in south eastern Queensland, well north of the target area. Species detailed in this report which are not far removed taxonomically from *A. linearifolia* include *A. hakeoides*, *A. neriifolia* and *A. pycnantha*; members of the '*Acacia microbotrya* group' are related to these taxa. In the past *A. linearifolia* was often confused with *A. adunca*, its phyllodes may also resemble those of *A. macnuttiana* and *A. forsythii*. However, none of these relatives occur within the target area and none develop significant woody biomass.



Map 36. Predicted area (blue) where *A. linearifolia* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 35), see also Table 5. Target area shown in yellow.

Figure 17. *Acacia linearifolia*



A – Tall, trees with erect, sparingly branched stems in forest, with inserts showing flowers/phyllodes & bark. (Photos: B.R. Maslin)

B – Mature plant in open site showing wide-spreading crown. (Photo: B.R. Maslin)

C – Stem base showing strong root development. (Photo: B.R. Maslin)

D – Mature stand showing good growth performance in cultivation at Burrendong Arboretum, N.S.W. (Photo: B.R. Maslin)

E – Cut stem showing vigorous young coppice regrowth (leaves bipinnate on coppice growth). (Photo: B.R. Maslin)

F – Stem core showing wood. (Photo: P. Macdonnell)

Distribution and habitat

Restricted to New South Wales where it occurs principally in the Scone–Denman district west to Gulgong–Dunedoo, there are outliers about 300–400 km to the south (from Binalong near Yass and The Rock near Wagga Wagga). According to Tame (1992) *A. linearifolia* mostly has a scattered distribution on the southern and central western slopes, but sometimes extends onto the tablelands. *Acacia linearifolia* is not especially common in the target area, its main area of occurrence lies just outside the region. In its natural habitat *A. linearifolia* grows in colluvial sands on the lower slopes and at the base of sandstone hills, or in shallow sand or sandy loam over sandstone or conglomerate on steep rocky slopes.

Flowering and fruiting

Flowers from August to October and seed is present in November and December.

Biological features

Apparently does not sucker. It coppices readily when stems are cut (coppice regrowth commencing with juvenile bipinnate foliage, maturing into phyllodes). *Acacia linearifolia* appears to have a fast growth rate (see below under **Cultivation**). Frost may damage young plants but they generally recover quickly (Stelling 1998). It's longevity is unknown but perhaps 20–30 years.

Cultivation

There is no trial information available for this species. However, we observed *A. linearifolia* under cultivation at the Burrendong Arboretum where it performed exceptionally well in the absence of supplementary watering (see Fig. 17D). Here plants estimated to be about 10 years old attained a height of 10–12 m with stems 20–26 cm dbh. They were grown close together (about 1 m apart) without any ill effect to their form. Burrendong Arboretum is located about 20 km due southeast of Wellington, just outside the target area near its north eastern corner (Wellington has a mean annual rainfall of 620 mm).

Weed potential

There are no records of weediness involving this species.

Wood

Detailed wood characters unknown but they are likely to be similar to those of *A. neriifolia* or *A. microbotrya*.

Utilisation

Ornamental

Well suited as an ornamental on account of its attractive growth form and its prolific flowering; it is commonly planted in places in New South Wales for this purpose (P. Kodela, pers. comm.).

Potential for crop development

Acacia linearifolia is regarded as having good prospects as a crop plant for high volume wood production. However, this species is presently not known in cultivation, other than as an ornamental, and therefore there is very little relevant information available for it. *Acacia linearifolia* is ranked as a category 1–2 species and would seem best suited for development as phase crop, although possibilities for it as a coppice and/or long cycle crop should not be discounted at this stage (see Table 6). The apparent absence of root suckering is regarded as a significant advantage for the management of this species as a phase crop. Plants of A. *linearifolia* develop an excellent growth form and commonly have strong, relatively unbranched, rather straight main stems. In cultivation it is expected that the plants could be spaced reasonably close without detrimental effect to their growth form or wood biomass production, despite the fact that they develop strong lateral roots. Indeed, limited field observations suggest that closely spaced plants have narrower crowns, develop straighter main stems and have fewer lateral branches compared with those in more open sites. *Acacia linearifolia* produces large volumes of woody biomass; the wood is pale-coloured and although its density is unknown it will possibly be similar to that of A. *microbotrya* (which averages about 830 kg/m^3) and if so it lowers its attraction for use in reconstituted wood products. The species appears to have a reasonably fast growth rate judging from its performance at Burrendong Arboretum. We would expect that if cultivated in appropriate sites plants of this species would reach harvestable size in about 5 years.

Field observations show that A. *linearifolia* resprouts well when stems are cut at about 0.5 m above the ground. However, it is not known if this growth has sufficient vigour to maintain the species as a viable coppice crop. Furthermore, it is not known what factors (such as cutting distance above ground or time of year to cut) promote best growth. Study of these important matters warrants investigation.

It is likely that A. *linearifolia* would produce appreciable quantities of seed and if so it would result in the creation of a soil seed bank that may lead to weed problems in adjacent or subsequent annual crops. (Alternatively the young seedlings may possibly be treated as a form of green manure.) One way of avoiding soil seed build up is to harvest plants before pods are produced; however, plants would need to have developed sufficient wood biomass by that time for such a technique to be viable.

The area predicted to be climatically suitable for the cultivation of A. *linearifolia*, based on its natural climatic parameters, is shown in Map 36. This analysis indicates that that A. *linearifolia* is climatically suitable for cultivation in the greater than 500 mm rainfall zones of the eastern and western target areas. These areas are well to the south and west of its natural distribution. Although its best performance is indicated for areas that receive greater than 500 mm mean annual rainfall it remains to be seen how much climatic and ecological plasticity will be evident in this species. Trials are warranted to assess if it has the potential to be cultivated for biomass production over a range of sites and soil types throughout many parts of the target area.

In view of the above it is recommended that intensive silvicultural assessment of this species be undertaken. There is much fundamental data needed to assess its crop potential. For example, the extent of provenance variation for growth rate and form, drought and frost tolerance, optimal plantation stocking rates and coppicing response. Comprehensive range-wide seed collections are recommended so that assessment trials can be conducted. To assess the extent of within provenance variation (which is likely to be substantial) individual family seedlots should be maintained wherever possible.

Any serious agroforestry investigation of A. *linearifolia* should include an assessment of its very close relative, A. *pustula*. Because A. *pustula* occurs in Queensland, well north of the target area, it was not assessed for this project.

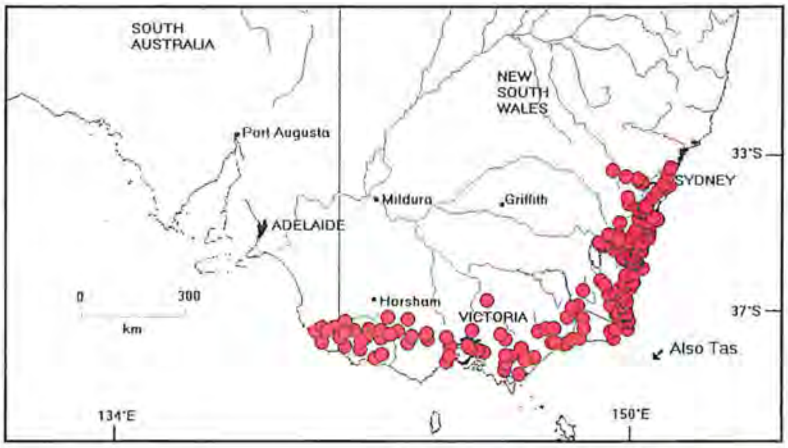
Acacia mearnsii De Wild.

Common Name

Black Wattle (Standard Trade Name).

Habit

Large spreading shrubs or small trees typically 5–10 m with dbh 10–35 cm but at times reaching 20 m with dbh to 45 cm. Open-grown specimens are freely-branched from near ground level and with a crooked main stem. In forest stands the stem is usually straighter and may be dominant for up to three-quarters of the tree height. It can form dense thickets especially where it has recolonised cleared land. Bark on old trees is brownish-black, hard and fissured but on younger stems and the upper parts of old trees it is grey-brown and smooth. The root system develops mainly in the soil surface layer and tap roots are short so that in plantations the species it is not very windfirm. This description is adapted from Doran & Turnbull (1997) and CAB International (2000).



Map 37. Distribution of *A. mearnsii*.

Botanical descriptions and illustrations/photographs are provided in Costermans (1981), Boland *et al.* (1984), Turnbull (1986), Fairley & Moore (1989), Whibley & Symon (1992), Tame (1992), Entwistle (1996), Tindale & Kodela (2001 & 2001a) and Kodela (2002).

There is a large body of literature concerning *A. mearnsii* and recent comprehensive reviews are provided in Wiersum (1991), Brown & Ho (1997), Doran & Turnbull (1997), Searle (2000) and CAB International (2000).

Taxonomy

This species belongs to *Acacia* section *Botrycephalae*, a group of 44 mostly arborescent species characterized by having bipinnate adult foliage and flower heads normally arranged in elongated racemes (Orchard & Wilson 2001). These species predominate in temperate areas of eastern and southeastern Australia (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). There are seven species of *Botrycephalae* detailed in this report, namely, *A. baileyana, A. dealbata* subsp. *dealbata, A. decurrens, A. filicifolia, A. leucoclada* subsp. *leucoclada, A. mearnsii* and *A. parramattensis.* A number of recent studies have suggested that species of section *Botrycephalae* are most closely related to certain racemose species of section *Phyllodineae* (foliage phyllodinous) from eastern Australia, see Maslin & Stirton (1998) and Maslin *et al.* (2003) for reviews. Of the phyllodinous species included in this report those having presumed closest affinities to species of *Botrycephalae* include *A. linearifolia, A. neriifolia* and *A. pycnantha*; members of the '*Acacia microbotrya* group' are not far removed from these species.

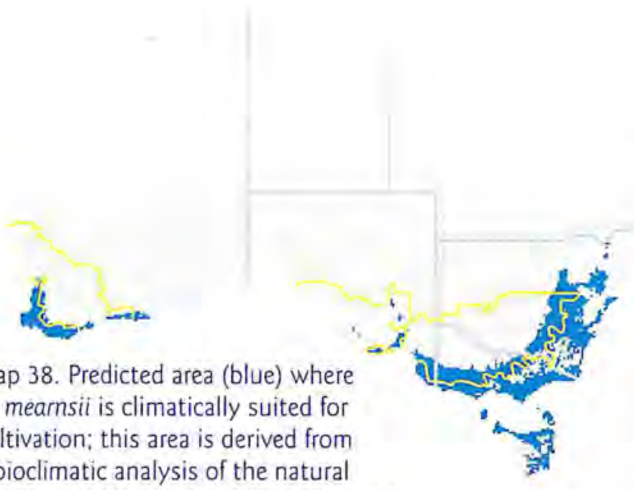
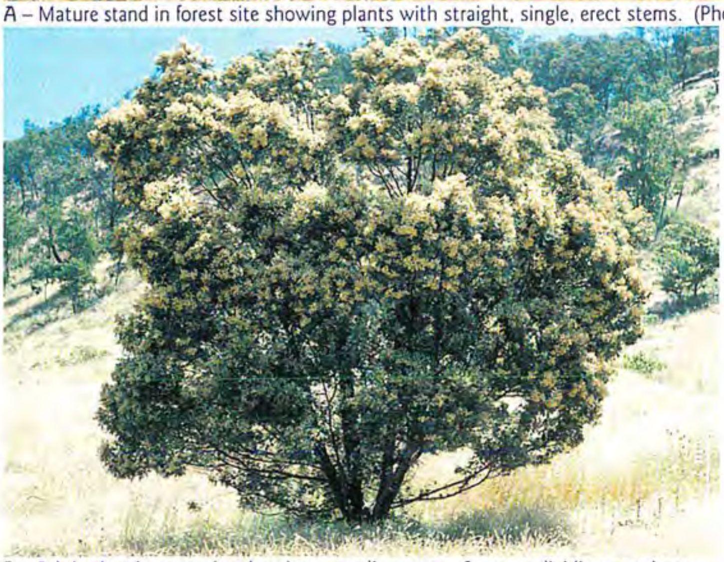

Map 38. Predicted area (blue) where *A. mearnsii* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 37), see also Table 5. Target area shown in yellow.

Figure 18. *Acacia mearnsii*

A – Mature stand in forest site showing plants with straight, single, erect stems. (Photo: J. Simmons)



B – Adult plant in open site showing spreading crown & stems dividing near base. (Photo: D. Boland)

C – Stem core from 5 year old plant in trial at Kowen, Australian Capital Territory. (Photo: P. Macdonell)

D – Branches showing bipinnate leaves & heads in racemes. (Photo: J. Plaza)

E – Plants in trial near Mt Gambier, S.A. (note straight, unbranched boles). (Photo: B.R. Maslin)

Acacia mearnsii is most closely related to *A. parramattensis* and *A. loroloba* (see *A. parramattensis* for further details). If hybridity is an indicator of close relationship then *A. mearnsii* has affinities to a number of other species in section *Botrycephalae* (see under **Genetics** below). A study by Tindale & Roux (1969) of flavonoid and condensed-tannin contents of the heartwood and bark of *Acacia* recognized four groups within section *Botrycephalae*; in this study *A. mearnsii* was placed in a group containing *A. constablei*, *A. decurrens*, *A. irrorata* subsp. *velutinella*, *A. parramattensis* and *A. trachyphloia*.

In the past the name *A. mollissima* was often erroneously applied to plants of this species.

Distribution and habitat

Occurs in south eastern Australia where it extends from near Sydney, New South Wales, southwards along the coast and tablelands (including the Australian Capital Territory) to Victoria and Tasmania, and extending west to near Naracoorte in South Australia. The main area of occurrence of this species is to the south and east of the target area but it reaches the temperate periphery of the region in Victoria. There are naturalized occurrences in New South Wales, the Mount Lofty Range, South Australia, and southwest Western Australia. Tindale & Kodela (2001) provide maps of both the natural and naturalized distributions in Australia. Searle (1997, 2000) provides details of the the occurrence of *A. mearnsii* in Australia.

Acacia mearnsii has been widely cultivated in a number of countries throughout the world (see under **Cultivation** below).

Acacia mearnsii grows in wet sclerophyll forest, woodland and coastal scrub, on hillsides, ridgetops and creekbanks (Kodela 2002). As summarised by Doran & Turnbull (1997) Black Wattle has been recorded on basalt, dolerite, granite and sandstone but is common on soils derived from metamorphic shales and slates (mainly loams, sandy loams, and deep forest podzols of moderate to low fertility with pH 5–6. 5). The best soils for Black Wattle are those which are moist, relatively deep, light-textured and well-drained; it is not common on poorly-drained or very infertile sites. The 50 percentile rainfall within its natural area of occurrence is 440–1600 mm.

Comprehensive summaries of habitat characteristics are given in Boland *et al.* (1984), Turnbull (1986), Doran & Turnbull (1997) and CAB International (2000). There are several papers providing climatic profiles for the species combining information from both natural and planted occurrences; the most recent of these are Booth & Hong (1991), Booth (1992; 1997) and Yan *et al.* (1996).

Flowering and fruiting

Flowers from October to December in Australia (Searle 1997), September to October in Brazil (Stein & Tonietto 1997) and late August to early October in South Africa (Sherry 1971). Plants commence flowering when about two years old. Seed matures about 12–14 months after flowering and is not retained on the tree for longer than two to three weeks, making the timing of collection critical (Searle 1997). In plantations appreciable quantities of seed are seldom produced before the fifth or sixth year (Sherry 1971). The above information is taken primarily from CAB International (2000).

Biological features

Acacia mearnsii is a fast-growing species, attaining up to 3 m/year after 3–5 years according to Wiersum (1991). It is relatively short-lived with a life-span of about 10–20 years; however, according to Searle (2000) under very favourable growing conditions it can live for more than 40 years. It reproduces by seed and is not known to sucker or coppice. *Acacia mearnsii* is sensitive to severe drought, strong winds, and frosts of –5°C or lower. Some flowers, usually near the base of the flower head, may be wholly male and trees bearing only male flowers have been observed (Sherry 1971). In a study of a population in New South Wales, Australia, Grant *et al.* (1994) reported that 90% of flowers were wholly male. A detailed review of the flowering biology of *A. mearnsii* is provided by Raymond (1997).

Genetics

Chromosome number: $2n = 26$ (Tindale & Kodela 2001).

Acacia mearnsii is regarded as an outcrossing species with partial self-compatibility. Estimates of outcrossing rates are variable, ranging from 48 to 100% (see review in Raymond 1997). A study of the breeding behaviour of *A. decurrens* and *A. mearnsii* showed that self-fertilization in both these species leads to a decrease in fertility and general vigour (Moffett & Nixon 1974). See also Midgley & Turnbull (2003) for summary of breeding systems in relation to the silviculture of *A. mearnsii*.

Searle *et al.* (2000) assessed genetic diversity in 19 natural populations of *A. mearnsii* using allozymes. Relatively moderate levels of diversity were detected at species level. Highest levels were detected in populations from New South Wales compared to those from Victoria, South Australia or Tasmania. Genetic differentiation was not concordant with natural distribution patterns, which the authors suggested could be due to the diffusion of seeds by humans. Provenance trials established for assessing the crop potential of this species should be mindful of this potential problem when conducting seed collections.

In an earlier allozyme study by P. Brain (pers. comm. in Boland 1987) a major difference between south-east Victorian and New South Wales provenances was detected for the leaf peroxidase enzyme.

As summarised by CAB International (2000) naturally-occurring interspecific hybrids involving *A. mearnsii* are uncommon; a hybrid with *A. parramattensis* is known while in South Africa hybridization, either spontaneous or induced, with *A. baileyana*, *A. dealbata*, *A. decurrens* and *A. irrorata* is recorded in cultivation (Moffett & Nixon 1958, Moffett 1965a & b, Sherry 1971, Li 1997).

Cultivation

Black Wattle is widely cultivated in a number of countries throughout the world. Principal growing areas include Brazil, China, India, Indonesia, South Africa and eastern Africa. South African plantations cover 124 000 ha (Li 1997), Brazil has over 200 000 ha (Higa & Resende 1994) and China 30 000 ha (Midgley & Turnbull, 2003). See CAB International (2000) for full list of countries where this species is planted.

As noted by Midgley & Turnbull (2003) variation within *A. mearnsii* for important characters such as bark thickness, wood density, tannin content, some pulp properties, stem diameter, stem form and the incidence of gummosis are currently not well defined but there are indications that improvements can be expected through selection (Fang *et al.* 1994, Dunlop *et al.* 2000).

Turnbull (1986), Doran & Turnbull (1997) and CAB International (2000) provide comprehensive summaries of the silvicultural characteristics, practice and management of *A. mearnsii*, and these sources provide additional information to that which is given here. See also Searle (2000) and Midgley & Turnbull (2003) .

Acacia mearnsii is a fast-growing pioneer species which reaches its maximum growth rate 3–5 years after planting. Deaths in plantations due to over-maturity are frequent after 10 years in South Africa. It is a light-demanding species, which is sensitive to fire when young (< 3 yr) and to temperatures below about –5°C. Being a nitrogen fixer, it will tolerate relatively infertile sites but requires a good supply of phosphorus for rapid growth.

Establishment

Acacia mearnsii has usually been propagated by seeds as propagation by cuttings has been difficult (Midgley & Turnbull, 2003). These authors note, however, that clonal plantations are now a possibility as vegetative propagation techniques in the past three years have improved markedly (Beck & Dunlop 1999). Raymond (1997) provides a summary of the results achieved with the various methods tried over many years. In environmental plantings in Australia Black Wattle has been shown to establish well using direct seeding techniques (Searle 2000).

To ensure rapid and complete germination, seed coat dormancy must be broken before sowing. Mechanical scarification can be very effective (Hendry & van Staden 1982) but the seed is more commonly treated by immersion in very hot water (90°C) for 30–60 seconds (Poggenpoel 1978) or in boiling water for 1 minute (Doran & Gunn 1987). Treated seed may be surfaced dried and stored safely for at least one year.

Nursery establishment is generally by sowing pre-treated seeds directly into the containers (Doran & Turnbull 1997) or into beds to produce bare-rooted seedlings (Gao 1997). Seedlings can reach plantable size (20 cm in height) in 4 months. Inoculation with appropriate rhizobium and mycorrhiza strains is rarely necessary but may be beneficial especially when seedlings are raised in sterilized media or planted on highly degraded soils. Rhizobium is applied routinely in Brazil (Stein & Tonietto 1997). When sowing directly in the field, the seed is sown in rows 1.8–2.7 m apart in well-cultivated and weed-free ground. Seeding rate is 1.2–2.4 kg/ha. Seedlings are thinned at regular intervals until routine spacings are achieved.

Yield

Typical yields for well-managed South African plantations 10–11 years old in Natal are 21 t/ha of bark (dry) and 112 t/ha of wood (air-dry) and in the colder southeastern Transvaal 16.6 t/ha and 74.8 t/ha, respectively. At this age, the trees are 17 m tall and 14 cm diameter in Natal, and 14 m tall and 13 cm diameter in Transvaal (Stubbings & Schonau 1982). On appropriate sites and where the trees are fertilized, a mean annual increment (MAI) over 7–10 years of 15–25 cubic metres/ha of wood is feasible. Brown & Ho (1997) report similar yields in other countries in Africa and in China. In Indonesia MAIs for wood and bark yields are 14–21 cubic metres/ha and 1.2–2 t/ha dry bark at 8 years and 11–16 cubic metres/ha and 0.9–1.5 t/ha dry bark at 12 years from planting (Wiersum 1991).

In trials involving 12 bipinnate acacias at three sites in Western Australia (Busselton, Darkan and Mt Barker), Barbour (2000) ranked A. *mearnsii* as the best species for wood production across all sites at 5.5 years of age. The study identified this species as having the most potential to be developed commercially for bark tannin (for wood adhesives) and fuelwood in Western Australia. The best volume per hectare yield was at the Busselton site which yielded nearly twice that of other provenances and other species. Differences in performance between natural provenances were not conclusive in these trials.

In trials involving 16 acacias at two sites in Victoria, A. *mearnsii* was the best performing species in terms of mean stem volume (Bird *et al.* 1998). These sites occured in the 700 mm mean annual rainfall zone.

Provenance

Trials in Brazil, southern China, South Africa and Australia have shown significant variation within and between provenances in growth performance and form, frost tolerance and tannin production. A breeding strategy to make optimum use of natural provenance variation within A. *mearnsii* for commercial characteristics such as volume and tannin yield, and to produce seed for plantations is described by Raymond (1987, 1997).

Pests and diseases

The following information is largely taken from the summaries provided in Doran & Turnbull (1997) and CAB International (2000).

Acacia mearnsii is susceptible to various pathogens, some of which are responsible for economic losses in plantations. Diseases of A. *mearnsii* have been reviewed by a number of authors (e.g. Lenné 1992 & Lee 1993) with the most recent reviews of Roux *et al.* (1995) and Wang (1997) listing a range of stem and foliar diseases, rusts and root diseases. In the list is an apparent physiological disorder known as 'gummosis', in which gum is exuded in the absence of any obvious injury. Gummosis is a serious problem in commercial plantations outside of the natural climatic range of A. *mearnsii* because it reduces bark quality and hinders its stripping. In South Africa this term has been applied to a complex of diseases associated with *A. mearnsii* (Roux *et al.* 1995). The most successful control of gummosis has been by selecting and breeding trees resistant to the disease (Wang 1997).

In Australia, the total number of insects associated with *A. mearnsii* is large. The leaf-eating Fireblight Beetle, *Pyrgoides orphana* (Coleoptera), is a serious pest (Elliott & de Little 1984) and was one of the early disincentives for planting the species in Victoria (Searle 1991). African Black Beetle can cause severe damage in cultivation trials in Western Australia (Barbour 1995).

In South Africa some 200 species of insects have been noted damaging trees of *A. mearnsii*, with about 30 of these of economic significance. The nature of the damage caused by the most serious pests and control measures are outlined by Wang (1997). Luyt *et al.* (1987) list white grub (*Lepidioto mashona*), grasshoppers, cutworms as problems in the nursery and a sap sucker, wattle mirid (*Lygidolon laevigatum*), amongst the most serious of pests in young plantations in Zimbabwe. The plant parasite *Loranthus* sp., as well as termites and a number of other insects cause problems in Tanzania (Kessy 1987). In southern Brazil heavy damage is caused by beetles (*Oncideres* spp.) which girdle twigs and branches (Vulcano & Pereira 1978, Stein & Tonietto 1997), and various stem borers can cause severe damage. In China some trees have been attacked by scarab insects, scale insects and termites (Zhiang & Minquan 1987).

Weed potential

Although *A. mearnsii* does not root sucker it does produce very large amounts of hard-coated seed which provide the means for the species to spread. The seed can remain viable in the soil for decades (Searle 2000) and following disturbance (e.g. fire) it can germinate prolifically. Although the species is not commonly recorded as being a serious environmental weed in Australia there are naturalized occurrences in the wetter areas of southern South Australia and southwest Western Australia (Tindale & Kodela 2001). Outside Australia, however, *A. mearnsii* is invasive and has become a weed in some countries where it has been introduced. It has become naturalized in South Africa where it is widespread in parts of the Transvaal, Swaziland, Natal and the Cape Province (Ross 1975) where it is a Declared Invader (category 2) species (Henderson 2001). *Acacia mearnsii* is locally established in southern Europe (Whibley & Symon 1992) and is naturalized in New Zealand (Webb *et al.* 1988). In South Africa there have been attempts at biological control the species (using seed-feeding weevils and mycoherbicides), however, this has provoked conflict with those who use *A. mearnsii* for commercial purposes (Selincourt 1992, Dennill *et al.* 1999).

Wood

The wood is fine-textured and has indistinct growth rings. Sapwood is very pale brown and the heartwood light brown with reddish markings. The basic density is around 530–608 kg/m^3 (Fang *et al.* 1991, Hillis 1997) and the air-dry density 550–750 kg/m^3 (Bootle 1983). Physical and mechanical properties of plantation-grown wood are described by Gupta & Kukreti (1983), Fang *et al.* (1991) and Clark *et al.* (1994). Green and seasoned timber has the same medium strength qualities as Blackwood (*A. melanoxylon*) (Searle 2000).

Utilisation

The following information on the utilisation of *A. mearnsii* is taken largely from the summary provided in Doran & Turnbull (1997).

Wood

The wood is hard but is moderately easy to work and takes a good polish. Preboring is necessary before nailing. Susceptible to termite and *Lyctus* attack. The sapwood absorbs preservatives readily but the heart wood is moderately resistant. The wood is used for house poles, mine timbers, tool handles, cabinetwork, joinery, flooring, construction timber, matchwood, and hardboard (Masonite). It is suitable for a wide range of paper and paperboard products (Logan 1987, Nicholson 1991, Guigan et al. 1991). Kraft pulps using 13% active alkali yielded about 53% of screened pulp of Kappa number 20. A cubic metre of A. mearnsii wood produces about 320 kg of pulp. Plantation-grown A. mearnsii is currently being used commercially in South Africa as a component of a wood furnish for kraft and soda-AQ pulp production, and A. mearnsii woodchips are exported from that country to Japan for use in the manufacture of kraft pulps (Logan 1987). In both South Africa (Sherry 1971) and India (Nilgiris area) it is used in the production of rayon.

The moderately dense wood, which splits easily and burns well, makes excellent fuelwood and charcoal. The charcoal is extensively used for cooking in Kenya and southern Brazil; a company in Brazil has developed special kilns for the production of activated carbon (for use in pollution control) from A. mearnsii (Boland 1987). The wood is used in Indonesia for domestic fuel and curing tobacco leaves (Berenschot et al. 1988).

Hillis (1997) provides a review of properties and uses of wood of Black Wattle and Searle (2000) provides a good summary of it uses.

Tannin

Acacia mearnsii produces the world 's most important vegetable tannin, especially suited for use in the manufacture of heavy leather goods. The bark is very rich in tannin (36–44% according to Midgley & Turnbull, 2003) but yields are influenced by several factors including genetic variability, age and environment. Tannin industries based on this species have been developed in Brazil (Oliviera 1968), China (Hillis 1989), Kenya (Kenya Forest Service 1971), India (Samraj & Chinnamani 1978, Gupta et al. 1981), South Africa (Sherry 1971), Tanzania (Kessy 1987) and Zimbabwe (Luyt et al. 1987). The main exporting countries of tannin are South Africa, Kenya and Tanzania and the main importers are the UK, Australia and the United States (Wiersum 1991). In addition to its use for leather tanning, the bark extract is used to prepare tannin formaldehyde adhesives for exterior grade plywood, particleboard and laminated timber (Boland 1987, Coppens et al. 1980). It also has a use as an anticorrosion agent of mild steel and cast iron (Moresby 1997). Other uses of wattle extract, including as a mud fluidizing agent for drilling mud, calcite depressant in ore flotation, flocculant in water treatment, ion-exchange resin and as a polyurethane-type coating for wood, are described by Wu (1997).

Hillis (1997a, 1997b) provide detailed accounts of bark properties and tannin chemistry, while Sun et al. (1997) describes production methods and Xiao (1997) the use of wattle extract in tanning leather.

Although once important in Australia, tannin production based on A. mearnsii has all but disappeared (Searle 1991, 2000).

Land use and environmental

Acacia mearnsii has been effective in controlling soil erosion on steep slopes and improving soil fertility (National Academy of Sciences 1980, Waki 1984, Boland 1987). In south eastern Australia Black Wattle is used in environmental plantings in areas receiving rainfall down to about 600 mm/annum (Searle 2000). Overseas the species has been used for shelterbelts, green firebreaks, as a shade tree in tea plantations and ornamental purposes (Wiersum 1991). *Acacia mearnsii* is regarded as a superior species in appropriate areas of China for environmental plantations, especially those for soil and water conservation (Ho & Fang 1997).

Fodder

The leaves have a high protein content (15%), but palatability trials with sheep showed milled leaves to be unpalatable on their own and were only acceptable when mixed with other feedstocks (Goodriche 1978). Goodriche considered that digestibility was probably affected by the high tannin content in the leaves and twigs (5.7% DW). Considered to be inferior stock feed in Japan but has been fed to cattle in Hawaii during drought periods.

Other uses

In central Java and in Kenya, foliage is used as a green manure to improve agricultural yield. Sawdust of black wattle has been found to be an excellent medium for growing edible mushrooms in China (Brown & Ho 1997). Poles with bark intact are used to support oyster racks in New South Wales (Searle 1996). Wool may be dyed with all parts of *A. mearnsii*; the colours may range from grey-fawn to gold depending on the mordants used (Martin 1974).

Potential for crop development

The optimal areas for successful cultivation of *A. meansii* are those receiving greater than 700 mm annual rainfall (Booth & Hong 1991), therefore this species is not likely to have wide application in the present target area (see below). Nevertheless, this is a versatile species that has had a long history of commercial use abroad and prospects for its cultivation within Australia are promising (see Searle 2000 for review). This species has a range of options for both industrial and environmental purposes. As summarised by Doran & Turnbull (1997) *A. mearnsii* yields high quality condensed tannin, paper pulp, rayon, charcoal and fuelwood. The use of *A. mearnsii* tannin in waterproof wood adhesives for the production of reconstituted wood is expanding. A useful species for erosion control, windbreaks and soil improvement. It is therefore appropriate to include it here to ensure that any prospects it may have for drier areas are not overlooked (despite the fact that it only just reaches the periphery of the target area).

Acacia mearnsii is ranked as a category 2 species and would be best suited to development as a phase crop (see Table 6). The absence of root suckering is regarded as a significant advantage for the management of this species as a phase crop. Development as a coppice crop is not an option for this species. *Acacia mearnsii* is a fast-growing species that has the ability to produce good quantities of wood biomass. It is adapted to a wide range of acidic soils (pH 5–6.5) and prefers areas where the minimum temperature does not fall below about –5°C. For the purposes of this project the most critical limiting climatic parameter for *A. mearnsii* is its intolerance of dryland conditions. For example, natural populations do not occur in the less than 500 mm rainfall zone. This will limit its potential for cultivation throughout major parts of the target areas (see below). Apart from water availability the maximum temperature in summer might be a limiting factor for effective growth (Barbour 1995). This species has a variable growth form. In good sites it usually develops strong, straight, sparingly branched main stems but on open sites it may branch freely from near ground level and the stems may become crooked. Poor stem form could limit the species utilisaton for timber from plantations. Therefore, appropriate selection of provenances and careful selection of sites for cultivation are likely to be important in developing this species as a crop. The wood is pale coloured and of relatively low density.

Acacia mearnsii produces prolific quantities of seed which would result in the creation of a soil seed bank that could lead to weed problems in adjacent or subsequent annual crops. (Alternatively young seedlings may possibly be treated as a form of green manure.) Harvesting plants before they reach biological maturity is one way of avoiding seed set. Although plants of this species can commence to flower when about two years old they apparently seldom produce appreciable quantities of seed before year five or six.

Many insects feed on black wattle and some cause serious, sporadic damage that affects its survival or growth and form; the Fireblight Beetle and perhaps Gall Rust fungus are particular problems. For further discussion see under **Pests and diseases** above.

The area predicted to be climatically suitable for the cultivation of *A. mearnsii*, based on its natural climatic parameters, is shown in Map 38 . This analysis indicates that in the New South Wales region of its natural distribution, *A. mearnsii* is well suited to climatic conditions as far west as the 500 mm rainfall isohyet. Best performance in the target area, however, will probably be achieved in areas that receive 600 mm or greater mean annual rainfall. Similarly in Western Australia suitable climatic conditions for growth fringe the target area and do not suggest that this species will have a major role to play in this region. The best prospects for *A. mearnsii* are in the 500–650 mm rainfall zone of New South Wales on valley soils, on sites where water from supplementary run-on from rainfall occurs. In Victoria, South Australia and (as already noted) Western Australia the prediction from bioclimatic analyses is less favourable and indicates that *A. mearnsii* is best suited to higher rainfall areas peripheral to the target area.

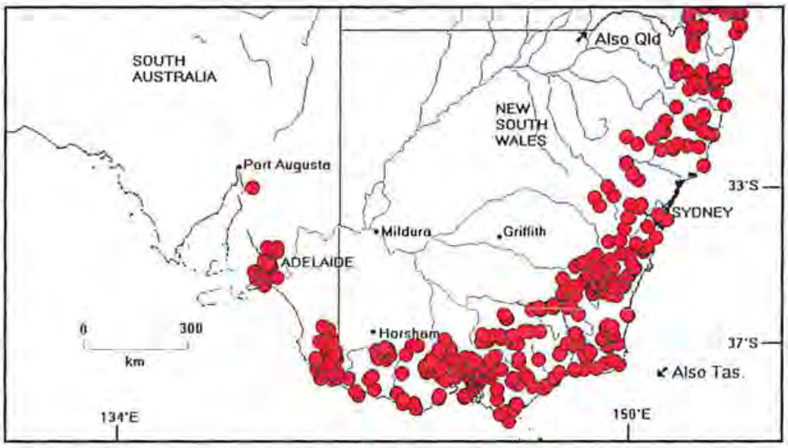
Acacia mearnsii has demonstrable weed potential both within Australia and abroad. However, it is not known if this will be a major problem in the drier environments of the present target area. Nevertheless, caution is needed if any wide-scale use of this species is undertaken, and such use must be accompanied by a thorough weed risk assessment (see also discussion on possible weed reduction strategies under **Weed potential of *Acacia* in target area** in the introduction to this report).

Because *A. mearnsii* has been so extensively cultivated (mainly abroad) there exists a large body of knowledge which should greatly facilitate any attempt to develop it as a crop plant in Australia. Searle (2000) provides a good overview of the agro-forestry potential of this species within this country but notes that further research is still needed to develop appropriate silvicultural techniques to facilitate its widescale planting.

Acacia melanoxylon R. Br.

Common Names

Blackwood (Standard Trade Name), Hickory, Sally Wattle, Mudgerabah; sometimes Tasmanian Blackwood or Swamp Blackwood.



Map 39. Distribution of *A. melanoxylon*.

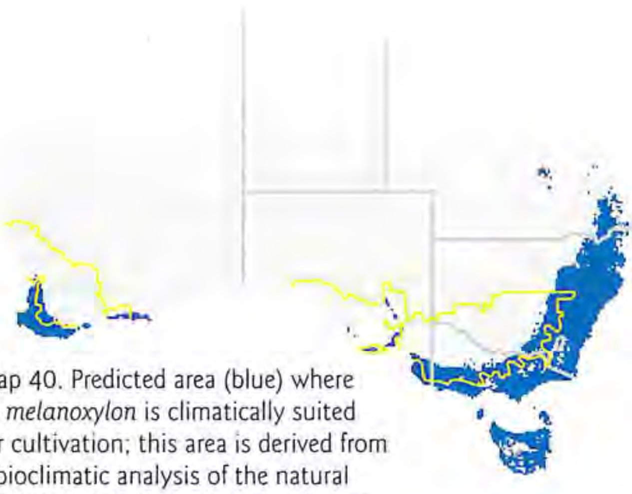
Habit

Trees often 10–20 m tall and 0.5 m dbh, but varies from small shrubs to one of the largest acacias in Australia, attaining heights up to 40 m and diameters of 1–1.5 m on lowlands in northwestern Tasmania, and in southern Victoria. In open situations the smaller and medium-sized Blackwood trees are freely branched from near ground level, but the largest plants have a well-developed trunk which is usually fairly cylindrical but may be shortly buttressed or flanged at the base. Crowns dense. May spread by root suckers. Juvenile bipinnate leaves often persist on young plants. Bark hard, rough, longitudinally furrowed and scaly, brownish grey to very dark grey. This description is adapted from Doran & Turnbull (1997).

Botanical descriptions and illustrations/photographs are provided in Maiden (1905), Costermans (1981), Stanley & Ross (1983), Boland *et al.* (1984), Simmons (1987), Floyd (1989), Fairley & Moore (1989), Whibley & Symon (1992), Tame (1992), Maslin & McDonald (1996), Cowan (1996), Cowan & Maslin (2001 & 2001a) and Kodela (2002).

Taxonomy

Acacia melanoxylon is referable to *Acacia* section *Plurinerves* a diverse, and probably artificial, group of about 212 species (Maslin 2001) which are characterized by having plurinerved phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Species of section *Plurinerves* are widespread in Australia with the main centres of richness located in the inland areas of the southwest and southeast of the continent (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). Five species of section *Plurinerves* are detailed in this report, namely, *A. cyclops*, *A. implexa*, *A. melanoxylon*, *A. stenophylla* and *A.* aff. *redolens*.



Map 40. Predicted area (blue) where *A. melanoxylon* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 39), see also Table 5. Target area shown in yellow.

Acacia melanoxylon is one of the most wide ranging tree species in eastern Australia and considerably variable, particularly in phyllode size and shape where the variation appears to be continuous. As discussed by Boland *et al.* (1984), Farrell & Ashton (1978) found considerable variation among populations in phyllode and fruit shape and size, and in the age of change from bipinnate to phyllodinous foliage. Phyllodes tended to be smaller and more symmetric in drier inland areas. Pods tended to be much smaller and more coiled and twisted in northern

Figure 19. *Acacia melanoxylon*

A – Tree with straight erect stem in forest site at Otway Ra., Victoria. (Photo: S. Searle)

B – Tree in open site (Major's Point, N.S.W.) showing wide-spreading crown. (Photo: M. McDonald)

C – Pods with seeds encircled by red aril. (Photo: P. Macdonell)

D – Plantation. (Photo: S. Midgley)

E – Stem core showing wood from 5 year old plant. (Photo: P. Macdonell)

F – Branch showing pale-coloured heads (in racemes) & multinerved phyllodes. (Photo: M. O'Leary) localities, and the change from bipinnate to phyllodinous foliage occurred much earlier in the progeny of trees from wetter areas. Similarly, Playford *et al.* (1991, 1993) demonstrated considerable allozyme variation (see under **Genetics** below). There is also variation in growth traits (Jennings 1991), frost resistance (Franklin 1987) and in certain anatomical features of the wood (Wilkins & Papassotiriou 1989).

Acacia melanoxylon is related to *A. frigescens* (alpine areas of Victoria) and seemingly also to *A. oraria* (northeast Queensland). It is also related to the two extra-Australian species *A. koa* (Hawaiian Islands) and *A. heterophylla* (Mascarene Islands). *Acacia melanoxylon* is sometimes confused with *A. implexa* (see species profile above).

Distribution and habitat

Widespread, often common in eastern Australia, extending from the Atherton Tableland in northern Queensland, south through tablelands and coastal escarpments of southeast Queensland, New South Wales, Australian Capital Territory and Victoria to Tasmania and South Australia (as far west as the Mount Lofty Ranges). Disjunctions occur throughout the range of the species, especially in Queensland and South Australia (see map in Cowan & Maslin 2001). The main area of occurrence of this species is to the south and east of the target area but it reaches the temperate periphery of the region in New South Wales, Victoria and South Australia. Maiden (1905) provides an informative account of the distribution, habit and habitat of this species in New South Wales and Victoria.

The species is grown as an exotic in a number of countries abroad (see under **Cultivation** below) and it has become weedy in places (see **Weed potential** below).

Acacia melanoxylon grows in a diversity of habitats, but favours fertile soils in high rainfall areas. It occurs in valleys and on flats in mountainous areas, often growing in wet sclerophyll forest and cooler rainforest (in areas receiving 750–1500 mean annual rainfall). The best growth is on slightly acidic, forest podsols and alluvia of high nutrient status, but as a smaller tree, the species grows on a wide range of podsols, sandy loams, kraznozems and even the residue from tin sluicing operations (Doran & Turnbull 1997).

Comprehensive summaries of habitat characteristics are given in Boland *et al.* (1984), Jennings (1991), Doran & Turnbull (1997) and CAB International (2000). A summary of its climatic requirements under both natural and cultivation conditions is given in Marcar *et al.* (1995).

Flowering and fruiting

Doran & Turnbull (1997) report that Blackwood flowering times vary over the geographic range of the species, tending to be in late winter–spring in the north and spring–summer in the south. However, this does not accord well with flowering times given by some other authors, for example, Pedley (1978) gives November to March (late spring–early autumn) as the main flowering period in Queensland while Cowan (1996) and Whibley & Symon (1992) give flowering as August to October (late winter–spring) in Victoria and South Australia respectively. To some extent these apparent discrepancies might be accounted for by the fact that, according to Pedley (1978), 'flowering and fruiting seems to occur throughout the year' in this species. Blackwood may flower from as early as 2 years of age (Ryan & Bell 1989). Ripe seed is available during summer–autumn (December to March) with a mid-February peak. According to Jennings (1991) little seed is retained on branches beyond April in the southern part of the distribution, however, Stelling (1998) reports that in southern New South Wales a large proportion of seed may be retained as late as August–September, although seed-eating insects may consume large amounts. There is some evidence to suggest that soil-stored seed is viable for at least 50 years (Whibley & Symon 1992).

Biological features

As summarised by Doran & Turnbull (1997) Blackwood is a hardy species that is considered both moderately drought and frost resistant (Anon. 1980) and tolerant of periodic waterlogging and slightly saline soils (but reduced growth can be expected at EC e less than 5 dS/m according to Marcar *et al.* 1995). Blackwood is a long-lived species; the oldest known plant was 210 years old when harvested near Smithton, Tasmania (Mesibov 1980, cited in Jennings 1991). Blackwood plantings in New Zealand withstand severe frosts down to about –7 °C. Below this temperature trees may be killed back to ground level but many recover by coppicing. In trials in southeastern Queensland, a tropical and subtropical provenance coppiced best when cut at 1 m and both displayed abundant root suckering (Ryan & Bell 1989). In Sri Lanka Blackwood is reported to vary in its coppicing ability and is considered an indifferent coppicer when compared to the eucalypts (Midgley & Vivekanandan 1987). As might be expected in a species with such a wide geographic range this species varies in a number of its morphological, biological, genetic and other attributes (see under **Taxonomy** above). This species is fire tolerant and young plants are shade-tolerant (Stelling 1998).

Genetics

Isozyme analysis of 27 provenances covering the distribution of *A. melanoxylon* showed a distinct genetic separation between populations occurring north and south of the Hunter River in New South Wales (Playford *et al.* 1991, 1993). Populations to the north of the Hunter River were much less heterozygous than the southern populations, although mean heterozygosity levels were high. This separation coincided with a disjunction in the distribution of the species indicating that the species has evolved separately in the two regions for a considerable time. Southern populations were further divided in northern Victoria. Most of the genetic diversity as assessed by allozyme variation was found within populations but there was an unusually high level of variation between populations (37.7%). This study also indicated that a population from Ebor (New South Wales, north of the Hunter R.) was atypical. The above information is taken from Doran & Turnbull (1997).

Toxicity

Bark and twigs reputedly used by aborigines to stupefy fish (Stelling 1998).

Cultivation

As an exotic *A. melanoxylon* has been most extensively grown in India and South Africa and shows promise in New Zealand and several countries in South America (Gleason 1986, Nicholas & Gifford 1995). It is also common in the hill country of Sri Lanka (Midgley & Vivekanandan 1987) and east Africa (e.g. in Ethiopia, Kenya and Tanzania) (Streets 1962). It is regarded as good or promising in parts of China (Wang *et al.* 1994). See CAB International (2000) for full list of countries where this species is planted.

The following information on the silviculture of Blackwood is taken from the summaries provided by Doran & Turnbull (1997) and CAB International (2000).

Establishment

Immersion in water at 90 °C for 1 minute will break seedcoat dormancy (CAB International 2000 provides a summary of seed pretreatment techniques). Treated seed is usually sown directly into polythene containers and seedlings reach plantable size in under six months. Seedling development is poor without rhizobia, so young seedlings may need to be innoculated if propagated in sterilised or new soil (Zwaan 1982). Studies in progress in Australia are showing some strains of rhizobia to be much more effective in stimulating growth of *A. melanoxylon* than others (A. Gibson, pers. comm., cited in Doran & Turnbull 1997). Phosphate fertilizers are usually beneficial in the nursery and in the field (see Darrow 1995 and Neilsen & Brown 1996 for details).

Vegetative propagation of selected trees using root cuttings has been applied successfully in Australia (Fielding 1948), New Zealand (Cornell 1994) and South Africa (Department of Forestry, South Africa 1971). Propagation of *A. melanoxylon* by tissue culture has been reported in New Zealand and South Africa (Jones and Smith 1988).

In Sri Lanka Blackwood has been established from seedlings or direct sowing (Streets 1962), however, direct sowing has been a failure in times of unseasonal drought (Anon. 1921, cited in Midgley & Vivekanandan 1987).

Care must be taken in site selection and silviculture in order to grow good timber trees of *A. melanoxylon*. While tolerant of a wide range of environmental conditions including soils of low fertility, it produces good timber only where it is sheltered from wind by topography, nurse-vegetation or mutual protection. Best results are achieved where trees grow in light-wells or gaps in an established canopy of other trees. Topsoil properties have proved important in the selection of suitable sites for Blackwood in South Africa; the preferred soils have a texture range from a sand to silt loam, high humus content, at least 0.7 m deep and of good drainage (Grey & Taylor 1983). Neilsen and Brown (1996) give details of site preparation procedures in Tasmania.

Although Blackwood is tolerant of very moist conditions and survives waterlogging for several months of the year in the swamps of Tasmania, it is important that the water is moving, however slowly, as Blackwood will not grow in stagnant, waterlogged areas (Jennings 1991). Blackwood is shallow-rooted and is susceptible to windthrow, particularly in wet soils.

Growth

In Tasmania, Blackwood is planted with *Pinus radiata* or eucalypts, especially *E. nitens*, at stockings of 62.5 Blackwood seedlings/ha and 1250 nurse crop trees/ha (Hickey 1988). The tree can be grown in single-species plantations but, because it will develop forks and heavy branches at wide spacing, close initial spacing (e.g. 2. 5 x 2. 5 m) followed by intensive pruning and thinning is necessary to produce timber trees. Final crop numbers should be about 100 stems/ha (Anon. 1978). In Tasmania Blackwood is managed as a 70-year rotation aiming at logs with a minimum diameter of 50 cm and a stocking of 200 stems/ha. In New Zealand, a stocking of 1600 trees per hectare is recommended with three or four thinnings to a density of 100–400 trees per hectare by the age of 10 years. Darrow (1995) reviews contemporary thinning and pruning practices.

Single bole, can sucker (especially with disturbance), coppices well after (severe) fire or if cut at about 15 cm above ground (if cut lower will revert to root suckering).

Yield

Over a wide range of sites in New Zealand, diameter growth of Blackwood averages 10–15 mm per year and rotations of 40 years are expected to produce trees of 50–60 cm dbh with an acceptable amount of heartwood and about 25 m tall. Similar growth rates are reported in South Africa where mean annual increment averages about 16 m^3/ha (Esterhuyse 1985, Zwaan & Sijde 1990). The species showed poor early development on seasonally dry lowland sites in Thailand (Pinyopusarerk & Puriyakorn 1987). In Tanzania Kessy (1987) reports that *A. melanoxylon* grows best at altitudes between 1220 m and 2140 m with a rainfall of 1000 mm or more on deep and fairly fertile soils. In trials at Mamba 20 year old trees attained heights ranging between 24 m and 32 m with 10–11 m of clean bole, and a girth at breast height of about 1.5 m; a total of 6.3 cubic meter log volume over bark was obtained from five trees. In Australia, a MAI of 15 m^3/ha is obtained on good quality sites in Tasmania. At this growth rate it is uneconomic to grow Blackwood unless combined with a nurse crop of clear wood *Pinus radiata* or eucalypt pulpwood (Allen 1992). Tropical provenances have been little tested. In species trials on subtropical and tropical sites in Queensland, subtropical provenances grew more vigorously than a Victorian provenance and had annual height growth exceeding 2 m (Ryan & Bell 1991). Four provenances of *A. melanoxylon* were represented in trials involving 16 acacias at two sites in Victoria

(Bird *et al.* 1998). All four provenances were amongst the worst performing provenances in terms of mean stem volume. Both trial sites were in the 700 mm mean annual rainfall zone.

Pests and diseases

Allen (1992) provides a summary of pests and diseases of Blackwood. In natural stands, Blackwood is attacked by a wide range of insects but none is seen as being of economic consequence (Jennings 1991). Seedlings may be defoliated by moths or grasshoppers, and larger trees attacked by wood borers, leaf eaters, psyllids and scale insects. Susceptibility to fungal diseases such as *Armillaria* and *Phytophthora* appears to be minimal. Significant pests in New Zealand are the ghost moth (*Aenetus virescens*) and pinhole borers (*Platypus* spp.). Various fungal diseases have been reported on young plants of *A. melanoxylon* in southern India including *Fusarium semitectum* which causes shoot dieback in two-year-old plants (Mohanan & Sharma 1988). Whilst relatively free of significant insect attack and pathogens, Blackwood is subject to a substantial number of vertebrate pests (see Allen 1992). The above information is taken from Doran & Turnbull (1997).

Weed potential

Within Australia *A. melanoxylon* is not generally considered a weed, however, in the high rainfall areas of southwest Western Australia it has become naturalized and is now spreading (Wheeler *et al.* 2002). It is not likely to be a problem in the drier areas encompassed by the target area as defined in this report. The species is also naturalized in South Africa where it is invading and displacing the indigenous vegetation in some areas (Ross 1975) where bird dispersal of the seed could be an exacerbating factor. Blackwood is difficult to control because of its fast growth rate and its vigorous regrowth from root suckers and regeneration from seed (Stirton 1980). In South Africa attempts at control of *A. melanoxylon* include both the use of herbicides and biocontrol agents (seed-feeding weevils) (Dennill *et al.* 1999). Blackwood is now naturalized in New Zealand (Webb *et al.* 1988) and is locally established in southern Europe and occasionally in California (Whibley & Symon 1992).

Wood

The heartwood is golden-brown to darker brown, sometimes with reddish tints and streaks. Sapwood is white, up to 10 cm wide and susceptible to attack by *Lyctus* borer. The grain is usually straight but is sometimes attractively figured with stripes, mottled, raindrop, birdseye and fiddleback patterns together with a beautiful surface lustre. The wood is only moderately hard and has a moderately low basic density, 465–670 kg/m^3 for 72-year-old trees and 390–576 kg/m^3 for 46-year-old trees in New Zealand (Harris & Young 1988); the basic density is given as 520–566 kg/m^3 by Ilic *et al.* (2000)* and 502 kg/m^3 by Clark *et al.* (1994). This latter paper summarizes the wood and kraft pulping properties of *A. melanoxylon* along with a number of other temperate and tropical acacias. Maiden (1905) provides a good discussion of the characteristics and uses of *A. melanoxylon* wood.

Utilisation

The following information on the utilisation of *A. melanoxylon* is taken largely from the summary provided in Doran & Turnbull (1997).

Wood

Blackwood is recognised as an outstanding cabinet timber in Australia. Formerly exported, supplies have dwindled and the annual production of about 10 000 m^3 is now used within Australia. Most timber comes from the natural forests of Tasmania where the resource is actively managed. Blackwood is prized for cabinet work, panelling, inlays, bent work and staves. Availability of sound large logs is limited and today the timber is mainly used for sliced veneer, especially on particle board for cabinet work and furniture, with 'scrap ' sizes for small fancy articles. The wood has good acoustic qualities and is suitable for violin backs. Small diameter, fast-grown logs do not develop the growth stresses

* The density range cited here represents a compilation of the Basic Density and the Estimated Basic Density from Air-dry (12%) MC values that are cited in Ilic *et al.* (2000).

of some eucalypt species and good sawn conversion can be expected from trees grown on 40–50-year rotations.

Blackwood has good pulpwood potential giving acceptable pulp yields and paper properties favourable for fine papers (Clark *et al.* 1994).

Because air dry wood of A. *melanoxylon* has relatively low density it ignites easily and burns quickly and quietly with large flame and little smoke but does not form hot embers (Groves & Chivuya 1989). The wood is used for fuelwood in India and Sri Lanka, although it would be considered of poor quality for certain cooking requirements and for room heating.

In South Africa the wood/sawdust of this species is reported to cause skin irritations (Henderson 2001).

Land use and environmental

Open-grown specimens retain their lower branches for many years and form excellent single-row shelterbelts. It grows well on some exposed sites, without attaining sawlog sizes. It also has a useful role in plantings for windbreaks, shade and screening in cool to mild climates with an adequate rainfall.

The food value of this species to wildlife is discussed in Bonney (1994).

Tannin

Not considered of value as a source of tannin by Maiden (1905).

Fodder

The foliage is harvested for cattle fodder in the Nilgiri Hills region of India, although tests in Australia show predicted *in vivo* digestibility at 40–50% or below animal maintenance levels (Vercoe 1987). It was classed as highly palatable in sheep grazing trials in Ethiopia (Kaitho *et al.* 1996).

Other uses

Useful for amenity planting (parks and large gardens) on account of its good growth form and dense crown. Aborigines reported to have used Blackwood for weapons (spear throwers and shields), fishing lines (from inner bark fibre), food (from gum) and as a fish poison (Stelling 1998).

Potential for crop development

Blackwood is regarded as having only reasonable prospects as a crop plant for high volume wood production in the target area. This species performs best in cool, moist conditions and it is likely to have only limited application for the target area. It is therefore ranked as a category 3 species (see Table 6). Blackwood is a long-lived, relatively slow growing species and is best suited to development as a long cycle crop (on a 20 years plus rotation) for high value solid wood products. It produces good quantities of low density woody biomass and has for many years been a source of timber of commerce both within Australia and abroad. Consequently there exists a large body of knowledge which should facilitate any attempt to develop it as a crop plant within the cropping zone.

Blackwood does not perform well on clay soils subject to prolonged waterlogging. Furthermore, its shallow root system predisposes it to windthrow. In cultivation A. *melanoxylon* needs to be managed properly to ensure that it does not become invasive. Also, its propensity to sucker (especially the northern provenances) may possibly present management problems in plantings of the species. Young plants need protection from grazing stock and wildlife.

The area predicted to be climatically suitable for the cultivation of A. *melanoxylon*, based on its natural climatic parameters, is shown in Map 40. This analysis indicates that A. *melanoxylon* is not particularly well suited to climatic conditions well beyond its natural distribution. This combined with its moderate growth rates suggests it does not have potential to be widely cultivated throughout either the eastern or western target areas. Within these regions *A. melanoxylon* could be considered a 'fringe species'. Acceptable growth rates will probably only be obtained on the most favourable sites such as valley soils or on mesic upland areas where the mean annual rainfall is in the vicinity of 600–650 mm. However, there are some indications that Blackwood might perform acceptably in some slightly lower rainfall areas. For example, it grows naturally near Naracoorte in South Australia (annual rainfall about 550 mm) where it displays a moderate growth rate, the plants attaining 7–10 m in height with boles 2.5–3 (–4.4) m long and 30–40 cm dbh; plants grown at Mt Gambier (annual rainfall about 800 mm) using seed from Naracoorte attained 20 cm dbh in 15 years (Neville Bonney, pers. comm.). If trials of Blackwood are established in the cropping zone then it would be advantageous to use seed provenances from the drier parts of the species range.

Provenance variation is highly likely to be substantial, particularly for attributes such as form and biomass production.

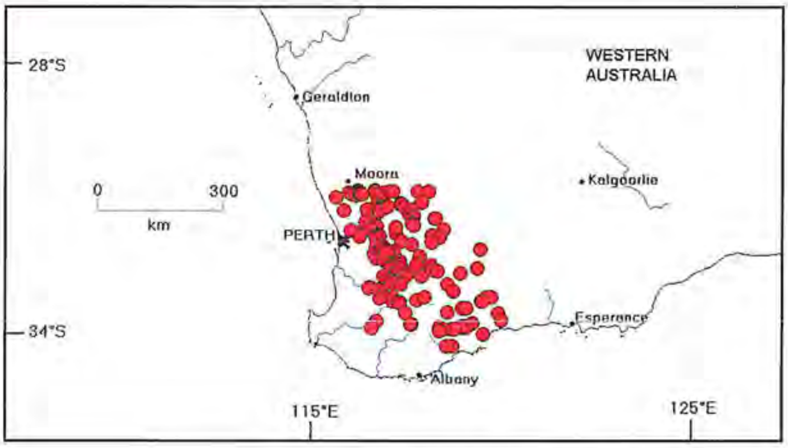
Acacia microbotrya Benth.

Common Name

Manna Wattle.

Special note

As discussed below under **Taxonomy** the concept of *A. microbotrya* adopted in this account is narrower than found in traditional definitions of the species (e.g. Maslin 2001 & 2001a). The taxon described here represents the 'typical' variant of the species (see under **Taxonomy** below) and it is likely that most of the previously published literature concerning *A. microbotrya* refers to this entity.



Map 41. Distribution of *A. microbotrya*.

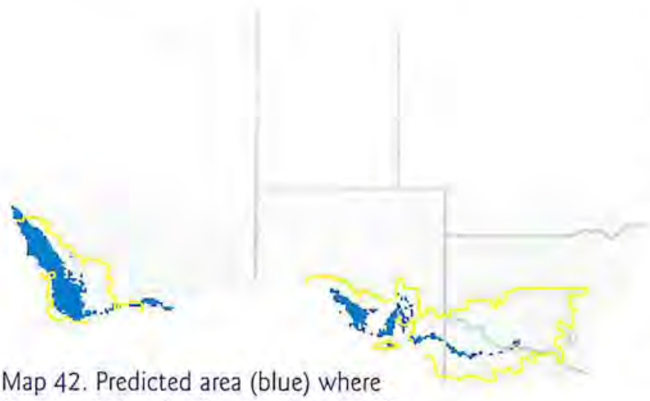
Habit

Obconic or rounded shrubs or small trees commonly 2–4 (–5) m tall but reaching 6–7 m in well-watered, temperate sites, sometimes single-stemmed but more commonly dividing at or near ground level (often 0.3–1 m above the ground) into 2–4 stout, straight to sub-straight (sometimes crooked) main stems which are 6–20 cm dbh, crowns dense and spreading, often freely root suckering and often forming dense clonal clumps. Bark smooth but becoming rough towards base of main stems with age.

Botanical descriptions and illustrations/photographs are provided by Simmons (1987: the illustration here may be of var. *borealis*), Maslin *et al.* (1998) and Maslin (2001 & 2001a).

Taxonomy

Acacia microbotrya is referable to *Acacia* section *Phyllodineae,* a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). More specifically this species is a Western Australian member of the Australia-wide '*Acacia microbotrya* group' (Maslin 1995). A number of other species from this group are detailed in this report, namely *A. bartleana, A. euthycarpa, A. retinodes, A. rivalis* and *A. wattsiana*. Species of section *Phyllodineae* are widespread in Australia with the main centres of richness located in temperate and adjacent semiarid areas of eastern, southeastern and southwestern Australia; species number greatly decline in the arid zone and in northern tropical/subtropical areas (Hnatiuk & Maslin 1988 and Maslin & Pedley 1988).



Map 42. Predicted area (blue) where *A. microbotrya* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 41), see also Table 5. Target area shown in yellow.

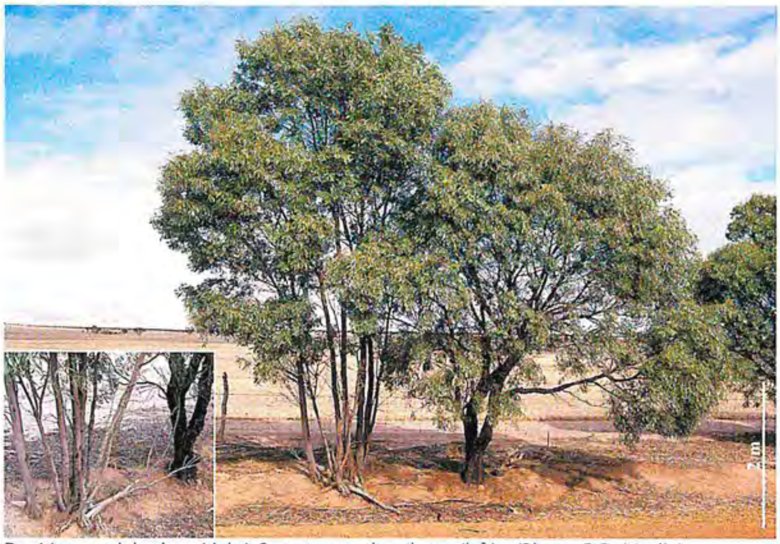
Current studies being conducted by the first author and others show that there are at least three separate entities encompassed by what is generally called *A. microbotrya*. (1) Typical *A. microbotrya*

Figure 20 *Acacia microbotrya*

A – Roadside stand showing sucker regrowth. (Photo: B.R. Maslin)


B – Plant in open site showing dense, rounded crown. (Photo: B.R. Maslin)


C – Regrowth from rootstock following fire. (Photo: B.R. Maslin)



D – Mature adult plant (right) & mature sucker clump (left). (Photo: B.R. Maslin)


E – Gum exuded from stem. (Photo: B.R. Maslin)


F – Branch showing pale coloured heads (in racemes). (Photo: B.R. Maslin)


G – 22 month old plants in trial at Coorow, W.A. (Photo: B.R. Maslin)

occurs in areas south of about the latitude of Moora; these plants have cream to pale yellow heads, green phyllodes and develop into small, robust trees to about 4 m tall. It is these plants to which the name A. *microbotrya* is applied in the present account. (2) North of Moora the plants have light golden heads, often shorter and more bluish phyllodes, and are commonly slightly smaller in stature than their southern counterparts; these northern plants probably correspond to what has been described as both A. *microbotrya* var. *borealis* and A. *daphnifolia*. These plants are not considered to have significant potential as a wood crop and are therefore not dealt with in the present account. (3) In the Dandaragan–Badgingarrra area there exists a particularly robust form; these plants reach about 7 m in height, they have narrower pods than the other two forms and have light golden to lemon yellow heads. These plants are treated as A. *bartleana* here (see species profile above). The taxonomic and genetic work which is currently in progress is attempting to elucidate the patterns of relationships between these three entities.

Distribution and habitat

Widespread and common in the wheatbelt region of Western Australia (largely confined to the target area), where it extends from south of Moora south to near Katanning, with scattered occurrences around Ongerup and Lake King. It occurs on a variety of soil types including texture contrast soils derived from laterite, sands and sandy loam surrounding granite rock outcrops or clay loam near rivers and drainage lines. It is probably slightly to moderately salt tolerant.

Flowering and fruiting

Acacia microbotrya flowers earlier in the season than many other acacias in southwest Western Australia. Plants produce a great profusion of flowers from April to early July. Pods with mature seed have been collected from October to December, and occasionally in January. Natural stands of this species normally produce heavy pod crops; the seeds are large, easily collected, and are easily separated from the pods by manual threshing methods (Maslin *et al.* 1998).

Biological features

Acacia microbotyra is hardy, drought- and frost-tolerant, and fast-growing; it probably has a life span of about 20–30 years (Gardner 1957). It commonly suckers and is likely to coppice (it resprouts from near the stem base following fire). In Sandalwood host trials at Narrogin, Western Australia, A. *microbotrya* produced root suckers in 4 or 5 year old stands with no or minimal root disturbance (Jon Brand, pers. comm.).

Cultivation

Acacia microbotrya is used in direct seeding programs for regeneration and shelter belt plantings in the northern wheatbelt region of Western Australia (P. Ryan, pers. comm.).

Trials

Assessment trials of this species were recently established in plots on farmland at various locations in south-western Australia by the "Search" project (see Acknowledgements). At age 10 months plants of the best performing provenance of A. *microbotrya* showed an average survival of 69% and an average height of 134 cm. The 'best' plot was located on an upslope site with light soil in the northern Avon Wheatbelt IBRA region, with plants averaging 310 cm high. At this early age A. *microbotrya* showed the best preformance of the eight species that were included in these trials.

Performance results of 4 year old plants in Sandalwood trials at Dandaragan and Narrogin will be published in Brand *et al.* (in prep.).

Pests and diseases

Newbey (1982) reported A. *microbotrya* in southern parts of its range to be susceptible to attack by woolly caterpillars, but these can be controlled and the trees will recover.

Weed potential

There are no records of weediness involving this species despite the fact that it grows throughout much of the extensively disturbed cropping zone, produces prolific quantities of seed and has a vigorous suckering propensity.

Wood

The basic density values range from 654 kg/m^3 to 959 kg/m^3 (mean 832 kg/m^3) based on analyses of 30 wood samples by CALM's NHT-supported 'Search' project (unpublished data). Note: This study preferentially sampled young and adolescent plants.

Utilisation

Land use and environmental

The species is reported to be useful as a low windbreak and shelter plant (Elliot & Jones 1982, Simmons 1987) and for amenity planting in wheatbelt towns of the south-west of Western Australia (Maslin *et al.* 1998). It has been used in direct seeding programs for regeneration and shelter belt plantings in the northern wheatbelt region of Western Australia (P. Ryan, pers. comm.).

Fodder

According to Hussey (pers. comm.) the phyllodes of A. *microbotrya* are nutritious but the plants do not withstand grazing.

Tannin

In the early days the bark of A. *microbotrya* was often used in home tanning and as a source of 'manna gum' for export (Gardner 1957).

Human food

Acacia microbotrya is one of the promising species suggested by Maslin *et al.* (1998) for trialing as a source of seed for human food. The seeds and gum have been used as food items by Australian Aborigines (Meagher 1974).

Gum

Plants of this species often have reasonable quantities of gum exuded on the trunks and branches. The question of commercial potential of gum from this species is sometimes raised; however, apart from the difficulty (and cost) of collection, it is not of a particularly high quality (an analysis of gum characteristics is given in Anderson *et al.* 1985). This matter would need to be explored more thoroughly before dismissing it as a commercial possibility.

Sandalwood host

This species is currently in trials near Narrogin being assessed for its potential as a host for Sandalwood (*Santalum spicatum*).

Other uses

Reported to be useful as a source of honey or pollen (Elliot & Jones 1982; Simmons 1987).

Potential for crop development

Acacia microbotrya is regarded as being reasonably prospective for development as a crop plant for high volume wood production. It is ranked as a category 2 species and its growth characteristics suggest that it has potential as a phase crop and possibly also as a coppice crop (see Table 6). *Acacia microbotrya* is fast growing, hardy and adaptable to different sites (with a preference for loam soils). It produces a reasonable amount of woody biomass but the wood is moderately dense which lowers its attraction for use in reconstituted wood products. In terms of wood biomass production its close relative, *A. bartleana*, would seem slightly more prospective. *Acacia microbotrya* has a reasonable growth form but there is variation in stem straightness and the degree of branching. Therefore, selection of appropriate provenances will be necessary if this species is progressed as a crop for high volume wood products. The propensity for *A. microbotrya* to vigorously root-sucker may or may not be advantageous in cultivation, it depends whether or not this attribute is required (or expressed) for the system in which it is to be placed. However, successful development of this species as a phase crop may depend upon locating non-suckering provenances, if they exist. Also, because *A. microbotrya* produces large quantities of seed it would by appropriate to harvest plants before they reach biological maturity to avoid creating a soil seed bank that may lead to weed problems in adjacent or subsequent annual crops. For this technique to be viable the plants will need to have produced acceptable quantities of wood prior to the first pod crops being set. An alternative might be to treat seedling recruitment as a form of green manure. Although *A. microbotrya* is reported to regenerate from the base following fire, the vigour, frequency and other attributes of resprouting are unknown, therefore the potential of this species as a coppice crop cannot be adequately assessed at present.

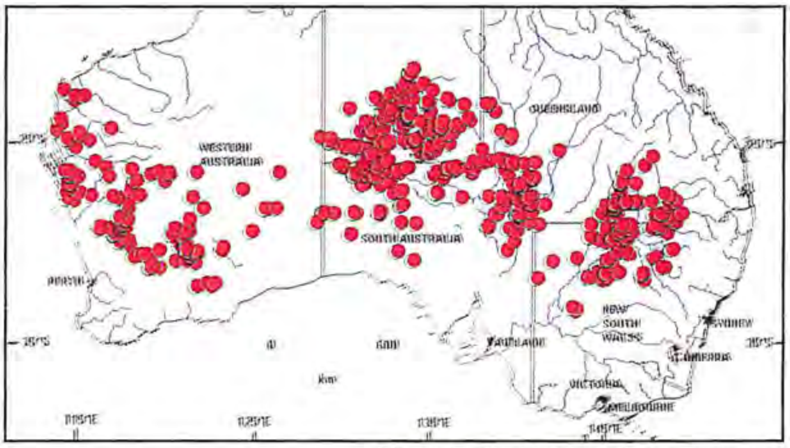
Acacia microbotrya is widespread in the Western Australian wheatbelt (but absent from southeastern areas, east of Ravensthorpe) where it is reasonably well known and used in regeneration and nature conservation projects. Possible associated benefits that might be derived from gum, seed for human consumption or as a Sandalwood host plant require further investigation.

The area predicted to be climatically suitable for the cultivation of *A. microbotrya*, based on its natural climatic parameters, is shown in Map 42 . This analysis indicates that *A. microbotrya* has good prospects for cultivation throughout much of the target area in Western Australia and also large parts of South Australia and a few places in Victoria and New South Wales. The area predicted for growth of *A. microbotrya* in the west essentially equates to its area of natural occurrence. As this species has a reasonably broad edaphic tolerance it has the potential to be widely cultivated throughout the western target area.

Acacia murrayana F. Muell. ex Benth.

Common Names

Colony Wattle, Murray's Wattle, Sandplain Wattle, Powder Bark Wattle, Fire Wattle.


Map 43. Distribution of *A. murrayana*.

Habit

Large shrubs or trees 2–6 (–8) m, single- or multi-stemmed from the base, main stems straight or sometimes rather crooked and with dbh to about 10–20 cm (note: few measurements made therefore needs confirming), commonly suckering to form clonal thickets; crowns bushy and often wide-spreading 3–8 m across. Bark smooth becoming fissured on trunks and main branches with age, grey or brown with a distinctive powdery white bloom (pruinose) at least when young.

Botanical descriptions and illustrations/photographs are provided by Cunningham *et al.* (1981), Turnbull (1986), Whibley & Symon (1992), Tame (1992), Mitchell & Wilcox (1994), Doran & Turnbull (1997), Maslin *et al.* (1998), Maslin (2001 & 2001a) and Kodela (2002); see also descriptions by Pedley (1980).

Taxonomy

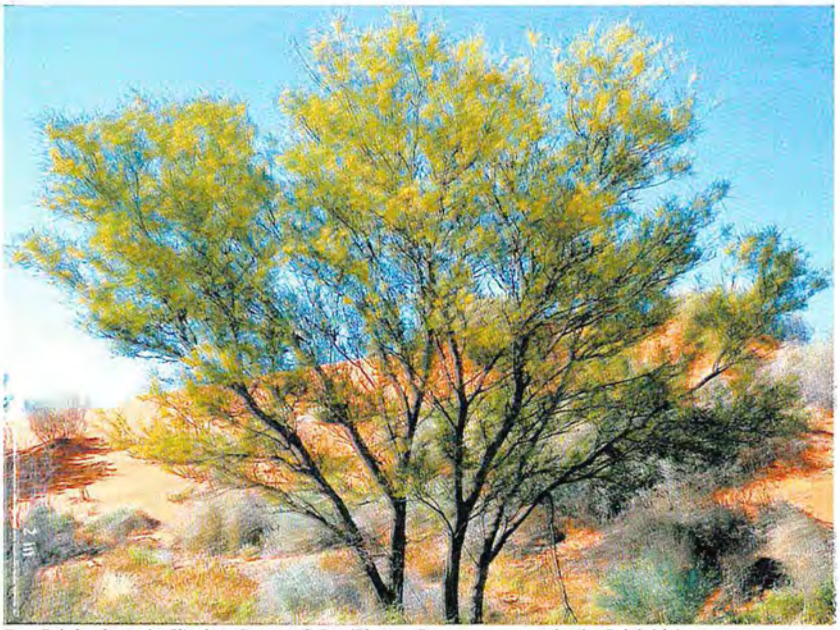
Acacia murrayana is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Species of section *Phyllodineae* are widespread in Australia with the main centres of richness located in temperate and adjacent semiarid areas of eastern, southeastern and southwestern Australia; species number greatly decline in the arid zone and in northern tropical/subtropical areas (Hnatiuk & Maslin 1988 and Maslin & Pedley 1988).


Map 44. Predicted area (blue) where *A. murrayana* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 43). see also Table 5. Target area shown in yellow.

Acacia murrayana, together with four close relatives (*A. gelasina*, *A. pachyacra*, *A. praelongata* and *A. subrigida*) comprise the informal '*Acacia murrayana* group' (see Maslin 1995 for discussion); only *A. murrayana* itself is included in this report. This species is not far removed taxonomically from *A. victoriae* (see species profile below).

Within *A. murrayana there* is marked variation in phyllode size and colour between plants from different areas and future studies may show the need to recognize new taxa to accommodate at least the two main phyllode forms (i.e. plants with narrow, green phyllodes are common in Queensland; elsewhere phyllodes are normally wider and pruinose). According to Maslin *et al.* (1998)

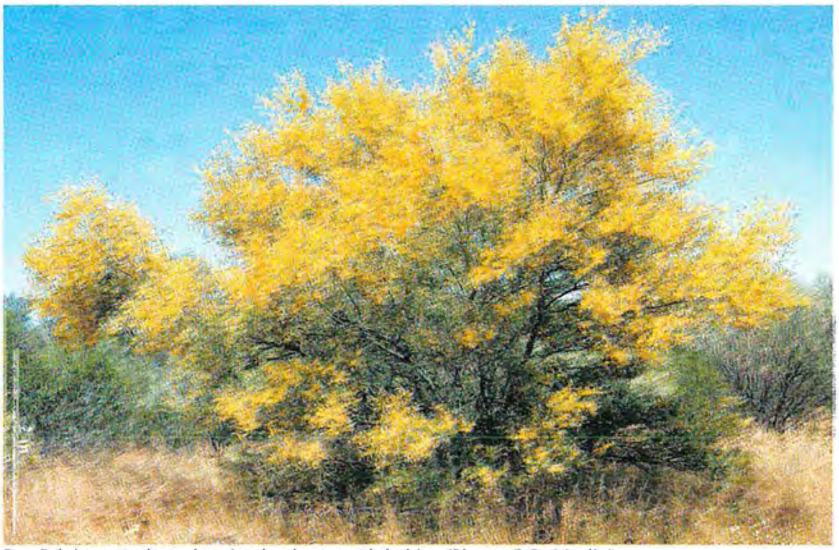
Figure 21. *Acacia murrayana*



A – Adult plants in Flinders Range, S.A. (Photo: Anonymous, ex herb. Adelaide)

B – Young stems (white pruinose). (Photo: J. Simmons)

C – Mature (papery) pods. (Photo: B.R. Maslin)



D – Adolescent plant showing bushy growth habit. (Photo: B.R. Maslin)

E – Branch showing golden heads (in racemes). (Photo: B.R. Maslin)

F – 2 year old plants in trials at Morawa, W.A. (Photo: J. Carslake) provenance variation in economic characters is also likely to be great, given the extensive natural distribution and occurrence on different soil types of this species.

Distribution and habitat

Widely distributed in the arid and semi-arid zones of Australia where it extends from the central-west coast of Western Australia eastwards through all mainland states (except Victoria) to the western margin of the Great Divide near Mitchell (Queensland) and Narrabri (New South Wales). This species only just reaches the target area in northern wheatbelt of Western Australia and the western plains of New South Wales. *Acacia murrayana* is one of only four species in this report that occur in both the eastern and westen target areas (the other three are *A. cyclops*, *A. hakeoides* and *A. victoriae*). Over its extensive range *A. murrayana* occurs predominantly on deep red sands but it may also occur on clay loams. It favours well-drained sites with access to run-on water such as the base of dunes, road verges and stream levees. It is tolerant of alkaline soils according to Elliot and Jones (1982) but results from glasshouse trials suggest that it is relatively salt-sensitive (Aswathappa *et al.* 1987). Further details on its ecology are given in Doran & Turnbull (1997), Cunningham *et al.* (1981) and Whibley & Symon (1992).

Flowering and fruiting

The main flowering period is from August to November (but will vary within this range depending upon geographic location) with pods maturing several months later, between November and January (Maslin *et al.* 1998). Plants flower profusely, commencing at an early age (e.g. 17 months, Ryan & Bell 1989). *Acacia murrayana* produces heavy pod crops during favourable seasons; however, in south western Queensland at least parrots are reported to remove much of the seed prior to maturity (Allen 1949). The pods may be rapidly harvested by shaking/threshing.

Biological features

An adaptable, fast-growing species with life-span of about 10–25 years, during which time in its natural habitat it rarely produces a trunk with a diameter over 10 cm (Maconochie 1982). It is highly fire-tolerant and drought-adapted according to Latz (1995), however Maconochie (1982) and Kube (1987) note that it is not especially drought-tolerant. It forms colonies from subsurface adventitious sprouts often a considerable distance from the parent plant. Established plants resprout readily after wildfires from epicormic buds in the relatively thick bark at the stem base, or from stem and major roots (Hodgkinson 1982). The growth pattern is distinctly seasonal with the main vegetative growth during spring (Maconochie 1973) and it loses many of its phyllodes in winter (Cunningham *et al.* 1981). It is relatively salt-sensitive (Aswathappa *et al.* 1987). The above information is taken largely from Doran & Turnbull (1997) and Maslin *et al.* (1998).

Toxicity

Webb (1948) reports that *A. murrayana* is suspected of causing sheep deaths in Queensland.

Cultivation

Field observations suggest that *A. murrayana* is an adaptable species capable of rapid growth when planted on favourable sites. As discussed by Maslin *et al.* (1998) *A. murrayana* should grow successfully in a wide range of well-drained soils (acid to alkaline sands, loams and texture-contrast types) in low-rainfall areas (<500–600 mm/yr) across southern Australia. Waterlogged sites should be avoided, but supplementary watering/irrigation can be expected to enhance longevity and fruiting in very low rainfall areas (< 250–300 mm/yr). *Acacia murrayana* was found to be relatively salt-sensitive in a salt tolerance trial based on testing glasshouse-grown seedlots (Aswathappa *et al.* 1987).

The following information on silviculture is taken mostly from Doran & Turnbull (1997) and Maslin *et al.* (1998), unless otherwise indicated.

Establishment

There are 19 900 viable seeds/kg and these have a thick testa that requires one of the routine treatments to break seedcoat dormancy (e.g. 1 minute immersion in boiling water). Germination rate averages 70%.

Declining stands can be regenerated either by coppicing and/or shallow ploughing to stimulate root-suckering. It responds to pruning after flowering according to Elliot and Jones (1982); pruning to one main stem which would facilitate mechanical harvesting.

Growth and survival

Reports of performance are variable and this is most likely due to some planting on inappropriate sites. In the Northern Territory at Alice Springs, *A. murrayana* grew reasonably quickly while rainfall was above average (390 mm/year) but plant health rapidly declined during dry periods (<150 mm/year). At 10 years it had grown into a multi-stemmed tree, 6 m tall with 3–4 stems of approximately 10 cm dbh (Kube 1987). The species exhibited low survival and comparatively slow growth in more humid climates (> 1000 mm/yr) in south-eastern Queensland (Ryan & Bell 1989) but showed early promise on coarse-textured soils near Longreach (Ryan & Bell 1991). It gave poor survival and growth to two years of age in southern Africa (Gwaze 1989, Maghembe & Prins 1994) and has shown poor survival and growth in dry tropical Africa (at Sarkin Hatsi, Burkina Faso, Harwood 1993). Plants grew moderately quickly in trial plantings at the Central Arid Zone Research Institute, Jodhpur (Rajasthan, India), but died prematurely during drought conditions (Thomson 1987).

Trials

Assessment trials of this species were recently established in plots on farmland at various locations in south-western Australia by the "Search" project (see Acknowledgements). At age 22 months plants of the best performing provenance of *A. murrayana* showed an average survival of 62% and an average height of 99 cm. The 'best' plot was located on a downslope site with heavy soil in northern Avon Wheatbelt IBRA region, with plants averaging 197 cm high.

Weed potential

Acacia murrayana has not been recorded as causing serious environmental weed problems, despite the fact that it produces large quantities of seed and has root-suckering ability. It can form sucker-induced thickets with the young trees often a considerable distance from the parent plant (Cunningham *et al.* 1981).

Wood

Basic density values ranged from 522 kg/m^3 to 850 kg/m^3 (mean 692 kg/m^3) based on analyses of 22 wood samples by CALM's NHT-supported 'Search' project (unpublished data). Note: this study preferentially sampled young and adolescent plants. Ilic *et al.* (2000) gives the air-dry density before reconditioning as 603 kg/m^3 (note: this value was erroneously listed in the basic density column in this work).

Utilisation

Wood

Highly suitable for fuelwood and charcoal (Thomson *et al.* 1994). The suckering habit will assist the management of this species for fuel. The small size of the stems will restrict the use of the wood to turnery articles and small round wood uses (Doran & Turnbull 1997).

Human food

Acacia murrayana is one of the most promising species suggested by Maslin *et al.* (1998) for trialing in southern Australia as a source of seed for human food. Maslin *et al.* (1998) provide summary of macronutrient composition of seeds. In the past, seed and gum of *A. murrayana* was a food source for Central Australian Aborigines (Latz 1995, House & Harwood 1992).

Land use and environmental

This species has potential for use in revegetation of arid and semi-arid areas. It is well-suited for providing windbreaks, visual screens and shade and shelter for stock and wildlife. Because it commonly suckers it has good potential for providing soil stabilisation.

Fodder

Although Central Australia plants of this species are reported to contain high levels of protein and phosphorus and reasonably low levels of fibre, they are only lightly grazed by cattle in that area (Chippendale and Jephcott 1963). According to Cunningham *et al.* (1981) in western New South Wales the foliage of this species is seldom browsed. Similarly Allen (1949) and Mitchell & Wilcox (1994) report that the phyllodes are rarely consumed by stock, but the pods are sought after. Dry matter digestibility of foliage was assessed by Vercoe (1989) as being below maintenance levels for livestock.

Other uses

It flowers profusely and may prove useful for ornamental purposes and as a pollen source for bees (Doran & Turnbull 1997).

Potential for crop development

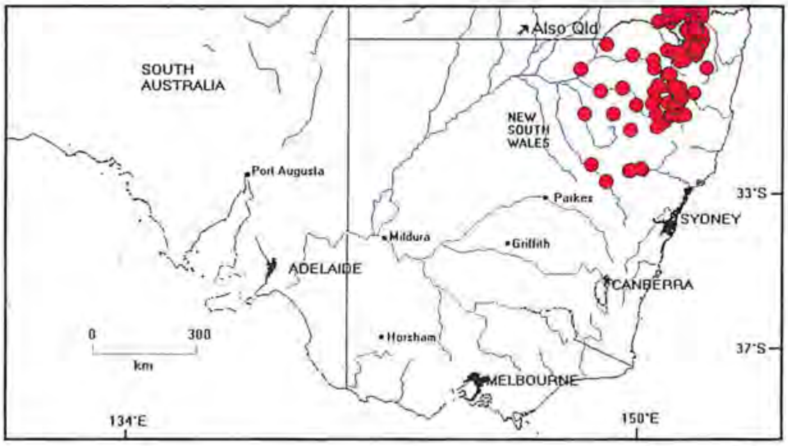
Acacia murrayana appears to have some prospects as a crop plant for high volume wood production. It is ranked as a category 2–3 species and would be best suited to development as a phase crop, and perhaps also as a coppice crop (Table 6). This adaptable species is capable of rapid growth when planted on favourable sites and should be suitable for cultivation in low-rainfall areas across southern Australia. *Acacia murrayana* tolerates a wide range of well-drained soils (waterlogged and saline sites should be avoided) and although it is drought-adapted it is not overly drought tolerant. Therefore, it remains to be seen if growth rates and survival decline under cultivation as profiles dry out; this is particularly relevant to the drier inland areas of the target zone. This species develops a good growth form (amenable to mechanical harvesting) and produces quite reasonable amounts of woody biomass. Wood density values are seemingly variable, however, at the lower end they are within the range that make them attractive for reconstituted wood products. In terms of wood biomass production *A. murrayana* would be out-competed by species such as *A. salicina* and *A. stenophylla* which occur within its geographic range. A potential constraint with respect to developing *A. murrayana* as a phase crop is its reported ability to flower at an early age. If this precocity results in pod set it may lead to the creation of a soil seed bank that may cause weed problems in adjacent or subsequent annual crops (on the other hand seedling regeneration may possibly be treated as a form of green manure). One way of avoiding soil seed build up is to harvest plants prior to them producing appreciable pod crops, however, plants will need to have developed sufficient woody biomass by that time for this to be viable. Although *A. murrayana* it is capable of resprouting from the base it is uncertain that such regrowth will be sufficiently vigorous to sustain the species as a coppice crop. The propensity for *A. murrayana* to vigorously root-sucker in nature may or may not be advantageous in cultivation, it depends whether or not this attribute is required (or expressed) for the system in which it is placed. It would be expected though that vigorous suckering would present particular difficulties for managing this species as a phase crop. Seed production for human food is a secondary product that may be derived from this species (it is similar to its close relative, *A. victoriae*, in this regard but *A. murrayana* has the advantage of having a better growth form and is less spiny).

The area predicted to be climatically suitable for the cultivation of *A. murrayana*, based on its natural climatic parameters, is shown in Map 44. This analysis indicates that *A. murrayana* has the potential to be cultivated in areas that receive less than 500 mm rainfall in the uniform and summer rainfall zones. This prediction reflects the fact that there are no known populations of this species that occur naturally in the winter rainfall zone. Nevertheless, trials are warranted to assess if this species has the potential to be cultivated in winter rainfall zones of the target areas. Based on the current climatic analysis the best cultivation potential for *A. murrayana* is on the western plains of New South Wales in the less than 500 mm rainfall zone. Wherever it is cultivated *A. murrayana* is likely to perform best on deep sandy soils where access to ground water is possible. There are many unknowns regarding provenance variation, silviculture and management of this species, and comprehensive research is warranted before its potential for biomass production can be properly assessed.

Acacia neriifolia A. Cunn. ex Benth.

Common Names

Oleander Wattle, Bastard Yarran, Silver Wattle, White Wattle, Black Wattle.



Map 45. Distribution of *A. neriifolia*.

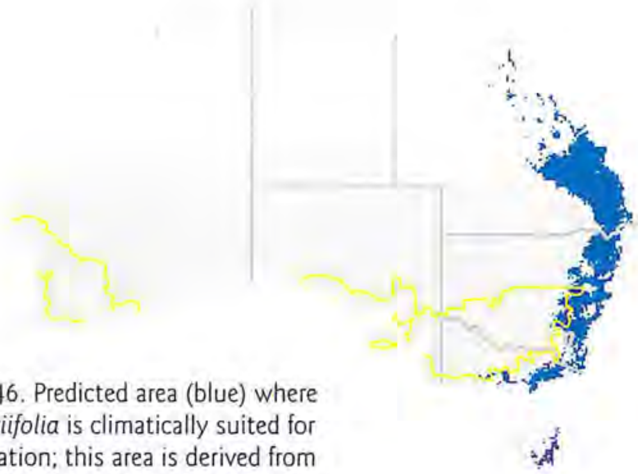
Habit

Erect or spreading, often shapely shrubs (2–5 m tall) or trees (to 6–8 m tall or occasionally 10–15 m), normally single-stemmed and sparingly branched for 2–4 m (tallest plants may be unbranched for 6–8 m), occasionally with up to 3 main stems from near the base, often freely-branched in open sites but with erect, sparingly branched habit in denser stands, main stems and branches straight to sub-straight or somewhat crooked, boles to about 15–25 cm dbh, strong, shallow lateral roots develop on at least some plants (in stony sites), crowns bushy and often terminal, sometimes retaining juvenile bipinnate foliage for a long time. Bark thin and tightly held, longitudinally fissured on main trunks, smooth on upper branches, pale- or dark-grey.

Botanical descriptions and illustrations/photographs are provided by Maiden (1920), Lebler (1981), Turnbull (1986), Simmons (1987), Tame (1992), Doran & Turnbull (1997), Maslin (2001 & 2001a) and Kodela (2002); it is also described in Cunningham *et al.* (1981) and Pedley (1980).

Taxonomy

Acacia neriifolia is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Species of section *Phyllodineae* are widespread in Australia with the main centres of richness located in temperate and adjacent semiarid areas of eastern, southeastern and southwestern Australia; species number greatly decline in the arid zone and in northern tropical/subtropical areas (Hnatiuk & Maslin 1988 and Maslin & Pedley 1988).



Map 46. Predicted area (blue) where *A. neriifolia* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 45), see also Table 5. Target area shown in yellow.

As discussed by Maslin (2001) *A. neriifolia* is a variable species in need of critical revision. Typical representatives of the species are normally recognised by their thinly coriaceous, commonly shallowly recurved phyllodes 4–9 mm wide, to c. 12 cm long and with a dense indumentum of short, straight, silvery white hairs covering the entire lamina or occurring in patches, they also have a rather prominent gland situated 0–8 mm above the pulvinus. Most of the variation occurs in Queensland populations (see Pedley 1980 for discussion). Plants from the

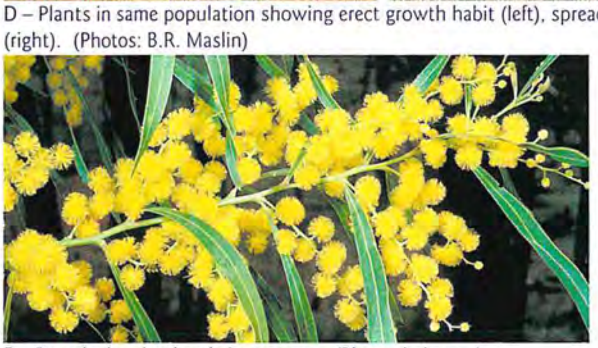
Figure 22. *Acacia neriifolia*

A – Mature plant in open site (note straight, stout stems/branches). (Photo: B.R. Maslin)

B – Stem base variation, branching above ground (left) & 3 stems from ground level (right). (Photos: B.R. Maslin)

C – Single stem (left) & stem showing weak epicormic growth (right). (Photos: B.R. Maslin)

D – Plants in same population showing erect growth habit (left), spreading branches (center) & closely-spaced regeneration (from seed) (right). (Photos: B.R. Maslin)



E – Branch showing heads in racemes. (Photo: L. Jessup)

F – Stem core. (Photo: P. Macdonell)

Granite Belt (around Stanthorpe) and Inglewood are rather large trees with coriaceous phyllodes to 21 cm long; this variant grades into 'typical' *A. neriifolia*. Specimens from the Toowoomba–Crows Nest area often have phyllodes to 12 mm wide with the gland to 2 cm above the pulvinus; the name *A. penninervis* var. *angustata* is likely to be referable to this entity (L.Pedley, pers. comm.). Like some other specimens from elsewhere in Queensland the indumentum on these plants may be sparse (sometimes completely absent from branchlets, phyllodes, raceme axes or peduncles, but not all organs simultaneously). A specimen from near Kingaroy shares characters of both the Toowoomba–Crows Nest variant and *A. pustula*. A few New South Wales specimens of 'typical' *A. neriifolia* have shorter than normal phyllodes (i.e. 4–6 cm long).

Acacia neriifolia is very closely related to *A. ingramii* (endemic in the Armidale district of northern New South Wales). Pedley (1980) treated *A. pustula* as a subspecies of *A. neriifolia*; although these species are closely related *A. pustula* is probably closer to *A. linearifolia* (see species profile above).

Species detailed in this report which are not far removed taxonomically from *A. neriifolia* include *A. hakeoides*, *A. linearifolia* and *A. pycnantha*; members of the '*Acacia microbotrya* group' are related to these taxa.

Distribution and habitat

Occurs mainly on the western slopes and tablelands of the Great Divide in Queensland (south of Emerald) and New South Wales (north of Dubbo). Although the natural distribution of *A. neriifolia* is outside the target area it occurs on the drier western plains of New South Wales very close to the north border in New South Wales. As detailed by Turnbull (1986) this species grows on gently undulating hills or in mountainous country, often on sandstone or granite but also andesite, basalt conglomerates and shale. The soils vary from infertile shallow rocky lithosols and podzolics of the mountain sides to deep, strongly structured red-brown, fertile volcanic krasnozems. The soils are acidic and well drained. Some of the tallest specimens have been found on the deep red-brown basaltic clays, but *A. neriifolia* can reach 8 m on shallow sandy soils. See Turnbull (1986) and Doran & Turnbull (1997) for additional habitat information.

Flowering and fruiting

Flowers from June to October with the main flush in July and August in the north and west of its range and about a month later in the south and east (Turnbull 1986). Mature pods have been collected in November and December. A light seed crop was observed on planted specimens in Queensland as early as 16 months (Ryan & Bell 1989).

Biological features

As summarised by Turnbull (1986) *A. neriifolia* is a fast-growing species that will withstand snow and heavy frosts. It is moderately drought tolerant (Simmons 1987). It grows best on relatively light, often stony, well drained sites. Under trial conditions it coppiced poorly when cut below 1 m and its coppicing performance was rated as only fair at 1 m (Ryan & Bell 1989). We observed epicormic growth on a few plants in the wild but we assessed this species to have generally a low coppicing ability. *Acacia neriifolia* is unlikely to sucker (but needs confirmation). Estimates based on our field observations are that this is generally a relatively short-lived species (perhaps 10–15 years, although some plants are likely to live longer).

Cultivation

Little known in cultivation but according to Tame (1992) is suitable for growing on a variety of soils and according to Turnbull (1986) does best on relatively light, often stony, well-drained sites.

We observed *A. neriifolia* under cultivation at the Burrendong Arboretum where it survived and performed well in the absence of supplementary watering. Burrendong Arboretum is located about 20 km due southeast of Wellington, just outside the target area near its north eastern corner (Wellington has a mean annual rainfall of 620 mm).

The following silvicultural information is provided by Turnbull (1986).

Establishment

Establish from seed. Seed immersed in boiling water for 1 minute has been shown to break seedcoat dormancy. Treated seed gives a germination rate of 70% and there are about 30 000–35 000 seeds/kg.

Yield

In field trials in southeast Queensland, one provenance (Toowoomba) grew very rapidly, averaging nearly 14 m tall and 19 cm in basal diameter in 4. 5 years (Ryan & Bell 1991). The other provenance tested (Blackdown Tableland) grew at only half this rate and was of poorer form, indicating the need to trial a range of seed sources when assessing the potential of this species.

Weed potential

There are no records of weediness involving this species.

Wood

Attractively marked, close-grained and tough (Maiden 1889); the sapwood is pale yellow and the heartwood mid-brown.

Utilisation

Wood

Regarded by Turnbull (1986) as a probable good source of fuel wood and has potential for post and pole production.

Fodder

It has some value as forage for animals during times of drought, with sheep said to find it more palatable than do cattle (Anderson 1968). Vercoe (1989) estimated the crude protein levels of phyllodes to be in the range 14–16% (dry matter) with a predicted in vivo dry matter digestibility of 33–35%. As the species came close to the minimum requirement for certain nutrients, it was recommended for further study of its fodder potential.

Tannin

The bark has a tannin content of 11–14% (Swain 1928) and was formerly used locally for tanning in southern Queensland (Maiden 1920).

Land use and environmental

It is some-times grown for windbreaks in Australia (Simmons 1987).

Other uses

An attractive species that could be used as a garden plant (Forestry Commission of New South Wales 1980, Cunningham *et al.* 1981) and in amenity plantings (Turnbull 1986).

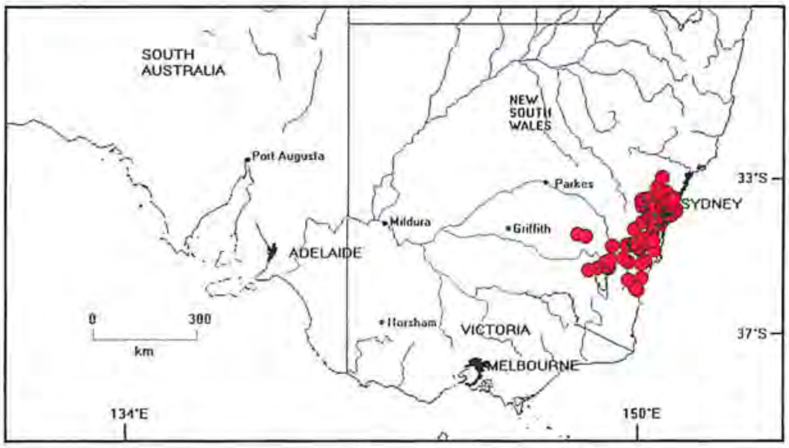
Potential for crop development

This is a relatively poorly known species for which there is little data available, however, it would appear to have reasonably good prospects as a crop plant for high volume wood production. It is ranked as a category 2–3 species and would be best suited to development as a phase crop (Table 6).

Acacia neriifolia is reported as having a relatively fast growth rate. However, according to Turnbull (1986) vigorous growth can be expected only on well drained sites where there is a short dry season; it does tolerate heavy frosts. The species is therefore most likely best suited for growing in the wetter peripheral regions of the target area. *Acacia neriifolia* is capable of producing a good growth form and good quantities of wood biomass. However, it is somewhat variable with respect to habit (it is most variable in southeast Queensland) and the selection of appropriate provenances for trial purposes will be important in its development. Furthermore, anecdotal field observations suggest that silviculture practice will influence plant form and biomass production. Closely spaced plants may be expected to develop straighter, less branched stems, but if grown too close the stems are likely not to develop significant amounts of wood. We would estimate that under appropriate growing conditions plants of this species might be expected to produce stems to about 15 cm dbh in 5–10 years. The wood is pale-coloured and although its density is unknown it will possibly be similar to that of *A. microbotrya* (which averages about 830 kg/m^3) and, if so, it lowers its attraction for use in reconstituted wood products. A potential constraint with respect to the development of this species as a phase crop is that it seems capable of producing seed at an early age. Such phenological precocity may result in the creation of a soil seed bank that may lead to weed problems in adjacent or subsequent annual crops. Alternatively, the seedlings regeneration may possibly be treated as a form of green manure. The probable absence of root suckering is an attractive feature in the management of this species as a phase crop plant.

The area predicted to be climatically suitable for the cultivation of *A. neriifolia*, based on its natural climatic parameters, is shown in Map 46. This analysis indicates *A. neriifolia* has the potential to be cultivated well south of its natural distribution, extending into the north eastern part of the eastern target area. The prediction suggests favourable growth mainly in 500–650 mm summer and uniform rainfall zones. It is suggested that sites receiving some supplementary water from run-on rainfall should be targeted. *Acacia neriifolia* grows naturally on the drier western plains of New South Wales to the immediate north of the target area where, according to Maiden (1920), it attains arborescent stature. This species is not suited for cultivation on heavy clay soils or in waterlogged conditions. Climatic conditions in Western Australia are predicted to be unsuited for the cultivation of *A. neriifolia* as none of its natural populations occur in the winter rainfall zone.

Acacia parramattensis Tindale



Map 47. Distribution of *A. parramattensis.*

Common Names

Parramatta Wattle, Sydney Green Wattle, Parramatta Green Wattle.

Habit

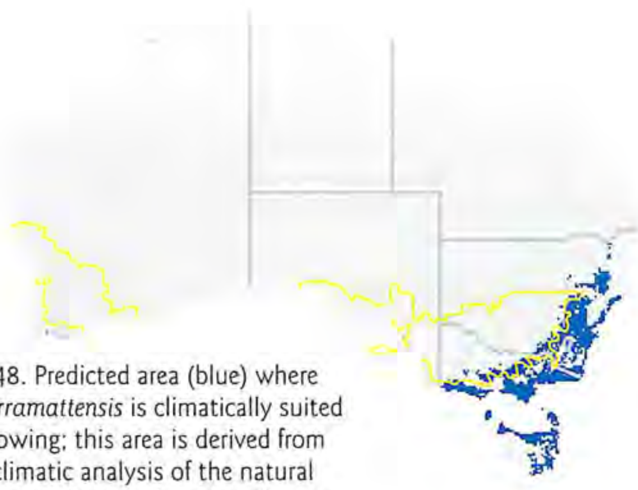
Erect shrubs or trees 2–7(–15) m tall, with a single-trunk commonly branching into 2–3 main stems at 0.3–0.5 m about the ground, trunks undivided (except for the lateral branches) for 1 m or more when plants growing close together, sometimes with 2 main trunks from ground level, the trunks straight, erect and to about 35 cm dbh, young plants have a conifer-type habit. Bark thin, smooth but becoming longitudinally fissured on old plants, black, brown or green.

Botanical descriptions and illustrations/photographs are provided in Burbidge & Gray (1970), Costermans (1981), Fairley & Moore (1989), Tame (1992), Tindale & Kodela (2001 & 2001a) and Kodela (2002); see also detailed description in Tindale (1962).

Taxonomy

This species belongs to *Acacia* section *Botrycephalae*, a group of 44 mostly arborescent species characterized by having bipinnate adult foliage and flower heads normally arranged in elongated racemes (Orchard & Wilson 2001). These species predominate in temperate areas of eastern and southeastern Australia (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). There are seven species of *Botrycephalae* detailed in this report, namely, *A. baileyana, A. dealbata* subsp. *dealbata, A. decurrens, A. filicifolia, A. leucoclada* subsp. *leucoclada, A. mearnsii* and *A. parramattensis*. A number of recent studies have suggested that species of section *Botrycephalae* are most closely related to certain racemose species of section *Phyllodineae* (foliage phyllodinous) from eastern Australia, see Maslin & Stirton (1998) and Maslin *et al.* (2003) for reviews. Of the phyllodinous species included in this report those having presumed closest affinities to species of *Botrycephalae* include *A. linearifolia, A. neriifolia* and *A. pycnantha*; members of the '*Acacia microbotrya* group' are not far removed from these species.

Acacia parramattensis is most closely allied to *A. mearnsii* but is distinguished by its velvety-pubescent branchlets (glabrous or sparsely appressed-hairy in *A. parramattensis*) and leaflets which are densely hairy on the lower surface (glabrous in *A. parramattensis*) (Tindale & Kodela 2001; see Tindale 1962 for further details). *Acacia parramattensis* is probably often mistakenly grown as *A. decurrens* according to Tame (1992).



Map 48. Predicted area (blue) where *A. parramattensis* is climatically suited for growing; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 47), see also Table 5. Target area shown in yellow.

A study by Tindale and Roux (1969) of flavonoid and condensed-tannin contents of the heartwood and bark of *Acacia* recognized

Figure 23. *Acacia parramattensis*

A – Adolescent plant (note straight erect main stem). (Photo: B.R. Maslin)

B – Stem base. (Photo: B.R. Maslin)

C – Portion of bipinnate leaf. (Photo: J. Plaza)

D – Stem core. (Photo: P. Macdonell)

E – 8 year old plant in trial at Uriarra, Australian Capital Territory. (Photo: S. Searle) four groups within section *Botrycephalae*; this study placed *A. parramattensis* in a group *containing A. constablei, A. decurrens, A. irrorata* subsp. *velutinella, A. mearnsii* and *A. trachyphloia*.

Distribution and habitat

Occurs in New South Wales where it is found chiefly from Yengo south to Tumut and west to Grenfell; it is common in around Sydney and Canberra and is possibly naturalized in Tasmania and areas of New South Wales (Tindale & Kodela 2001).). The main area of occurrence of this species is to the east of the target area but it reaches the temperate periphery of the region in New South Wales where it is not common. Grows in open forest or woodland, chiefly on sandy loams or clays derived from shale (Tindale & Kodela 2001). It often grows on heavier soils according to Tame (1992).

Flowering and fruiting

The main flowering period is from late November to early February, although in rare cases it may continue until April; it takes 12 months for the seeds to ripen and mature pods are present between November and February (Tindale 1962).

Biological features

Limited information is available for this species. Tame (1992) reports it to be short lived but fast growing (however, see below under **Yield** for note on growth rate). Field observations could not confirm that the species is likely to sucker or coppice. Searle *et al.* (1998) however reported root suckering in 32 month old plants under trial near Canberra, while, Barbour (2000) found no evidence of root suckers or coppicing in 62 month old plants under trial in Western Australia. *Acacia parramattensis* was ranked as one of the most frost tolerant species In two trials near Canberra (Searle 1998). An analysis of its gum characteristics is given in Anderson *et al.* (1971).

Genetics

Chromosome number: $n = 13$ (B. Briggs in Tindale 1962)

A hybrid with *A. mearnsii* is known according to CAB International (2000). The species is suspected of hybridizing with *A. dealbata* (Maslin, unpublished information) and specimen label information at the NSW Herbarium suggests that *A. parramattensis* hybridises with *A. baileyana*.

Toxicity

An unidentified cyanogenic glycoside has been reported to occur in the leaves of this species by Secor *et al.* (1976) but it apparently does not occur in all plants of this taxon (Conn *et al.* 1985). As noted by Maslin *et al.* (1987) the glycoside occurs at very low concentrations and the endogenous enzyme necessary to hydrolyse this into toxic HCN is absent. The species is therefore not considered a risk to stock from cyanogenic poisoning.

Cultivation

Although *A. parramattensis* is often grown for ornamental purposes in Australia there is little information available concerning its propagation. Searle *et al.* (1998) document succesful silvicultural protocols for the species based on two trials near Canberra.

Yield

Three provenances of *A. parramattensis* were represented at two sites in fuelwood trials near Canberra, A.C.T. (CSIRO 2001). The sites at Kowen and Uriarra had a mean annual rainfall of 630 mm and 824 mm respectively. Based on assessments at 2.6 and 5.2 years of age, variation among provenances for survival and growth was not great. Interestingly, the performance of all three provenances was similar at both sites despite differences in rainfall between sites. In these trials the early growth of

A. *parramattensis* was better than later growth. For example, at age 2.6 years plants from all three provenances had a mean height range of 3.8–4.0 m and a dbh range of 4–4.3 cm; while at age 5.2 years the mean height range was 4.8–5.5 m and the dbh range 5.5–6.1 cm. At trials involving 12 bipinnate acacias in Western Australia Barbour (2000) the performance of A. *parramattensis* was not particularly notable. On a volume per hectare yield basis this species was amongst the worst performers. Mean stem volumes for these provenances of A. *parramattensis* were less than half for those obtained for A. *mearnsii* in trials involving 16 acacias at two sites in Victoria (Bird *et al.* 1998). These data suggest limited prospects for short rotation cropping for biomass from A. *parramattensis*.

Pests and diseases

African black beetle can cause severe damage in cultivation trials in Western Australia (Barbour 1995).

Weed potential

Not widely reported as being a problem weed, however, it is possibly naturalized in Tasmania and areas of New South Wales according to Tindale & Kodela (2001). This species spreads by seeds which occur in great abundance.

Wood

Basic density 606 kg/m^3 (Clark *et al.* 1994).

Utilisation

Wood

Acacia parramattensis was one of several temperate species reported by Clark *et al.* (1994) as having kraft pulp yields within the range of commercial pulpwoods. The species pulped to relatively high yields (50–56%) and its pulps bleached readily to high brightness, but not within the range required for some high grade papers.

Potential for crop development

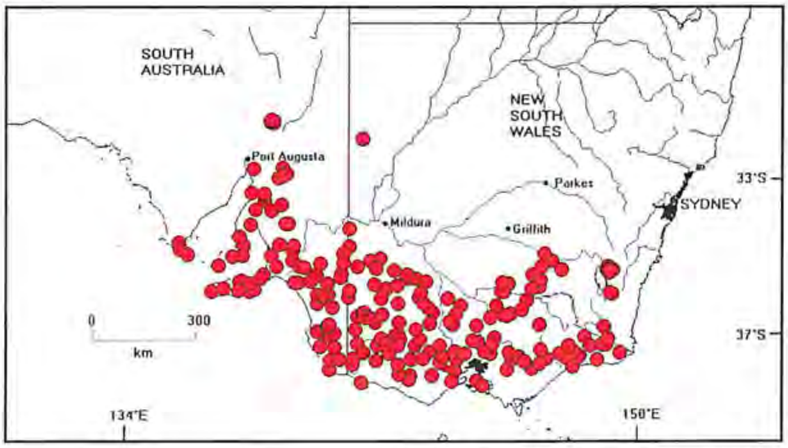
Because of a paucity of information it is difficult to accurately assess the wood crop potential of this species. Based on available evidence it is provisionally ranked as a category 3 species and its growth characteristics show that it would be most suited to development as a phase crop (Table 6). However, it remains to be seen whether or not this species is capable of achieving acceptable growth rates and biomass production within the target area. Despite A. *parramattensis* having some desirable growth characteristics the species is rare in the target area and is likely to have only limited application (see below). We suspect that it would be out-performed by other members of section *Botrycephalae* such as A. *decurrens* and A. *mearnsii*. It develops a good growth form that would be amenable to mechanical harvesting. It also produces reasonable quantities of pale coloured, low density wood (basic density 606 kg/m^3) within the range considered desirable for reconstituted wood products. It is to be expected that this species, like other members of section Botrycephalae, will produce large quantities of seed from an early age. If this is the case then it could possibly constrain its development as a phase crop because such phenological precocity would result in the creation of a soil seed bank that could lead to weed problems in adjacent or subsequent annual crops. Alternatively this seedling regeneration could possibly be treated as a form of green manure. The absence of root suckering is an attractive feature in the management of this species as a phase crop plant.

The area predicted to be climatically suitable for the cultivation of A. *parramattensis*, based on its natural climatic parameters, is shown in Map 48. This analysis indicates that A. *parramattensis* has the potential to be cultivated well to the south and south east of its natural distribution. However, within the eastern target area suitable climatic conditions are predicted to be relatively limited. Based on the bioclimatic prediction A. *parramattensis* is not suited for cultivation in the western target area. This is probably due the long dry season experienced in that region of Western Australia compared its area of natural occurrence. We tentatively suggest cultivation on valley soils of the 550–650 mm rainfall zone of the eastern target area. Areas subject to heavy frosts should be targeted. Based on limited trial results, provenance variation may not be great for this species. Relatively rapid early growth suggests that if site selection is favourable short rotations could be achieved for this species but this remains to be verified. Although natural populations of A. *parramattensis* in the west of its range are characterised by rather spindly trees of low stature, they usually have straight stems and fine lateral branching. This attribute suggests that the potential for controlled hybrid combinations of A. *parramattensis* with related targeted species could warrant investigation.

Acacia pycnantha Benth.

Common Names

Golden Wattle and more (see Cunningham *et al.* 1981). *Acacia pycnantha* is the official floral emblem of Australia (for details see Boden 1985, Hitchcock 1991 and Whibley & Symon 1992).



Map 49. Distribution of *A. pycnantha*.

Habit

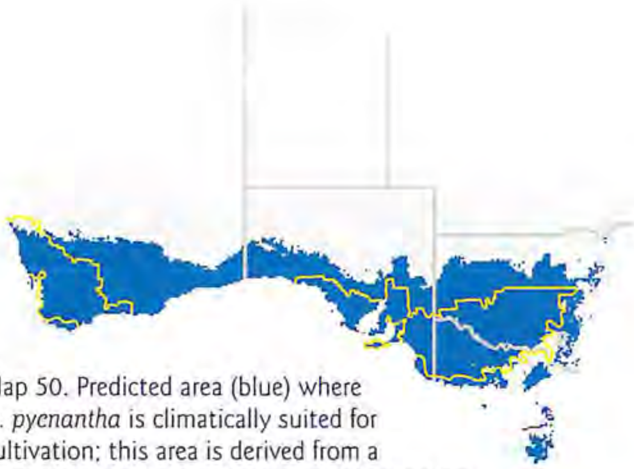
Shrubs 4–5 m high branching near ground level into 2–3 (–6) main stems, or single-stemmed trees to 8–10 m high, smaller (0.5–1 m tall) and/or spindly in some areas, largest plants occur in wetter areas of the range, the main stems are typically straight to sub-straight with few lateral branches and measure about 10–25 cm dbh; crowns terminal; strong, shallow lateral roots are developed, at least on skeletal soils. Bark smooth but aging finely to longitudinally fissured on main stems, especially towards their base, dark brown except pruinose on some forms.

Botanical descriptions and illustrations/photographs are provided by Maiden (1908a), Costermans (1981), Cunningham *et al.* (1981), Tame (1992), Whibley & Symon (1992), Maslin *et al.* (1998), Maslin (2001 & 2001a) and Kodela (2002).

Taxonomy

As discussed by Maslin (2001) *A. pycnantha* is a somewhat variable species. It is normally a tall shrub or tree, but small, spindly forms which flower when 0.5–1 m high sometimes occur (e.g. some plants in the Bendigo 'Whipstick' forest, Victoria). Plants with pruinose stems and branches are scattered throughout the range (e.g. the most northerly populations in South Australia). Costermans (1981) records two forms from Victoria, namely, plants from open forests with dark green shiny phyllodes and golden flower-heads, and plants from mallee areas with paler, dull, narrower phyllodes and paler coloured flower-heads. A pendulous variant and a pale-headed variant are known in cultivation (Elliot & Jones 1982).

Acacia pycnantha is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Species of section *Phyllodineae* are widespread in Australia with the main centres of richness located in temperate and adjacent semiarid areas of eastern, southeastern and southwestern Australia; species number greatly decline in the arid zone and in northern tropical/subtropical areas (Hnatiuk & Maslin 1988 and Maslin & Pedley 1988).



Map 50. Predicted area (blue) where *A. pycnantha* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 49). see also Table 5. Target area shown in yellow

Figure 24. *Acacia pycnantha*

A – Mature tree. (Photo: B.R. Maslin)

B – Adolescent tree (stems rather slender). (Photo: B.R. Maslin)

C – Mature plant (pruinose variant). (Photo: B.R. Maslin)

D – 4 year old plant in on-farm revegetation trial near Wagga Wagga. (insert 3 year old stem). (Photo: B.R. Maslin)

E – Section of stem (typical variant). (Photo: B.R. Maslin)

F – Section of stem (pruinose variant). (Photo: B.R. Maslin)

G –Branch showing golden heads in racemes. (Photo: B.R. Maslin)

Acacia pycnantha is not far removed taxonomically from a number of others detailed in this report, namely, *A. hakeoides*, *A. linearifolia* and *A. neriifolia*; members of the '*Acacia microbotrya* group' are related to these taxa. This species has its closest affinities with *A. hakeoides*, *A. williamsonii* (with which it hybridizes, see under **Genetics** below), *A. hamiltoniana* and *A. obtusata* (none of these species, except *A. hakeoides*, is detailed in this report). It has been reported as also hybridising with *A. podalyriifolia* in cultivation in Europe; these putative hybrids were described under the names *A. siebertiana* and *A. deneufvillei* (Maslin 2001). *Acacia pycnantha* is sometimes confused with *A. saligna* (see species profile below) but the two are not closely related; *A. saligna* is readily distinguished by the relatively large gland at the base of the phyllode. It is also sometimes confused with *A. obliquinervia* and *A. leiophylla*, and has affinities with *A. pedina* (none of these species are detailed in this report).

Distribution and habitat

Widespread in Victoria, extending west to the Flinders Range, Yorke Peninsula, southern Eyre Peninsula and Kangaroo Island in South Australia, with isolated occurrences in southern New South Wales, the Broken Hill area and near Canberra in the Australian Capital Territory. It is often of scattered occurrence in the drier inland parts of its range but is commonly locally abundant in wetter areas. This species is common in parts of the eastern target area but its distribution extends beyond the boundary of the region. *Acacia pycnantha* has become naturalized in wetter parts of Victoria and Tasmania, and in various places in New South Wales and south-west Western Australia; it is also regarded as a weed in parts of South Africa (see under **Weed potential** below). Grows on a wide variety of soils including calcareous sands, deep podsolic sands, red earths, clays and skeletal, stony loams in *Eucalyptus* forest or woodland, open scrub and heath. Whibley & Symon (1992) provide a detailed description of ecological preference for South Australian populations.

Flowering and fruiting

Flowers from late July to October/November. Floral development is described by Buttrose *et al.* (1981). Pods mature between November and January. Plants typically set seeds annually with very heavy crops being produced every couple of years; on average there are 33 000 viable seeds per kg (Maslin *et al.* 1998). The mature pods can be rapidly harvested manually and the seeds readily detach from the pods.

Biological features

Acacia pycnantha is reported to have a moderately fast growth rate, attaining about 0.5–1.5 m per year according to Maslin *et al.* (1998). At Mt Remarkable in South Australia (mean annual rainfall about 330 mm) we observed about 10 year old plants attaining 4–6 m in height with stems 6–13 cm dbh; these plants grew on skeletal soil with *Eucalyptus cladocalyx*. For additional growth information see below under **Performance and yield.** This species typically lives for 15–30 years according to Maslin *et al.* (1998). It does not sucker but older specimens do coppice, albeit poorly so (Maslin *et al.* 1998). It may form dense thickets (regeneration from seed), especially in disturbed sites such as roadverges and following fire; in these cases the plants often have spindly, erect stems. *Acacia pycnantha* is reputed to be drought-hardy (attested by the fact that plants grow well around Broken Hill without additional watering, fide Hall *et al.* 1972). The plants are somewhat frost-tender when young but according to Stelling (1998) mature plants are reasonably frost tolerant. The species flowers precociously (i.e. within 2–3 years of planting). Aspects of its pollination biology (and plant/animal interaction, especially in relation to nectar secretion by phyllode glands) is summarised by Whibley & Symon (1992) and discussed by Bonney (1994).

Genetics

Putative natural hybrids between *A. pycnantha* and *A. williamsonii* occur in the Bendigo 'Whipstick', Victoria and these plants superficially resemble *A. hakeoides*; other putative hybrids, of cultivated origin (in Europe), involving *A. pycnantha* and *A. podalyriifolia* are *A. x deneufuillei* and *A. x siebertiana* (Maslin 2001).

Toxicity

Although the seeds contain protease inhibitors (Kortt 1985), such compounds are common and can be deactivated by heat treatment or cooking (Liener 1980, Harwood 1994).

Cultivation

Acacia pycnantha has been well known in cultivation as a ornamental for many years. It will grow in a variety of soils and (according to Anderson 1968) prefers a reasonably hot, low humidity climate with a moderate rainfall. Small plantings of *A. pycnantha* have been established for agronomic assessment of species currently in demand by processors of *Acacia* seed for the Australian native bushfood industry (Graham & Hart 1997). According to G.S. Perrin (in Maiden 1908a) *A. pycnantha* is more amenable to cultivation than *A. decurrens* in that it can be pruned to a better shape (prune central growth when young to encourage bushiness, Stelling 1998), occupies less space in plantations and its bark is much better to strip.

Establishment

Acacia pycnantha is readily propagated from seed which requires a boiling or hot water treatment to break dormancy. Harding (1940) examined the effects of various boiling/soaking pre-treatment methods and reported that boiling for 5 seconds was more effective than for 2 minutes and both were better than no treatment. The species has also been established by direct sowing on prepared soil (Hall *et al.* 1972).

Performance and yield

Performance under cultivation may be erratic, with individual plants dying for no apparent reason (Maslin *et al.* 1998). Plants are somewhat frost-tender when young and Maiden (1908a) suggested that by growing them in situations with a westerly aspect, so that the sun will not shine on them too early after a severe frost, would facilitate the cultivation of this species in rather cold districts.

Plants should be spaced widely, e.g. 8–10 m, for maximum flowering and seed production (Maslin *et al.* 1998).

We inspected a plantation of *A. pycnantha* near Wagga Wagga during this project. The site was located within the 450 mm rainfall zone and experienced occasional frosts; the land was ripped and controlled for weeds prior to planting. In one plot (which was direct seeded, using local provenances) four year old plants had attained 3 m in height and developed straight, robust main stems about 7 cm dbh. A second plot (a wetter site, seedlings planted) showed similarly robust plants that had attained 4 m in height with stems 7 cm dbh in just three years.

Maiden (1908a) reported on plants cultivated (on sand over clay) in New Zealand. At one site 4 year old plants reached about 2 m in height with stems 5 cm dbh, and at another 6 year old plants reached about 3 m with stems about 9 cm dbh (by comparison, 6 year old plants of *A. decurrens* in this same area attained about 6 m in height with stems 12 cm dbh). Maiden did not provide climate information for the site so it is not possible to determine how factors such as water availability, temperature or frost may have affected growth performance.

Pests and diseases

As noted by Maslin *et al.* (1998) *A. pycnantha* plants may be variously affected by a wide range of insect pests and diseases. These include the rust fungi *Uromyces phyllodorium*, *U. simplex* and *U. tepperianum* (Gibson 1975). It is also susceptible to Trichilogaster wasps which produce galls in the heads (thus reducing or completely eliminating seed set); the degree of gall wasp infection varies from year to year and might be dependent upon seasonal conditions (Martin O'Leary, pers. comm.).

Weed potential

The species is an environmental weed in South Africa (Ross 1975 and Stirton 1980) and has become locally established in southern Europe (Whibley & Symon 1992). As discussed in Henderson (2001) *A. pycnantha* is a Declared Weed species in South Africa where attempts at control have included both the use of herbicides and biocontrol agents. Initial results from using bud-galling wasps (*Trichilogaster* species) indicate that they have considerable potential as a biocontrol agent of *A. pycnantha* by reducing seed set (see Olckers & Hill 1999 for review).

Within Australia *A. pycnantha* is naturalized in southwest Western Australia (where it is regarded as an environmental weed) and eastern Tasmania (Maslin 2001: see map on p. 615), and also in places in New South Wales (Kodela 2002). This species spreads by seed which is produced in profusion and which may remain viable in the soil for many decades.

Wood

Based on our limited field sampling the wood of this species appears to have moderately heavy wood with a well-developed heartwood. When cut a clear gum is exuded at interface of sapwood and heartwood. The wood sample collected split upon drying. According to Maslin *et al.* (1998) the wood is non-durable in ground contact.

Utilisation

Wood

Wood makes an excellent fuel (Maslin *et al.* 1998), it burns well and produces a hot fire (Stelling 1998).

Land use and environmental

In Victoria *A. pycnantha* is often included in shelterbelt plantings, with *Eucalyptus cladocalyx* (Maslin *et al.* 1998) and in western New South Wales it is planted as windbreaks (Cunningham *et al.* 1981). Langkamp & Plaisted (1987) report that the species has been used for mine-site rehabilitation at Broken Hill in western New South Wales. It is useful for soil stabilisation on account of its fibrous roots (Stelling 1998). A good source of food for wildlife (Stelling 1998).

Fodder

No reported usage.

Tannin

Formerly highly prized for its tannin-rich bark which, according to Maiden (1889), contains 25–40% tannin (but higher returns have been obtained according to Hall *et al.* 1972); the tannin quality may be superior to that of *A. mearnsii* (see Searle 1991 for review).

Human food

Acacia pycnantha is regarded by Maslin *et al.* (1998) as a promising species for the production of seed for human consumption. The seeds are reported to have been consumed by Aborigines in the south-east corner of South Australia (Campbell *et al.* 1946) and are apparently quite palatable (W. Bates in Maslin *et al.* 1998). Gum was also a food source for traditional aborigines (Cleland 1966); an analysis of gum characteristics is given in Anderson & Bell (1976).

Other uses

Widely planted as an ornamental, especially on account of its profusion of strongly perfumed, golden flower-heads. The phyllodes of *A. pycnantha* have been used to dye will a golden colour using an alum mordant (Martin 1974).

Potential for crop development

Acacia pycnantha is regarded as having prospects as a crop plant for high volume wood production. It is ranked as a categroy 2 species and would be suited for development as a phase crop (Table 6). This is a hardy, resilient species that neither root suckers nor coppices (or has only weak coppicing ability). It is capable of reasonably fast growth rates and producing good quantities of woody biomass (see Wagga Wagga trials noted above), but the wood is likely to be moderately dense (perhaps similar to *A. microbotrya* which averages about 830 kg/m^3) and if so it reduces its attraction for use in reconstituted wood products. The species is also capable of developing a good growth form but it is somewhat variable in this respect with plants from wetter areas generally attaining a more arborescent stature than those from drier inland sites (which may be shrubby or spindly, although on better watered sites in good soil some may develop into sizeable trees). The selection of appropriate provenances for trial purposes will therefore be important in its development as a crop plant. Apart from what has already been noted above other desirable attributes of this species are its reputed drought-hardiness, its adaptability to a variety of soil types, and its ability to establish very well when direct seeded. Potential secondary benefits that might be derived include tannin production and seed for human consumption. Hall *et al.* (1972) suggest that on better sites there may be economic potential for growing plantations of *A. pycnantha* on a 7–10 year rotation for tannin. Because *A. pycnantha* has the ability to flower (and presumably produce pod crops) at a young age it could result in the creation of a soil seed bank which may lead to the species becoming a weed during the subsequent annual crop phase (on the other hand seedling regeneration may possibly be treated as a form of green manure).

The area predicted to be climatically suitable for the cultivation of *A. pycnantha*, based on its natural climatic parameters, is shown in Map 50. This analysis indicates *A. pycnantha* is potentially suited for cultivation throughout both the eastern and western target areas. This climatic match to the target areas is one of the most comprehensive of all 35 species treated in this report. This species also appears suited to a wide range of sites but cultivation on heavy clay soils and waterlogged conditions is not recommended. The successful cultivation of *A. pycnantha* (the form originally described as *A. westonii* by Maiden 1921, which occurs naturally on Mt. Jerrabomberra) at the Australian National Botanic Gardens in Canberra suggests it has moderate to high levels of frost and cold tolerance (although young plants are reported to be frost tender).

A potential issue in any development of *A. pycnantha* as a crop is its demonstrable weediness. This species spreads by seeds which are produced in great abundance annually. Already it is proving to be an environmental weed in the vicinity of Narrogin, Western Australia, and it might be expected to pose similar problems in other semi-arid parts of the target zone, at least outside its natural geographic range. Therefore, caution must be exercised in any wide-scale use of *A. pycnantha*, and such use must be accompanied by a thorough weed risk assessment. The potential weed risk associated with this species may constrain its use to its native geographic range (see also discussion on other possible weed reduction strategies under **Weed potential of *Acacia* in target area** in the introduction to this report).

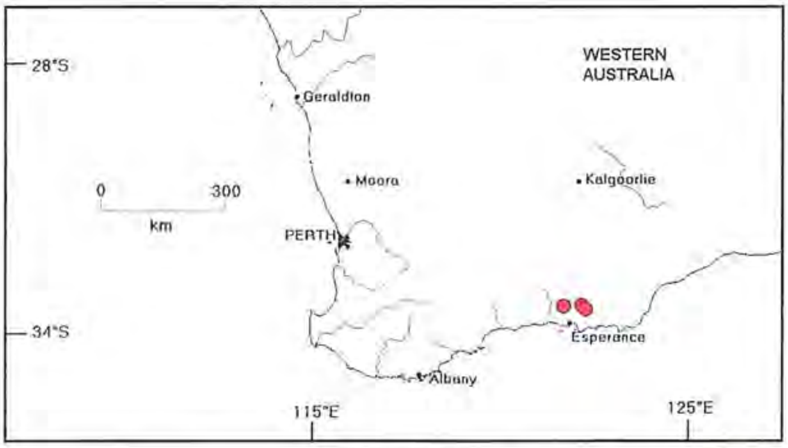
Acacia affin. *redolens*

Common Name

None known.

Habit

Small trees 4–7 m high, may reach 10 m in good sites; dividing at 0.5–1.8 m above ground level into 2–3 main stems (9–20 cm dbh); stems and main branches sub-straight; crown bushy.



Map 51. Distribution of *A.* affin. *redolens*.

Taxonomy

Acacia affin. *redolens* is referable to *Acacia* section *Plurinerves* a diverse, and probably artificial, group of about 212 species (Maslin 2001) which are characterized by having plurinerved phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Species of section *Plurinerves* are widespread in Australia with the main centres of richness located in the inland areas of the southwest and southeast of the continent (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). Five species of section *Plurinerves* are detailed in this report, namely, *A. cyclops*, *A. implexa*, *A. melanoxylon*, *A. stenophylla* and *A.* affin. *redolens*.

Taxonomic work is needed to properly ascertain the status of this seemingly new taxon. Until now it has been confused with its normally prostrate, presumed close relative, *A. redolens* (which is not included in this report) but has a very different growth form and does not have vanilla-scented foliage. In habit it resembles some forms of *A. cyclops* (with which it is sometimes sympatric) but it is unlikely that the two species are especially closely related.

Distribution and habitat

An uncommon taxon confined to the south coast of Western Australia. Plants definitely referable to this taxon occur in a few scattered localities from near Scaddan eastwards for about 40 km (to near Mt Burdett); however, it could possibly extend west to the Fitzgerald River but further study is needed to check this. *Acacia* affin. *redolens* is confined to the target area and is not very common in the places where it occurs. It grows in waterlogged clay-loam over clay or in grey sand over clay adjacent to waterlogged depressions and it may be able to tolerate at least low to moderate salinity.

Map 52. Predicted area (blue) where *A.* affin. *redolens* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 51), see also Table 5. Target area shown in yellow.

Flowering and fruiting

Flowers in June to July. Mature pods occur in December.

Biological features

Probably lives for more than 20 years. Growth rate unknown. No evidence of suckering. Coppicing/pollarding

Figure 25. *Acacia* affin. *redolens*

A – Mature plant showing spreading crown. (Photo: B.R. Maslin)

B – Branch showing mealy white flower buds. (Photo: B.R. Maslin)

C – 1 year old plant in trials at Katanning, W.A. (Photo: J. Carslake)

D – Stem of relatively young plant showing small development of heartwood. (Photo: B.R. Maslin) unknown (probably unlikely). Produces a reasonable quantity of fruit but the pods can be difficult to collect when plants are tall.

Cultivation

Trials

Assessment trials of this species were recently established in plots on farmland at various locations in south-western Australia by the "Search" project (see Acknowledgements). At age 10 months plants of the best performing provenance of A. affin. *redolens* showed an average survival of 79% and an average height of 94 cm. The 'best' plot was located on a downslope site with heavy soil in the Avon Wheatbelt IBRA region, with plants averaging 145 cm high. At this early age A. affin. *redolens* was demonstrating similar grow performance to A. *cyclops* which was also included in the 'Search' trials. *Acacia* affin. *redolens* was one of the few acacias in these trials that is apparently resistant to locust attack (J. Carslake, pers. comm.).

Weed potential

No records of weediness for this species and it is unlikely to cause problems in this regard.

Wood

Wood relatively hard; old plants develop a considerable amount of dark brown, attractively marked heartwood (heartwood less on younger plants). Basic density values range from 732 kg/m^3 to 835 kg/m^3 (mean 782 kg/m^3) based on analyses of 6 wood samples by CALM's NHT-supported 'Search' project (unpublished data). Note: This study preferentially sampled young and adolescent plants.

Utilisation

No recorded uses.

Potential for crop development

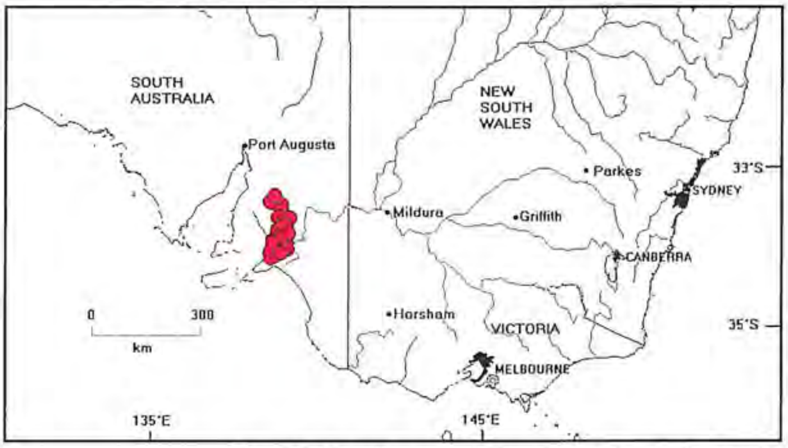
This poorly known species is not regarded as particularly prospective as a crop plant for high volume wood production. It is ranked as a category 4 species and would seem best suited as a phase crop (Table 6). *Acacia* affin. *redolens* is included here because it has a reasonably good growth form and produces reasonable amounts of woody biomass (although it is not known if it is capable of quickly producing acceptably high volumes of wood; furthermore, the wood is fairly dense which lowers its attraction for use in reconstituted wood products). Its tolerance of water-logged clays soils (which is an uncommon habitat for *Acacia*) could also be a useful attribute. This is one of the relatively few arborescent Acacias that occurs in the target area along the south coast of Western Australia. Because A. affin. *redolens* is taxonomically distinct from other species detailed in this report it may possess unique, desirable attributes; it is therefore worth undertaking further study to assess these possibilities. *Acacia* affin. *redolens* is likely to have similar performance characteristics to A. *cyclops* but unlike that species is seemingly neither susceptible to locust attack nor aggressively weedy.

The area predicted to be climatically suitable for the cultivation of A. affin. *redolens*, based on its natural climatic parameters, is shown in Map 52. Climatic conditions predicted to be suitable for A. affin. *redolens* are relatively narrow. They comprise a relatively narrow band of terrain extending throughout the eastern and western target areas. This is due to the narrow range of climatic parameters experienced in the restricted natural geographic range of this taxon. Its potential to be more widely cultivated will be dependent on its ability to grow in rainfall areas that experience less than 400 mm mean annual rainfall and its ability to grow in uniform and summer rainfall zones. Its preference for waterlogged clay soils suggests that it has good prospects for cultivation in discharge areas throughout the target area.

Acacia retinodes Schldtl. ('typical' variant)

Common Name

Wirilda.



Map 53. Distribution of *A. retinodes* 'typical variant'.

Special note

The taxonomy of *A. retinodes* is currently under review (see **Taxonomy** below). It is likely that most of the previously published literature concerning *A. retinodes* refers to the 'swamp' variant of the species. Therefore, unless otherwise noted, the information presented here for the 'typical' variant is derived from our field observations of plants and from unpublished information generously provided by Martin O'Leary (Adelaide Herbarium).

Habit

Typically single-trunk (infrequently with 2–3 trunks from ground level), shapely trees 5–6 m tall but can attain 8–10 m in places, the bole is usually straight, 1–2 m long and attains about 30 cm dbh, main branches erect, straight to sub-straight and to about 15–20 cm diam, suckers but not vigourously so; crowns dense. Bark furrowed, rough (surface variably friable), persistent and black-brown.

A botanical description and illustration is provided by Maslin (2001a); it is photographed in Whibley & Symon (1992: 143, 145: the line drawings in this account are not of the 'typical' variant) and Maslin *et al.* (1998: the habit photograph on p. 43).

Taxonomy

The Flora of Australia treatment of *A. retinodes* by Maslin (2001) was modified in Maslin (2001a) to accommodate the two variants ('typical' and 'swamp') that are now recognized within var. *retinodes*. This report uses the most recent taxonomy of the species, which is based on as-yet unpublished research by M. O'Leary (Adelaide Herbarium), except that a fourth form, the 'Normanville' variant, is also recognised here.

Specimens referable to *A. retinodes* can be accommodated within the above three variants and *A. retinodes* var. *uncifolia*. Each of these four taxa is detailed separately in this report and a key to their recognition is given below. For the most part the taxa are allopatric, however, in a few places in South Australia their ranges abut, for example, at Normanville (where var. *retinodes* 'typical' and the 'Normanville' variant occur close together) and on Kangaroo Island (where var. *retinodes* 'swamp' and var. *uncifolia* occur, but do not hybridize).

Map 54. Predicted area (blue) where *A. retinodes* 'typical variant' is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 53), see also Table 5. Target area shown in yellow.

Figure 26. *Acacia retinodes* 'typical' variant

A – Mature trees with large quantity of wood biomass. (Photo: B.R. Maslin)

B – Bark dark coloured & rough. (Photo: B.R. Maslin)

C – Slender coppice regrowth. (Photo: B.R. Maslin)

E – Stem core showing pale-coloured wood. (Photo: P. Macdonell)

D – Habit variation at Spring Gully, S.A. (Photos: P. Macdonell).

1 Heads mostly 34–52-flowered, yellow to golden; branchlets often lightly pruinose; phyllodes blue-green to blue-grey, often lightly pruinose, 6–22 cm long .... var. *retinodes* ('swamp' variant)

1: Heads mostly 18–30-flowered, cream to pale yellow; branchlets not pruinose; phyllodes green or grey-green, not pruinose 2

2 Phyllodes 3–6 cm long; pods 5–7 (–8) mm wide; coastal habitats .... var. *uncifolia*

2: Phyllodes 6–16 cm long; pods 8–11 mm wide 3

3 Erect trees with a single, well-defined bole; hillside habitats .... var. *retinodes* ('typical' variant)

3: Spreading, multi-trunk, low branching trees; coastal habitats .... 'Normanville' variant

Acacia retinodes is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, groupof about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). More specifically this species is a South Australian member of the Australia-wide '*Acacia microbotrya* group' (Maslin 1995). A number of other species from this group are detailed in this report, namely, *A. bartleana*, *A. euthycarpa*, *A. microbotrya*, *A. rivalis* and *A. wattsiana*. Species of section *Phyllodineae* are widespread in Australia with the main centres of richness located in temperate and adjacent semiarid areas of eastern, southeastern and southwestern Australia; species number greatly decline in the arid zone and in northern tropical/subtropical areas (Hnatiuk & Maslin 1988 and Maslin & Pedley 1988).

If hybridity can be taken as an indicator of relationship then Wirilda is not far removed taxonomically from *A. argyrophylla* or *A. brachybotrya* (see under **Genetics** below).

Distribution and habitat

Occurs in the Mt Lofty Ranges, South Australia, where it extends from Mount Bryan south through the Barossa Valley, Adelaide Hills to Delamere on the Fleurieu Peninsula. This rather restricted natural distribution lies both within and outside the target area. Wirilda has become naturalized near Mt Gambier in southeast South Australia (see **Weed potential** below). Grows in loams or clay loams and on rocky hillsides or plains.

Flowering and fruiting

Flowers in summer (December to February) and unlike var. *retinodes* 'swamp' it has a single, well-defined flowering period. Pods with mature seeds have been collected from late December to March. The seeds mature more or less simultaneously, unlike the 'swamp' variant where seed tends to ripen throughout the year (but with a major seed drop between December and March).

Biological features

A hardy, frost tolerant species that appears to be long-lived (probably lives for about 30–40 years). It has a moderately fast growth rate but not as rapid as var. *retinodes* 'swamp'; in a domestic garden in the Adelaide hills (where it may have received some watering) it attained 1.5 m in height in 1–2 years. Young sucker regrowth grows rather fast (1–2 m per year). Wirilda has moderate root suckering ability (it suckers best in disturbed roadside sites). Plants are known to coppice, but it is not known how vigorously. From limited field observations plants coppiced when cut near ground level (up to about 0.3 m), but not when cut at about 2 m above the ground.

Genetics

Acacia semiaurea is a species of horticultural origin and possibly represents a hybrid between *A. retinodes* (perhaps the 'typical' variant, Martin O'Leary pers. comm.) and either *A. argyrophylla* or *A. brachybotrya*; there very few specimens of *A. semiaurea* in existence (Maslin 2001a).

Cultivation

There are no known significant plantings of Wirilda (most plantings of *A. retinodes* are of the 'swamp' variant).

Weed potential

There is a small naturalized occurrence of Wirilda near Mt Gambier where original plantings have spread to form small clonal colonies (with the plants rather widely spaced, not close together as often happens in *A. hakeoides*). However, this taxon is not regarded as having any significant weed potential. It suckers most prolifically in disturbed sites such as along disturbed roadverges, however, it is not known to invade adjacent bush or farmlands.

Wood

No data available but would be expected to be similar to *A. bartleana* (see species profile above) on account of the two species being related.

Utilisation

Land use and environmental

According to Elliot & Jones (1982) *A. retinodes* is a useful windbreak species (although it is not know to what variant of the species these authors were referring, however, it would apply to all of them).

Secondary plant products

According to Maiden (1889) the bark of *A. retinodes* is considered a good source of tannin (NB. It is likely that Maiden was referring to the 'swamp' variant of the species in this publication). Plants of Wirilda yield good quantities of gum (see note under 'swamp' variant concerning gum properties).

Fodder

Foliage is grazed by sheep and probably cattle. Indeed, it is possible that over-grazing by stock has led to natural population decline in the Adelaide hills (M. O'Leary, pers. comm.).

Human food

The seeds of *A. retinodes* are considered by Maslin *et al.* (1998) as having potential as a source of human food.

Potential for crop development

Acacia retinodes 'typical' variant is regarded as having good prospects as a crop plant for high volume wood production. It is ranked as category 1–2 and would seem best suited for development as a phase crop, but it may also have some prospects as a long cycle crop for specialty wood products (Table 6). Although *A. retinodes* 'typical' does have some coppicing ability, the vigour and frequency of this attribute is unknown and it is therefore not possible to assess its potential as a coppice crop at present. Its moderate suckering propensity would not be expected to pose problems for management under cultivation. However, the species does produce large quantities of seed and it would by appropriate to harvest plants before they reach biological maturity to avoid creating a soil seed bank that may lead to weed problems in adjacent or subsequent annual crops (although the seedling regeneration may possibly be treated as a form of green manure). For this to be a viable strategy it would require that the plants had produced acceptable quantities of wood by then. It is not known at what age flowering and fruiting commences. *Acacia retinodes* 'typical' is similar to *A. bartleana* from Western Australia in displaying a good growth form and producing good quantities of woody biomass. Although its wood characteristics are as yet unknown they can be expected to be similar to those of *A. bartleana* (and if so the wood will be moderately dense which would lower its attraction for use in reconstituted wood products). Indications are that the foliage of A. *retinodes* 'typical' may have some fodder potential (an attractive feature for coppice crops).

The area predicted to be climatically suitable for the cultivation of A. *retinodes* 'typical', based on its natural climatic parameters, is shown in Map 54. Although A. *retinodes* 'typical' has a rather restricted natural distribution in South Australia, the analysis indicates that it is well suited to climatic conditions well beyond this region and has potential for widespread cultivation in the 300–450 mm rainfall zone of the target area. Almost all of the target area in South Australia and Western Australia and a large proportion of the target areas in Victoria and New South Wales are predicted to have climatic conditions suited to the cultivation of A. *retinodes* 'typical'. This is a remarkable prediction given the relatively narrow natural distribution of this species. Within this predicted area, A. *retinodes* 'typical' would probably perform best on loamy fertile soils; heavy clays and waterlogged conditions should be avoided.

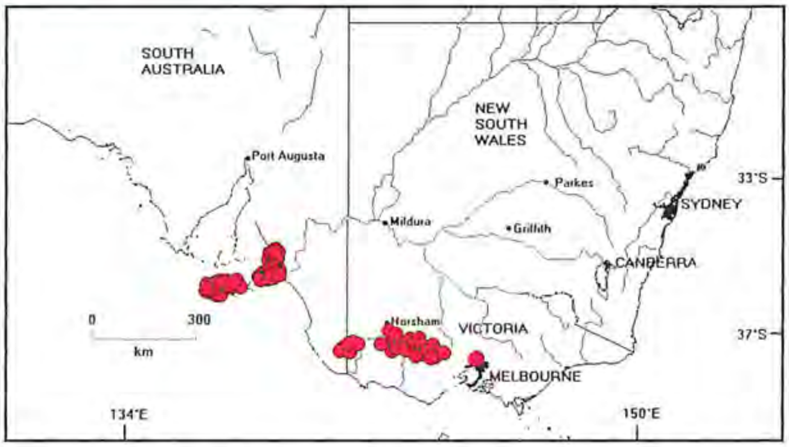
Acacia retinodes Schldtl. ('swamp' variant)

Common Name

Swamp Wattle.

Special note

As discussed under A. *retinodes* 'typical' above there are four entities currently recognized within this species. It is likely that most of the previously published literature concerning A. *retinodes* refers to the entity discussed below as the 'swamp' variant. Therefore, the information presented in this profile is taken from these published accounts, supplemented by our own field observations and from unpublished information generously provided by Martin O'Leary (Adelaide Herbarium).



Map 55. Distribution of *A. retinodes* 'swamp variant'.

Habit

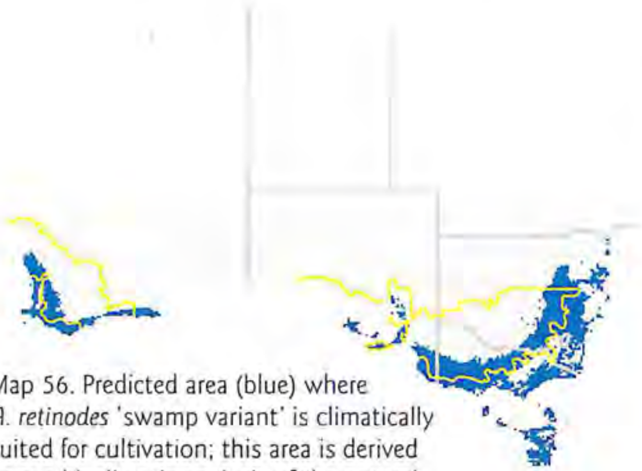
Trees commonly 5–6 m tall but can reach 8–10 m in wettest sites, single-stemmed or sometimes dividing at or near ground level into a few (2–4) main stems, main stems straight and 10–30 cm dbh, habit somewhat spindly on plants from within dense regrowth populations and on some plants from western Kangaroo Island; crowns spreading, openly branched or dense. Bark smooth, thin, persistent.

Botanical descriptions and line drawings are provided in Costermans (1981), Whibley & Symon [1992: the photographs in this account are of the 'typical' variant] and Maslin (2001a); it is photographed in Maslin *et al.* [1998: the flowers/pods on p. 43].

Taxonomy

See note on the taxonomy of this variant under A. *retinodes* ('typical' variant) above.

Swamp Wattle is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). More specifically this species is a member of the Australia-wide '*Acacia microbotrya* group' (Maslin 1995). A number of other species from this group are detailed in this report, namely, A. *bartleana*, A. *euthycarpa*, A. *microbotrya*, A. *rivalis* and A. *wattsiana*. Species of section *Phyllodineae* are widespread in Australia with the main centres of richness located in temperate and adjacent semiarid areas of eastern, southeastern and southwestern Australia; species number greatly decline in the arid zone and in northern tropical/subtropical areas (Hnatiuk & Maslin 1988 and Maslin & Pedley 1988).



Map 56. Predicted area (blue) where *A. retinodes* 'swamp variant' is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 55), see also Table 5. Target area shown in yellow.

Figure 27. *Acacia retinodes* 'swamp' variant

A – Mature plant on edge of dense regrowth (from seed) stand. (Photo: B.R. Maslin)

B – Stem dividing near ground. (Photo: B.R. Maslin)

C – Stem undivided. (Photo: B.R. Maslin)

D – Branch showing pale-coloured heads. (Photo: B.R. Maslin)

E – Section of stem showing lightweight wood. (Photo: B.R. Maslin)

It is possible that either the name *A. semperflorens* or *A. provincialis* (see **Genetics** below) may ultimately be shown as the correct name for Swamp Wattle, however, this matter is yet to be resolved.

Distribution and habitat

Occurs in South Australia from near Mt Crawford through the Fleurieu Peninsula, Kangaroo Island and the far southeast, eastwards to the Grampians, Glenelg River and near Melbourne in Victoria (Maslin 2001a). The main area of occurrence of this species is to the south of the target area but it reaches the southern temperate periphery of the region. This species has been long cultivated abroad (see under **Cultivation** below). In its natural habitat *A. retinodes* 'swamp' variant grows in seasonally waterlogged or perpetually wet soil (acidic sand to clay) in swamps and along watercourses (M. O'Leary, pers. comm.).

Flowering and fruiting

Flowering peak is in spring (September to November), with scattered flowering occurring throughout the year. The seeds of Swamp Wattle are smaller than those of *A. retinodes* ('typical' variant) and unlike that variant they tend to ripen over an extended period of time. There is a major seed drop between late December and February but seeding then continues, with smaller amounts of seed usually produced throughout the year.

Biological features

In suitable environments Swamp Wattle displays a very fast growth rate (probably faster than *A. pycnantha*). For example, plants in cultivation in Adelaide Hills reached 3 m in 2 years and developed trunks 10–15 cm dbh. It is rather short-lived with a life span of around 10–20 years. The plants can be either frost tolerant (at Mylor in the Adelaide Hills) or frost sensitive (on Kangaroo Island), and according to Maslin *et al.* (1998) are slightly saline tolerant. Swamp Wattles does not sucker and its coppicing ability is presumably absent or low (although it is known that if potted plants are cut at about 10 cm above the soil they can develop a few main shoots with one usually dominating as a leader stem over time). Swamp Wattle is fire sensitive, but regenerates well from seed following fire. Unless otherwise stated the above information was supplied by Martin O'Leary (pers. comm.) and complemented by our field observations of the species.

Genetics

Acacia provincialis was described from cultivated material in France and was said by its original authors to represent a hybrid between *A. retinodes* and *A. cyanophylla* (= *A. saligna*); having inspected these original specimens they appear to be simply *A. retinodes*. It is very unlikely that hybrids between *A. retinodes* and *A. saligna* would occur.

Cultivation

This species has been long-used for ornamental purposes. According to Maslin *et al.* (1998) *A. retinodes* has been cultivated successfully in Mediterranean climates abroad (e.g. Rome, Italy) and in tropical highlands (e.g. Dalat, Vietnam); Whibley & Symon (1992) report it being occasionally established in California. It is not known with certainty what variant of the species was involved in these plantings but it is assumed to be Wirilda. According to Graham & Hart (1997) small plantings of *A. retinodes* have been established for agronomic assessment for use in the Australian native bushfood industry. The species is sometimes used for revegetation purposes in southern Australia, especially along roadverges. Despite its usage there appears to be no trial data available for this taxon.

From observations of wild populations it appears that plant spacing affects growth form and the amount of wood produced. Plants growing close together develop erect, relatively unbranched main stems, but if too close they often develop a spindly growth form. More widely spaced plants produce larger volumes of woody biomass.

Weed potential

No records of weediness for this species.

Wood

Based on our limited field examination of this species it produces an exceptionally lightweight wood relative to its volume. Shrinkage upon drying caused large splits in the sample that we collected.

Utilisation

Wood

Land use and environmental

Sometimes used for roadside revegetation purposes. According to Elliot & Jones (1982) *A. retinodes* is a useful windbreak species (although it is not know to what variant of the species these authors were referring, it would apply to all of them).

Secondary plant products

The bark is considered a good source of tannin (Maiden 1889). Plants of this species yield good quantities of gum, but not as much as is found on plants of the 'typical' variant. The gum has good solubility but the resulting solution is of low viscosity and this property, together with its dark colour, makes it unlikely to be of any commercial importance (Anderson *et al.* 1972: these analyses were based on gum from plants cultivated at Montevideo, Uruguay).

Fodder

Foliage is grazed by cattle and sheep (Martin O'Leary, pers. comm.).

Human food

The seeds of *A. retinodes* are considered by Maslin *et al.* (1998) as having potential as a source of human food.

Other uses

Widely cultivated for horticultural purposes; although the flowers are unobtrusive they occur sporadically throughout much of the year, with the main flush in spring. The phyllodes of *A. retinodes* can be used to dye wool a yellow to fawn colour with an alum mordant (Martin 1974).

Potential for crop development

Swamp Wattle is regarded as having reasonably good prospects as a crop plant for high volume wood production. It is ranked as a category 2 species and would be best suited to development as a phase crop (Table 6). In suitable environments Swamp Wattle displays a very fast growth rate, it does not root sucker and its coppicing ability is seemingly absent or only weakly expressed. These are all desirable attributes of a phase crop plant. The species produces reasonable quantities of woody biomass; the wood is pale coloured and is likely to have a low density value (thus attractive for use in reconstituted wood products). The growth form of Swamp Wattle is good and reasonably close-spacing of plants in cultivation could be tolerated but if grown too close the plants are likely to be spindly and wood volumes reduced. Harvesting of plants prior to them reaching biological maturity will prevent the creation of a soil seed bank that may lead to the species becoming a weed in adjacent or subsequent annual crops (although the seedling regeneration may possibly be treated as a form of green manure). For this to be a viable strategy it would require that the plants had produced acceptable quantities of wood prior to attaining reproductive maturity. It is not known at what age flowering and fruiting commences.

The area predicted to be climatically suitable for the cultivation of A. *retinodes* 'swamp variant', based on its natural climatic parameters, is shown in Map 56. This analysis indicates that Swamp Wattle is suited to climatic conditions well beyond its natural distribution. A large proportion of the eastern and western target areas are predicted to have climatic conditions suited to its cultivation despite its relatively restricted natural distribution. Although the analysis indicates that A. *retinodes* 'swamp variant' could be cultivated over a wide area within the 450–650 mm rainfall zone of the target area it may be suitable for only specific sites within this zone. In its native habitat this species grows in wet areas and its apparent high water requirement may well constrain where it can be cultivated. Plants established for revegetation purposes died out on dry sites at Anstey Hill in the Adelaide foothills (annual rainfall approximately 500 mm). Even if suitable soils are located for its establishment it is not known how it will perform as soil profiles dry out under cultivation.

Acacia retinodes Schldtl. ('Normanville' variant)

Common Name

None known.

Habit

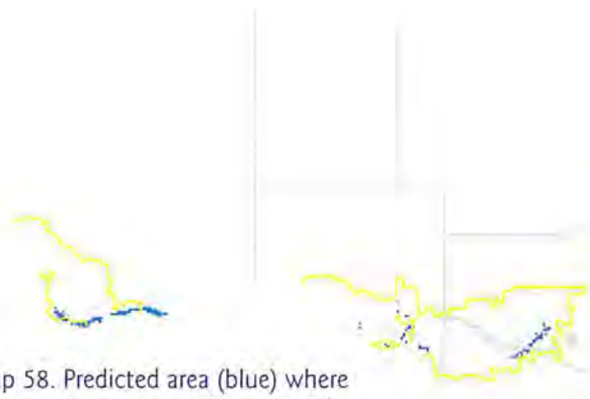
Obconic or rounded trees to 6–10 m tall, single-stemmed or more commonly dividing into 2 to many main stems at (or just above) ground level, main stems sub-straight, moderately branched and to 24–30 cm dbh; crowns spreading. Bark smooth to sub-smooth, thin and tightly held.

Map 57. Distribution of *A. retinodes* 'Normanville variant'.

Taxonomy

See note on the taxonomy of this variant under *A. retinodes* ('typical') above. Maslin (2001a) suggested that the Normanville variant might represent a natural hybrid between *A. retinodes* var. *retinodes* 'typical' variant and *A. retinodes* var. *uncifolia*. This suggestion was based on an assessment of morphological criteria, not on genetic evidence. In the absence of detailed study its taxonomic status remains uncertain.

The Normanville variant of *A. retinodes* is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). More specifically this species is a South Australian member of the Australia-wide '*Acacia microbotrya* group' (Maslin 1995). A number of other species from this group are detailed in this report, namely, *A. bartleana*, *A. euthycarpa*, *A. microbotrya*, *A. rivalis* and *A. wattsiana*. Species of section *Phyllodineae* are widespread in Australia with the main centres of richness located in temperate and adjacent semiarid areas of eastern, southeastern and southwestern Australia; species number greatly decline in the arid zone and in northern tropical/subtropical areas (Hnatiuk & Maslin 1988 and Maslin & Pedley 1988).



Map 58. Predicted area (blue) where *A. retinodes* 'Normanville variant' is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 57), see also Table 5. Target area shown in yellow.

Conservation status

Not currently classified as rare or endangered. However, given its very restricted distribution within a fairly disturbed habitat, it should be assigned a conservation rating.

Distribution and habitat

Restricted to a very small area near Normanville at the southern end of the Fleurieu Peninsula in South Australia. This region lies just outside the target area. It comprises two populations about 2 km apart

Figure 28. *Acacia retinodes* 'Normanville' variant

A – Mature tree with large quantity of wood biomass (insert showing the near-population). (Photos: B.R. Maslin)

B – Stem base (with insert showing gum exudation). (Photo: B.R. Maslin)

C – Branch showing pale-coloured heads in racemes. (Photo: B.R. Maslin)

D – Section of branch (from plant in A). (Photo: B.R. Maslin) and is reasonably common in the areas where it occurs. Grows in sandy loam along a seasonal creek on the leeward side of low coastal dunes and also in remnant banksia scrub at the base of low hills .

Flowering and fruiting

Flowers from mid-June to September. Fruiting period unknown.

Biological features

Growth rate is unknown but judging from the other three taxa included in A. *retinodes* it is likely to be at least moderately fast. This variant does not appear to root sucker. It probably has at least moderate coppicing ability because we observed one plant that had been pollarded at about 0.5 m above the ground which produced 4 main stems (12–14 cm dbh) above the cut. Copious amounts of gum were exuded from the stems of these plants. It is probably relatively long-lived.

Cultivation

Not known in cultivation.

Weed potential

No records of weediness and it is unlikely to cause problems.

Wood

Field observations from a single plant show the wood to be not dense, the sapwood pale brown and the heartwood dark brown.

Utilisation

No recorded uses except that it is employed locally around Normanville in revegetation programs (P. Lang, pers. comm.). This variant could be a candidate species for use in windbreaks.

Potential for crop development

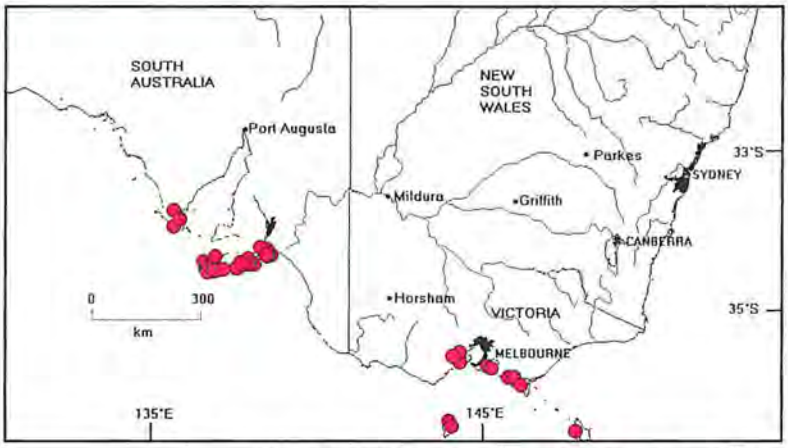
Because of a paucity of information it is difficult to accurately assess the wood crop potential of this variant. It is provisionally ranked as a categroy 2–3 taxon and may have prospects for development as both short and long duration crops (Table 6). The striking feature of this variant is its large woody biomass production. The growth form is reasonable and the wood appears not to be overly dense (it might be similar to, or less than, that of A. *microbotrya* which averages about 832 kg/m^3). The plants have the ability to coppice but whether the vigour is sufficient to sustain them as coppice crops is unknown. Similarly, their growth rate is unknown but is likely to be moderately fast in appropriate environments (under natural conditions it favours light, well-drained sandy soil). The apparent absence of root suckering would be an advantage in the management of this taxon. Perhaps one of the main draw-backs of this variant is its extremely narrow genetic base. Genetic improvement through hybridization with the other variants of A. *retinodes*, or with some other members of the '*Acacia microbotrya* group', might be a possible but would be expensive. Because of its potential for the production of relatively large quantities of woody biomass, research is needed to assess the taxonomic status of this entity and to determine whether or not it is of hybrid origin.

This variant has a highly localised natural distribution and the bioclimatic analysis (see Map 58) indicates that it is climatically suited to very small and discontinuous parts of the target area. These are in South Australia (near its native habitat), Western Australia (southern coastal regions) and New South Wales (west of Albury north to approximately the West Wyalong region). However, we expect that this variant would be capable of being cultivated over a wider area, perhaps similar to that of *A. retinodes* 'typical' variant. The Normanville variant is most likely to do best on well-drained sandy soils.

Acacia retinodes var. *uncifolia* J.M. Black

Common Name

None known.



Map 59. Distribution of *A. retinodes* var. *uncifolia*.

Habit

Shrubs or trees 5–10 m high, single-stemmed or with few (usually 2–4) main stems from near ground level, main stems crooked or more or less straight and to 15 cm or more dbh, often much-branched from low down, in sheltered sites it forms dense groves; crowns bushy. Bark smooth but becoming longitudinally fissured on main trunks of older plants.

Botanical descriptions and line drawings are provided in Costermans (1981), Whibley & Symon (1992: the photographs in this account are of the 'typical' variant), Maslin *et al.* (1998) and Maslin (2001 & 2001a).

Taxonomy

The taxonomy of *A. retinodes* and its allies is currently under review (see 'typical' variant above) and it is likely that this research will show that var. *uncifolia* should be recognized as a distinct species.

Acacia retinodes var. *uncifolia* is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). More specifically this variety is a South Australian member of the Australia-wide '*Acacia microbotrya* group' (Maslin 1995). A number of other species from this group are detailed in this report, namely, *A. bartleana*, *A. euthycarpa*, *A. microbotrya*, *A. rivalis* and *A. wattsiana*. Species of section *Phyllodineae* are widespread in Australia with the main centres of richness located in temperate and adjacent semiarid areas of eastern, southeastern and southwestern Australia; species number greatly decline in the arid zone and in northern tropical/subtropical areas (Hnatiuk & Maslin 1988 and Maslin & Pedley 1988).

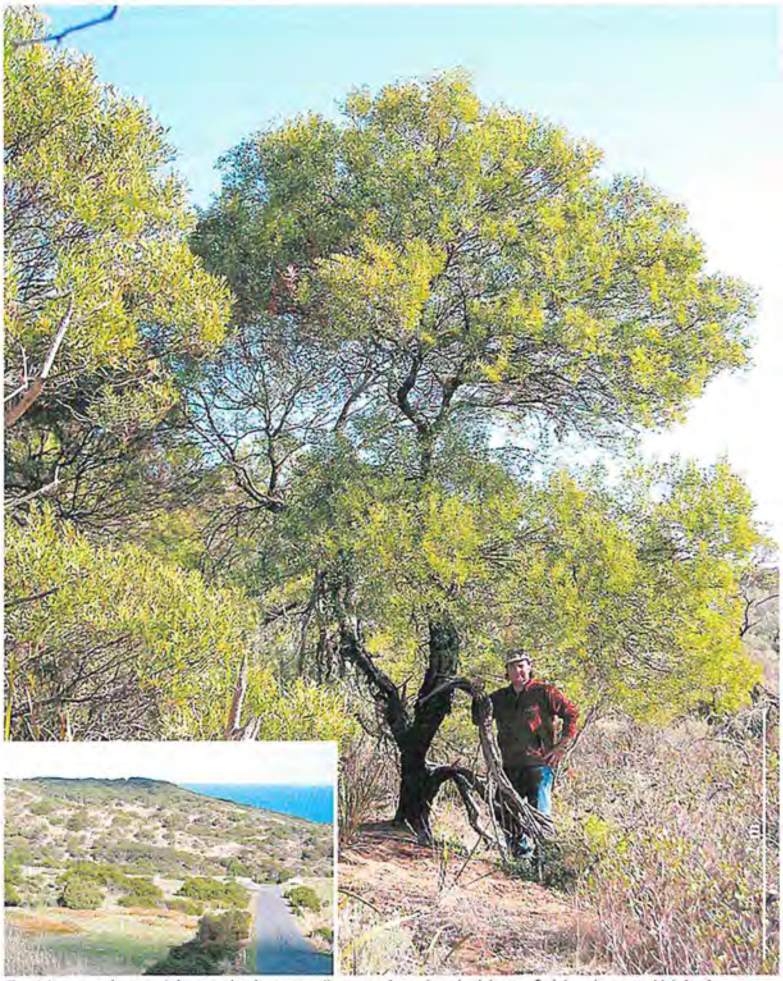
The phyllodes of var. *uncifolia* may resemble some individuals of *A. euthycarpa* (see species profile above) or *A. flocktoniae* from New South Wales (not included in this report).

Map 60. Predicted area (blue) where *A. retinodes* var. *uncifolia* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 59), see also Table 5. Target area shown in yellow.

Distribution and habitat

Variety *uncifolia* has a discontinuous distribution in coastal areas of south-eastern Australia where it occurs on the southern Eyre Peninsula, Kangaroo Island and the Fleurieu Peninsula in South Australia, Geelong to Wilsons Promontory in Victoria and on both King and Flinders Islands, Tasmania. This distribution occurs along the southern

Figure 29. *Acacia retinodes* var. *uncifolia*


A– Mature plant with crooked stems (insert showing habitat of this plant at Waitpinga Beach, S.A.) (Photos: B.R. Maslin)


B – Stem base. (Photo: B.R. Maslin)


C – Branches showing pale heads (in racemes) & short phyllodes. (Photo: B.R. Maslin)

D – Large plant at Cape Schanck, Victoria. (Photo: B.R. Maslin)


E – Young plant on dune showing lateral root. (Photo: J. Kenrick)


F – Section of stem showing relatively dense wood. (Photo: B.R. Maslin)

periphery of the target area in South Australia but is outside the region in the other States. *Acacia retinodes* var. *uncifolia* occurs on dunes and sandy soils over limestone in near-coastal habitats. Details of its ecology and distribution in Tasmania are given in Lynch (1993).

Flowering and fruiting

Flowering time appears to be quite variable. Peak flowering occurs from October to December in South Australia (Whibley & Symon 1992), from December to February in Victoria (Bernhardt *et al.* 1984) and about December to April in Tasmania (Lynch 1993). However, occasional flowering plants may be found in most other months of the year. Mature pods have been collected between November and January (little data available).

Biological features

Growth rate is fast, it is resistant to salt spray and is probably frost-sensitive (Martin O'Leary, pers. comm.) In Tasmania var. *uncifolia* suckers and resprouts following 'cool' fires; also regenerates from seed following fire (Lynch 1993). Pawley (1994) reports it to sucker from cut roots. However, in South Australia the plants have not been seen to either sucker or coppice (Martin O'Leary, pers. comm.). This variety is highly self-incompatible (Kenrick & Knox 1985), thus cross-pollination is essential for seedset. See Bernhardt *et al.* (1984) and Kenrick & Knox (1985) for discussions of pollination biology and breeding systems. Gum exuded from stems of a number of plants that we observed at Waitpunga Beach, South Australia.

Genetics

Details of the breeding system of *A. retinodes* var. *uncifolia* (based on plants growing at Cape Schanck, Victoria) are discussed in Kenrick & Knox (1985).

Cultivation

Not known in cultivation.

Weed potential

The weed potential of this species is seemingly very low.

Wood

Based on our limited field observations this species appears to have a relatively heavy wood with a well-developed heartwood. When cut a gum exudes at the interface of the sapwood and heartwood. Shrinkage upon drying caused minor end fractures in the wood that we sampled.

Utilisation

Land use and environmental

According to Elliot & Jones (1982) *A. retinodes* is a useful windbreak species (although it is not known to what variant of the species these authors were referring, it would likely apply to all of them).

Potential for crop development

Acacia retinodes var. *uncifolia* is regarded as only moderately prospective for development as a crop plant for high volume wood production; the other taxa comprising *A. retinodes* would appear to offer better potential than this variety. This variety is ranked as category 3 and its growth characteristics suggest that it would be best suited for development as a phase crop (Table 6). Variety *uncifolia* is reported to have a fast growth rate but there is no trial result information available, therefore it is not known if it would attain acceptable growth rates and biomass production in the areas where it would be intended to cultivate it. Although var. *uncifolia* produces reasonable quantities of woody biomass its stem form is often not very good (rather crooked). Limited field observations suggest that plants from Cape Schanck, Victoria, have better form (taller stature and straighter stems) than those from South Australia, but it is not known to what extent site conditions contribute to these differences. Selection of appropriate provenances for inclusion in field trials will be important; in nature plants vary not only in growth form but apparently also in their suckering ability (suckering plants could pose management problems in cultivation of phase crops).

The area predicted to be climatically suitable for the cultivation of *A. retinodes* var. *uncifolia,* based on its natural climatic parameters, is shown in Map 60. Although this variety has a natural distribution at the margin of the target area the analysis indicates that it is suited to climatic conditions well beyond this range. Relatively large areas of the eastern and western target areas have climatic conditions suitable for the cultivation of this variety. However, natural populations have a strong preference for calcareous sands and this may preclude its widespread cultivation on diverse soil types.

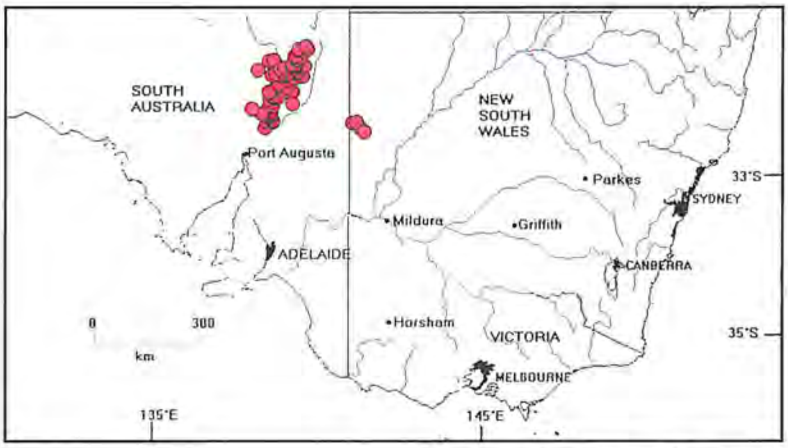
Acacia rivalis J.M. Black

Common Name

Creek Wattle.

Habit

Obconic shrubs or trees 3–5 m high, dividing at or near ground level into few to many stems, or with a single main stem for up to about 1 m before dividing into ascending branches; main stems more or less straight and 7–10 cm dbh (few plants measured); crowns dense and rounded with the ultimate branchlets often +/- pendulous. Bark smooth and thin.



Map 61. Distribution of *A. rivalis*.

Botanical descriptions and illustrations/photographs are provided by Costermans (1981), Tame (1992), Simmons (1987), Whibley & Symon (1992), Maslin *et al.* (1998), Maslin (2001 & 2001a) and Kodela (2002).

Taxonomy

Acacia rivalis is referable to *Acacia* section *Phyllodineae,* a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). More specifically this species is a South Australian member of the Australia-wide '*Acacia microbotrya*' group' (Maslin 1995). A number of other species from this group are detailed in this report, namely, *A. euthycarpa*, *A. microbotrya*, *A. retinodes*, *A. bartleana* and *A. wattsiana*. *Acacia rivalis* is closely related to *A. retinodes* and *A. calamifolia* (which is not considered a prospective species for development as a crop plant for wood production). Species of section *Phyllodineae* are widespread in Australia with the main centres of richness located in temperate and adjacent semiarid areas of eastern, southeastern and southwestern Australia; species number greatly decline in the arid zone and in northern tropical/subtropical areas (Hnatiuk & Maslin 1988 and Maslin & Pedley 1988).

This species appears to have limited genetic variation.

Map 62. Predicted area (blue) where *A. rivalis* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 61), see also Table 5. Target area shown in yellow.

Distribution and habitat

Occurs in South Australia from Hawker (just outside the target area) north to near Mt Harris in the North Flinders Range. It is also recorded from near Broken Hill, New South Wales, but possibly is not native there (see Jacobs & Pickard 1981). Maslin (2001) records the species from near Lake Bring and Wilgena, about 500 km to the west of the Flinders Range, however, these records are now known to represent a taxon of uncertain identity (M. O'Leary,

Figure 30. *Acacia rivalis*

A – Mature plant (left-hand stem broken at base due to crown weight) with insert showing much-branched main stem. (Photos: B.R. Maslin)

B – Slender coppice regrowth from root stock; insert showing gum on stem. (Photos: B.R. Maslin)

C – Section of stem showing dense wood. (Photo: B.R. Maslin)

D – Flowering branch. (Photo: comm. M. O'Leary) pers. comm.). Grows in tall shrubland on ridges and rocky shaly hills or along watercourses, in shallow calcareous loam.

Flowering and fruiting

Flowers between April and November, peaking in September to October. Pods ripen over about a year, maturing between mid-September and early November. Pods and flowers are often found together on the same plant (Whibley & Symon 1992). Large quantities of seed are produced by this species.

Biological features

Moderate to fast growth rate (Whibley & Symon 1992); when grown on heavy clay soil around Adelaide (where rainfall is higher than within the natural range of the species) plants can attain about 2 m in height in about 2 years (M. O'Leary, pers. comm.). It seemingly does not sucker but some plants produce thin coppice regrowth from around the base of the mains stems when cut at ground level. It regenerates abundantly from seed after fire. It is relatively short-lived with a life span of probably 15–20 years (D. Kraehenbuehl, pers. comm.) Moderate amounts of gum are exuded from the stems and branches on plants in the wild.

Genetics

Possibly hybridises with A. *araneosa* (which is not considered a prospective taxon for this project) in the northern part of Flinders Range.

Cultivation

Little known in cultivation. The species is readily established from seed (Martin O'Leary, pers. comm.).

Weed potential

There are no records of this species posing weed problems.

Wood

Based on our field observations of a single plant this species produces a heavy wood relative to its volume. Heartwood to sapwood ratio is similar. Minor end splitting occured upon drying.

Utilisation

Land use and environmental

Because of its attractive growth form A. *rivalis* would be suited for cultivation as an ornamental or for amenity planting in dry inland areas.

Gum

This species formed the basis of a small commercial gum industry around Blinman, South Australia, in the early part of the twentieth century (Whibley & Symon 1992).

Human food

Regarded by Maslin *et al.* (1998) as a lesser known species that is worth considering as a source of seed for human consumption. At Umberatana (north-west of Arkaroola) seeds of this species are reported to have been ground into a flour and consumed by Aborigines (Johnston & Cleland 1943).

Fodder

It is not known to be browsed by stock (Cunningham *et al.* 1981).

Potential for crop development

Acacia rivalis is regarded as having moderate prospects as a crop plant for high volume wood production. It is ranked as a category 2–3 species and displays a number of growth characteristics that suggest it has potential for development as a phase crop (Table 6). This is a hardy species and despite occurring naturally in low rainfall areas is reported to have a moderate to fast growth rate; it seemingly neither coppices nor suckers (or these attributes are only weakly expressed). *Acacia rivalis* displays a good growth form, however, in cultivation at least it can develop a dense, heavy crown, the weight of which may cause stems to split at ground level as the plants age (see Fig. 30A). Stem splitting, however, may be less of a problem on single-stemmed plants and may be alleviated by crown thinning. The species produces a reasonable quantity of woody biomass but the wood appears reasonably dense (it may be similar to *A. microbotrya* which averages about 830 kg/m^3, and if so it lowers the species attraction for use in reconstituted wood products). Because this species produces large quantities of seed it would be appropriate to harvest plants before they reach reproductive maturity to avoid creating a soil seed bank that may lead to weed problems in adjacent or subsequent annual crops. For this to be a viable strategy it would require that the plants had produced acceptable quantities of wood by then. It is not known, however, at what age flowering and fruiting commences. An alternative might be to treat the seedling recruitment as a form of green manure. Secondary products that might be derived from this species would include seed for human food and gum.

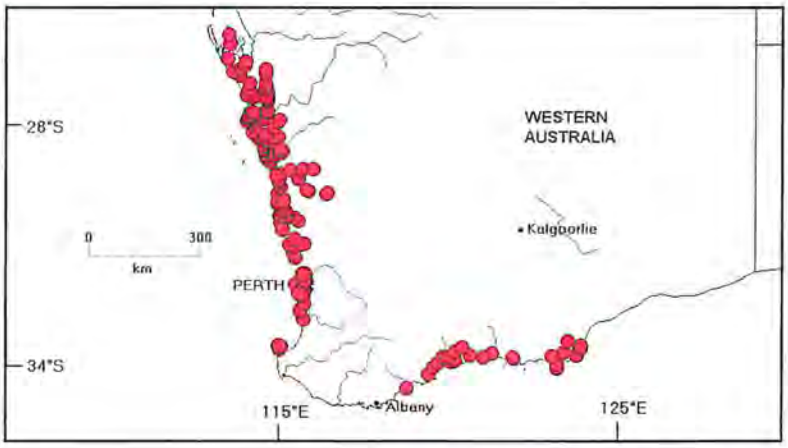
The area predicted to be climatically suitable for the cultivation of *A. rivalis*, based on its natural climatic parameters, is shown in Map 62. This analysis indicates that *A. rivalis* is suited to climatic conditions well beyond its natural range. All of the eastern and western target areas in the less than 400 mm rainfall zone are predicted to have climatic conditions suitable for its cultivation. This species is a good prospect for dry sites in these regions. Within these regions it has potential for cultivation on loamy calcareous soils. Note that although this species does not grow naturally within the target area it occurs very close to its northern boundary in South Australia.

Acacia rostellifera Benth.

Common Name

None known.

Habit



Map 63. Distribution of *A. rostellifera.*

Dense shrubs or trees commonly 2–5 m tall. A 'typical' plant has main stems 5–10 cm dbh; the largest plant observed during this survey measured 6–7 m tall and 10 m across, it branched near ground level into about 4 trunks, each 15–20 cm dbh (main trunk about 60 cm diam at ground level); normally aggressively suckering and commonly forming thickets. When growing within dense clonal thickets the plants are often rather spindly with stems about 2–3 cm dbh. Bark longitudinally fissured on main stems (especially at base), smooth on branches, grey.

Botanical descriptions and illustrations/photographs are provided by Chapman & Maslin (1992) and Maslin (2001 & 2001a).

Taxonomy

Acacia rostellifera is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion).

Acacia rostellifera is one of 12 species of a group of closely related taxa referred to by Chapman & Maslin (1992) as the '*Acacia bivenosa* group'. *Acacia rostellifera* and *A. salicina* are the only members of this group detailed in the report. *Acacia rostellifera* is particularly closely related to the widespread arid zone species, *A. ligulata*.

A somewhat variable species with respect to phyllode shape and size. A narrow phyllode form occurs on yellow sandy soil from north of the Murchison River near Ajana to Shark Bay (Chapman & Maslin 1992).

Map 64. Predicted area (blue) where *A. rostellifera* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 63), see also Table 5. Target area shown in yellow.

Distribution and habitat

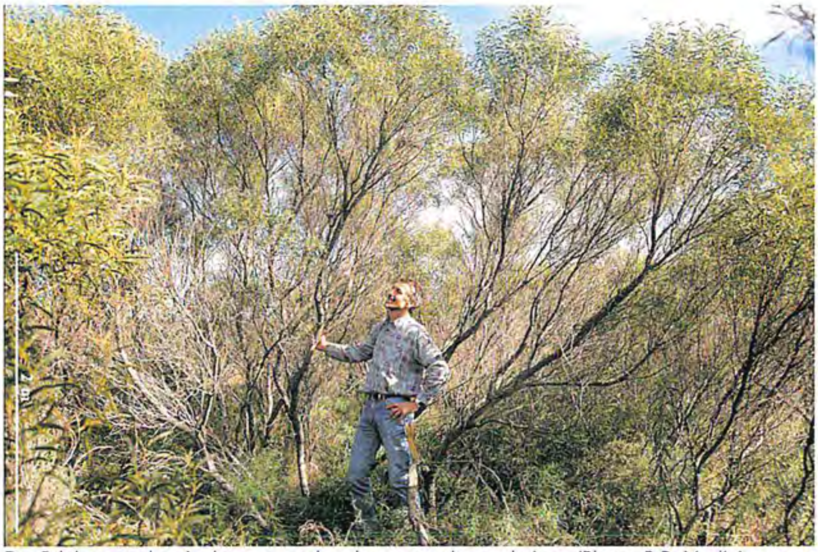
Endemic in Western Australia where it occurs in coastal areas from Shark Bay south to Cape Naturaliste and then from Bremer Bay east to Israelite Bay; around Geraldton it extends inland through Northhampton to near Yuna and south to Latham. Normally the species is very common in the places where it occurs and it usually forms dense, monotypic, clonal thickets. Grows most commonly in porous coastal sand; along roadverges inland from Geraldton it may occur on granitic rocky sand.

Figure 31. *Acacia rostellifera*

A – Large, mature plant with spreading habit, in open roadverge site near Geraldton, W.A. (Photo: B.R. Maslin)

B – Forming dense thickets in coastal dunes. (Photo: B.R. Maslin)

C – Branch showing heads in short racemes. (Photo: B.R. Maslin)



D – Adolescent plant in dense coastal sucker regrowth population. (Photo: B.R. Maslin)

E – Pods brittle; seeds with red aril. (Photo: B.R. Maslin)

F – 22 month old plant in trial at Dongara, W.A. (Photo: J. Carslake)

Flowering and fruiting

Flowers mainly between July to October and pods with mature seeds have been collected from December to March.

Biological features

A hardy plant probably with moderately fast growth rate; it probably has a life span of about 20 years. *Acacia rostellifera* normally has an aggressively suckering habit and commonly forms thickets; its coppicing/pollarding ability is unknown (but may well be present since its close relative A. *ligulata* has a high coppicing ability, see Thomson *et al.* 1994). Presumably because it commonly reproduces vegetatively it tends to fruit somewhat irregularly. When present the pods often occur scattered over the plants and the seed can be somewhat tedious to collect. An analysis of the gum characteristic of A. *rostellifera* is provided by Anderson *et al.* (1984).

Genetics

Natural hybrids appear to occur between A. *rostellifera* and A. *xanthina* (which is not considered a priority taxon in the report) around Leeman which is south of Geraldton, Western Australia.

Cultivation

Not known in cultivation but was recently included in some provenance trials in the wheatbelt region of Western Australia (but plants are too young to give meaningful information).

Weed potential

The species' root-suckering habit and tendency to form dense thickets may possibly lead to some weediness when conditions are favourable.

Wood

Pale coloured throughout (scarcely any dark heartwood developed). Basic density values range from 727 kg/m^3 to 948 kg/m^3 (mean 835 kg/m^3) based on analyses of 13 wood samples by CALM's NHT-supported 'Search' project (unpublished data). Note: This study preferentially sampled young and adolescent plants.

Utilisation.

Land use and environmental

Well-suited to sand dune stabilisation.

Potential for crop development

Acacia rostellifera is regarded as having only moderate prospects as a crop plant for high volume wood production. It is ranked as a category 3 species and would seem best suited to light-textured soils as a phase crop (Table 6), however, its vigorous suckering propensity may present difficulties for its management. Under natural conditions A. *rostellifera* displays a moderately fast growth rate and is capable of producing quite good quantities of woody biomass, however, the wood is rather dense which lowers its attraction for use in reconstituted wood products. Plants from open sites tend to be quite wide-spreading and low-branched but growth form improves in denser stands. If grown too close together, however, the plants may become somewhat spindly. Collecting seed could prove difficult.

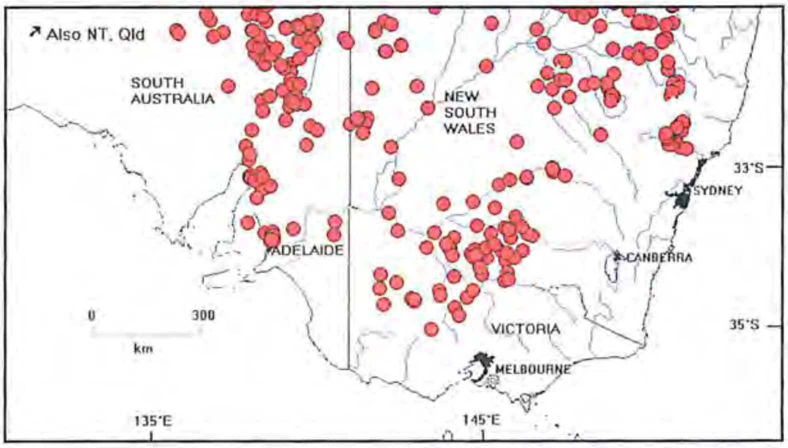
As discussed by Chapman & Maslin (1992) A. *rostellifera* belongs to a group of 12 closely related species, the '*Acacia bivenosa* group'. *Acacia salicina* is a member of this group and is detailed below and treated as a Priority 2 taxon. A number of other members of the group occur within the target area and of these A. *ligulata* (widespread in the arid zone) may possibly have some limited application. It is, however, generally a wide-spreading much-branched shrub with marginal woody biomass production. Also, field observation of one plant in South Australia showed the wood to be very dense with an extensive development of very dark heartwood.

The area predicted to be climatically suitable for the cultivtion of A. *rostellifera*, based on its natural climatic parameters, is shown in Map 64. This analysis indicates that A. *rostellifera* is well suited to climatic conditions beyond its natural range. It has the potential to be grown throughout both the western and eastern target areas including large parts of South Australia and into target areas in Victoria and southern New South Wales. These predicted areas could be more extensive if this species demonstrates an ability to also grow in uniform and summer rainfall zones. Within the area predicted to have suitable climatic conditions, A. *rostellifera* will be best suited to grow on deep sandy soils. Trials are warranted to ascertain if variation among provenances exists for edaphic specificity.

Acacia salicina Lindley

Common Names

Cooba (Standard Trade Name), Native Willow, Broughton Willow, Black Sally Wattle and many more, see Cunningham *et al.* (1981).



Map 65. Distribution of *A. salicina*.

Habit

Erect or spreading shrubs or trees 7–13 (–20) m tall, with a well-defined single main trunk or sometimes forked or with several stems at 1–2 m or less above the ground, the main stems are straight to sub-straight, to 40–60 cm dbh and +/- sparingly divided into ascending to erect branches, often clonal due to vigorous suckering habit; crowns dense, often spreading and the branches pendulous. Bark on main stems thin, rough, longitudinally fissured and grey-brown.

Botanical descriptions and illustrations/photographs are provided by Cunningham *et al.* (1981), Costermans (1981), Simmons (1987), Turnbull (1986), Whibley & Symon (1992), Tame (1992), Bonney (1994), Maslin & McDonald (1996), Doran & Turnbull (1997), Chapman & Maslin (2001 & 2001a) and Kodela (2002).

Taxonomy

Acacia salicina is referable to *Acacia* section *Phyllodineae,* a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion).

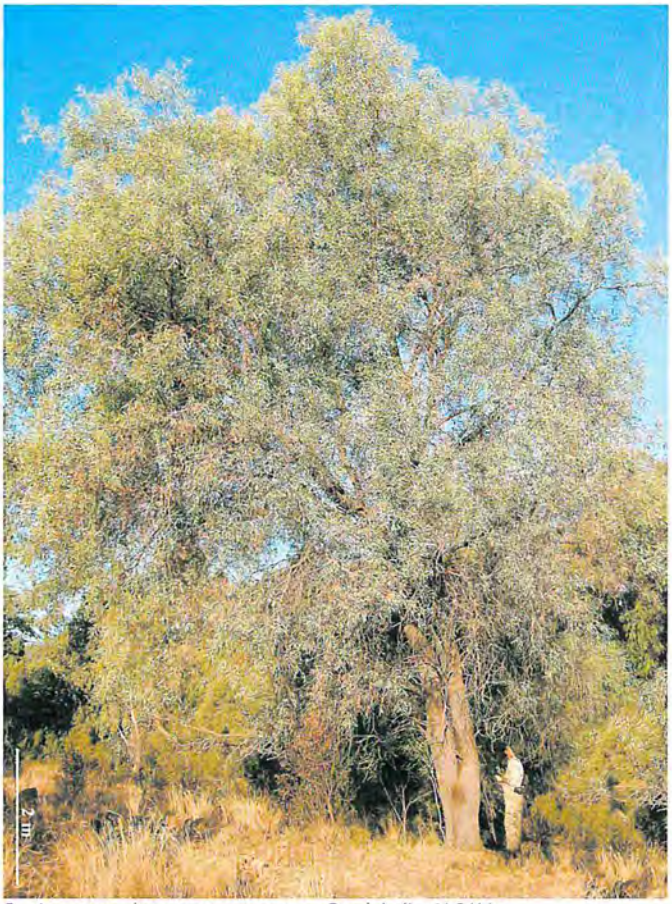
Acacia salicina is one of 12 species of a group of closely related taxa referred to by Chapman & Maslin (1992) as the '*Acacia bivenosa* group'. *Acacia salicina* and *A. rostellifera* are the only members of this group detailed in the report. There is little information available on provenance variation within this species.

Map 66. Predicted area (blue) where *A. salicina* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 65), see also Table 5. Target area shown in yellow.

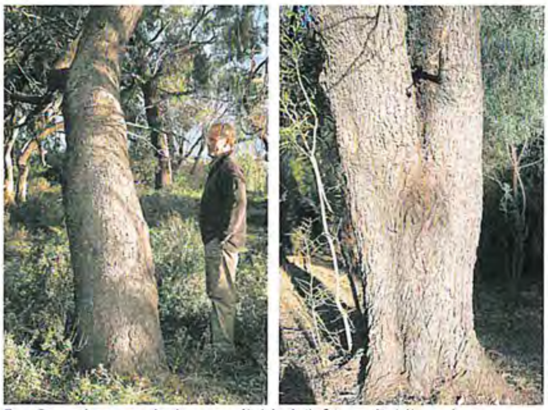
Distribution and habitat

Widespread in eastern Australia, predominantly in central Queensland and western New South Wales, but extending to Northern Territory, South Australia and Victoria. A flowering collection from near Wiluna, Western Australia, appears to be *A. salicina*, however, pods are needed to confirm the identification and field examination needed to ensure that it is native to the area where it is purported to occur. *Acacia salicina* is widespread and common in the arid zone and reaches the drier regions of the target area (along water courses) in South Australia, Victoria and New South Wales.

Figure 32. *Acacia salicina*



A – Large tree along watercourse near Condobolin, N.S.W. (Photo: B.R. Maslin)



B – Stem base variation, undivided (left) or dividing above ground (right). (Photos: B.R. Maslin)

C – Stem base variation, dividing near ground (left) or undivided (right). (Photos: B.R. Maslin)

D – Habit variation in stand near Yacka, S.A. (Photos: B.R. Maslin)

E – Pod (woody); seeds with red aril. (Photo: B.R. Maslin)

F – Stem sections showing variation in the low density wood, no heartwood on young sucker regrowth (left). (Photos: B.R. Maslin)

Acacia salicina has been planted and is incorporated into trials in a number of countries abroad (see under **Cultivation** below).

Acacia salicina grows mostly along water courses and on flat alluvial plains and floodplains, but extends also to minor drainage areas and sandy tracts in rocky hilly country, and sand dunes. Major soil types are dark cracking clays (black earths) of the floodplains, and acid and neutral red earths (but also it tolerates alkaline situations). Comprehensive summaries of habitat characteristics are given in Turnbull (1986), Doran & Turnbull (1997) and CAB International (2000); see also Pedley (1980), Cunningham *et al.* (1981) and Whibley & Symon (1992) and Marcar *et al.* (1995).

Flowering and fruiting

Has a long but irregular flowering period which appears to peak from April to June. Similarly, it seeds irregularly in the wild and is not reliable in its seed set. In Queensland pods mature in the second half of the year (Pedley 1980), in southern New South Wales December to January (Stelling 1998), while in South Australia February to April is the usual seed-collecting period (Bonney 1994). The irregularity in fruiting can cause problems with seed collection and consequently increase the cost of seed.

Biological features

Acacia salicina is a relatively fast-growing tree (see below under **Yield**) which root suckers vigorously, often forming clonal clumps. Under favourable conditions its roots have the capacity to grow into deeper subsoils to tap water (Lovenstein *et al.* 1991). It coppices well when young (Ryan & Bell 1989). It is moderately drought-, frost- and waterlogging-tolerant, and is moderately to highly salt-tolerant (expect reduced growth at EC_e 10 dS/m and reduced survival at EC_e 15 dS/m) (Marcar *et al.* 1995). It is long-lived (greater than 50 years) according to Thomson *et al.* (1994). For information on growth rates and survival see under **Cultivation** below. An analysis of gum characteristics of A. *salicina* is given in Anderson & McDougal (1988).

Genetics

Many hybrids occur among members of the '*Acacia bivenosa* group' but none involving A. *salicina* have been recorded (Chapman & Maslin 1992). There are no tree improvement programmes underway for this species (CAB International 2000).

Toxicity

Although the phyllodes are eaten to some extent they are not widely used; they contain large amounts of tannins and are suspected of poisoning hungry cattle (Everist 1969). The green pods are rich in saponin (Everist 1969) but according to Cunningham *et al.* (1981) are readily eaten by sheep. The tannin-rich bark was been used by traditional aborigines to poison fish (Hurst 1942).

Cultivation

Acacia salicina has been planted in North Africa for shade and shelter and in the Middle East for fodder production; it has been incorporated into trials in Australia, Cape Verde, India, Israel, Kenya, Pakistan, Philippines, Spain, Thailand and Yemen (see CAB International 2000 for references and summary of details, also for full list of countries where this species is planted).

CAB International (2000) provides an comprehensive summary of the silvicultural characteristics and management of A. *salicina*, and the following information is taken largely from this source.

Establishment

Treating seeds with boiling water as routinely prescribed is usually sufficient to break seed-coat dormancy but it has been suggested by Aveyard (1968) that soaking in concentrated sulfuric acid for 20 minutes is a more effective treatment for fully matured seed (Turnbull 1986). Khajuria & Singh

(1990) report 50% germination by immersion in boiling water for 1 minute. Rehman *et al.* (1999) report that soaking in water at 70°C was the most effective way to break dormancy, with soaking times of 1–100 minutes permitting maximum germination. There are 15,200 viable seeds/kg and germination rate averages 69% (Doran and Turnbull 1997).

Acacia salicina has been found to be a promising species for establishment by direct sowing of seed in arid areas (Singh *et al.* 1991). In laboratory experiments by Rehman *et al.* (1999) the percentage and rate of germination were reduced by 50% at 152–175 and 225–250 mM NaCl respectively, and *A. salicina* was amongst the most salt tolerant of 10 *Acacia* species tested. Hardening by soaking in water for 10 h and then redrying had no effect on germination percentage but did increase germination rate under both saline and non-saline conditions (Rehman *et al.* 1998).

Seedlings establish well from seed directly sown into pots filled with appropriate soil potting mixtures. It takes about 3–5 months to produce seedlings ready for planting depending on climatic conditions. Antitranspirants have been shown to reduce water loss in seedlings of *A. salicina* and they may be useful for safely transporting seedlings from nursery to plantation sites without being watered (Lahiri *et al.* 1986).

A procedure for rapid micropropagation of *A. salicina* was described by Jones *et al.* (1990). Procedures for initiating shoots and roots from callus supplemented by various hormones are provided by Zhao *et al.* (1990).

Good nodulation was observed in soil: manure-filled pots with no inoculation (Khajuria & Singh 1990). However, there are likely to be benefits from inoculation of nursery seedlings with *Rhizobium*. Reports of field nodulation are variable.

In a trial on a saline, sodic soil in Rajasthan (India), gypsum application (1.25 t/ha) slightly improved survival and growth up to 12 months (Hussain *et al.* 1990).

Field experiments in the Negev Desert, Israel, have shown that *A. salicina* can tap moisture in deeper soil profiles when surface water has been harvested and allowed to recharge these depths; this use of water stored at depth permitted intercropping with safflower, which used water in the upper profiles (Lovenstein *et al.* 1991).

Yield

In species evaluation trials, annual growth rates usually fall in the range of 1–2 m (Bell *et al.* 1991, Hafeez 1993, Kimondo 1991, Mitchell 1989, Ryan & Bell 1991, Webb 1973 unpublished cited in Turnbull 1986). However lower growth rates have been recorded. For example: (i) in southern Spain, trees were only 0.7–0.8 m tall after 16 months (Hyde *et al.* 1990); (ii) in southeast Queensland (Burrows & Prinsen 1992; mean annual rainfall was 455 mm during the experimental period) and southeast Spain (Tilstone *et al.* 1998) trees were only about 1 m tall after 3.5 years; and (iii) in Kenya (Jama *et al.* 1989; annual rainfall 700 mm) trees were only 2.6 m tall after 6 years. On a moderately to highly saline site in northeast Thailand, survival was 42% and trees were 1.9 m after 5 years (NE Marcar, unpublished data). On a slightly saline soil irrigated with good quality water in Pakistan, *A. salicina* grew to 5.3 m tall and 5.6 cm d.b.h. in 40 months (Hafeez 1993).

In a rain fed runoff farming system in the arid zone of Israel, the mean annual total fresh biomass was c. 25 kg/tree for the 2-year rotation, and 30 kg/tree for a 4-year rotation (Zohar *et al.* 1988). Total above-ground dry matter after three years was 15 and 19 t/ha for *A. salicina* grown at 625 and 1250 trees/ha under arid zone conditions with surface water harvesting (Lovenstein *et al.* 1991).

Pests and diseases

Acacia salicina suffers moderate levels of damage from bag shelter moth (*Ochrogaster lunifer*) (Marcar *et al.* 1995). It is also damaged, in Australia, by acacia rust (*Uromyces fusisporus*) (Lee 1993).

Weed potential

The species' root-suckering habit and tendency to form dense thickets may possibly lead to some weediness when conditions are favourable.

Wood

The heartwood is dark brown (sapwood much paler) and attractively marked, close-grained, tough and moderately heavy with an air-dry density of 675 kg/m^3 (Cause *et al.* 1974). Ilic *et al.* (2000) provide an estimated basic density from air-dry (12%) MC as 550 kg/m^3. Everist (1969) reports the wood to be dark coloured but fairly soft. Singh & Khanduja (1984) report a density of 1010 kg/m^3 but it is not clear whether this refers to air dry or basic density.

Utilisation

The following information is derived primarily from the comprehensive summaries provided by Turnbull (1986), Doran & Turnbull (1997) and CAB International (2000).

Wood

Acacia salicina wood should make a satisfactory fuel; Singh & Khanduja (1984) report good calorific value (18,900 kJ/kg dry weight) and recommended it for intensive short-rotation fuelwood biomass cultivation. It is reported to take a high polish and has been used for quality furniture for which purpose it rivals the well-known furniture timber *Acacia melanoxylon* (Baker 1913). In the early days of European settlement the wood of this species was used for the manufacture of furniture, bullock yokes and cart shafts (Cunningham *et al.* 1981).

Land use and environmental

According to Turnbull (1986) *A. salicina* is a desirable species for planting in moderately dry country of Australia. In Israel *A. salicina* is reported as being successfully grown under irrigation as an ornamental and for windbreaks (Weinstein & Schiller 1979). In North Africa and the Middle East it is used for shade and is commonly planted in shelterbelts and windbreaks (Heth & Dan 1978, Kaplan 1979, Weinstein & Schiller 1979). Because it suckers freely *A. salicina* can be used to stabilise sandy areas and to control erosion. In its natural environment it is regarded as useful for maintaining the stability of river banks (Anderson 1968) and in mine-site rehabilitation (Langkamp 1987). *Acacia salicina* was one of the most successful species in a tree establishment trial on coal mine spoil in New South Wales in terms of survival and growth (Hannan 1979). It successfully establishes on areas disturbed by open-cut mining in central Queensland, either as volunteer or as part of the broadcast seed mix used in rehabilitation (Grigg & Mulligan 1999). On steep slopes of Cape Verde it is planted as a soil stabiliser (Sandys-Winsch & Harris 1992).

Fodder

Within Australia the phyllodes and pods of *A. salicina* are eaten readily by sheep but are not widely utilised (Everist 1969 and Cunningham *et al.* 1981). It has been planted with other acacias as a fodder species in the arid zone of Libya and shows promise in trials in semi-arid areas of Iran (Webb 1973 unpublished, cited in Turnbull 1986), Israel (Heth and Dan 1978), Kuwait (Firmin 1971) and Tunisia (Le Houerou 2002). Nevertheless, a number of studies in which *A. salicina* has been one of several species tested, have concluded that palatability, intake and digestibility of phyllodes is poor to satisfactory at best (Vercoe 1989 found its protein, nutrient and digestibility levels to be close to maintenance requirements). High levels of tannin are usually deemed responsible for these more unpromising results (Fonolla *et al.* 1992, Degen *et al.* 1997, Kaitho *et al.* 1998), and are also suspected of poisoning hungry cattle (McCosker & Hunt 1966). Low digestibility [33 and 37% for *in vivo* (goats) and *in vitro* organic matter (Ventura *et al.* 1999)] and energy values (0.28 forage units/kg DM – Fernandez-Galvan & Mendez 1989; 3.2 MJ net energy/kg DM – Ventura *et al.* 1999) were found from trials in the Canary Islands. Kaitho *et al.* (1997) point out that although palatability in short-term studies is generally poor, species such as A. *salicina* may well provide useful fodder in times of feed scarcity. Le Houerou (2002) notes that although the foliage is readily eaten by small stock and camels its feed value is definitely below that of A. *saligna*.

Other uses

Its drooping habit and attractive foliage makes it desirable for amenity planting. Phyllodes reputedly burnt and ash smoked to produce a narcotizing effect (Stelling 1998). The tannin-rich bark was been used by traditional aborigines to poison fish (Hurst 1942).

Potential for crop development

Acacia salicina is the most prospective species for high volume wood production for the dry inland regions of the target area in eastern Australia. It is ranked as a category 1–2 species and would seem suited as both a phase and long duration crop (Table 6). Although young plants are reported to coppice well it is not known if the species resprouts with sufficient vigor to sustain the species as a coppice crop. *Acacia salicina* is a hardy, vigorous, long-lived, relatively drought-tolerant tree that will grow on a wide range of soils (acid and alkaline) and is tolerant of saline conditions. Young plants should be protected from grazing animals. *Acacia salicina* is relatively fast growing (under favourable conditions) and produces excellent quantities of woody biomass. The plants show a good growth form with normally straight or sub-straight boles, main stems and branches. The wood is not dense (estimated basic density is 550 kg/m^3) and is within the range of being suitable for reconstituted wood products; however, density values are likely to vary with plant age and growing conditions. The wood has a good calorific value making it suited as a fuelwood and is also reported to be suited to high value end-products such as furniture. The propensity for A. *salicina* to vigorously root-sucker in nature may or may not be advantageous in cultivation, it depends whether or not this attribute is required (or expressed) for the system in which it is placed. It is presumably root disturbance that induces suckering. It is not known if non- (or low-frequency) suckering provenances exist but if they do then these may well be important in the crop development of this species. Associated benefits from using A. *salicina* are its application in soil conservation, provision of good shade and shelter, and to a lesser extent, the provision of fodder. The difficulty in obtaining range-wide representative seed collections due to sporadic and unreliable seed-set in A. *salicina* will hinder its domestication.

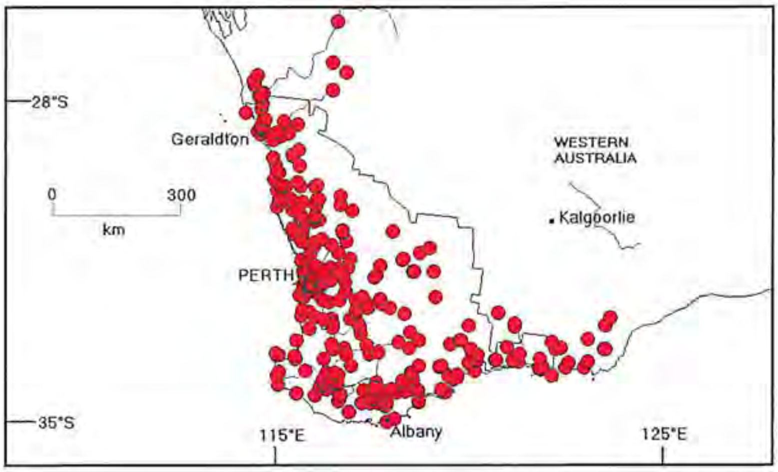
The area predicted to be climatically suitable to for the cultivation of A. *salicina*, based on its natural climatic parameters, but excluding areas with <250mm annual rainfall, is shown in Map 66. This analysis indicates that A. *salicina* could be grown throughout large areas of both the eastern and western target areas. However, its preference for heavy clay soils and high water tables may mitigate against its widespread cultivation in these areas. Natural populations of A. *salicina* occur mainly along watercourses so it remains to be seen how well it will perform under cultivation when ground water becomes a limiting factor. Nevertheless, limited overseas experience shows the species as having a deep root system and this would aid its survival as profiles dry out.

Because of the interest in cultivating A. *salicina* (mainly abroad) there exists a large body of knowledge which should greatly facilitate any attempt to develop it as a crop plant in Australia.

Acacia saligna (Labill.) H. Wendl.

Common Names

Coojong, Golden-wreath Wattle, Orange Wattle, Blue-leafed Wattle, Port Jackson Willow.



Map 67. Distribution of *A. saligna*.

Habit

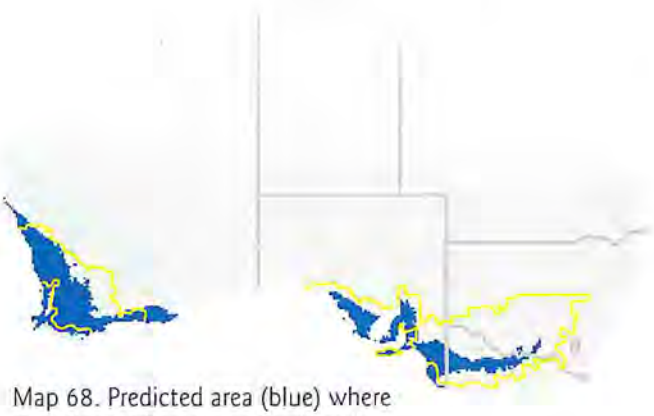
Variable shrubs or trees 2–10 m tall, either single- or multi-stemmed, mature trunks 5–40 cm dbh and straight to rather crooked, often suckering and sometimes forming thickets, in sand the main root may grow to 16 m deep (Knight *et al.* 2002) but sub-surface lateral roots are also developed (Messines 1952). See below under **Taxonomy** for further habit details.

Botanical descriptions and illustrations/photographs of *A. saligna* are provided in Maslin (1974), Costermans (1981), Simmons (1988), Tame (1992), Whibley & Symon (1992), Doran & Turnbull (1997), Maslin (2001 & 2001a) and Kodela (2002). The characteristics and uses of the species are described more fully in Hall & Turnbull (1976a), Michaelides (1979), Crompton (1992), Fox (1995) and Doran & Turnbull (1997).

Taxonomy

Acacia saligna is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion).

As currently defined *A. saligna* is a very variable species, not only in morphological characters such as phyllodes, bark and growth form, but also in ecological and biological attributes. Understanding the complex patterns of variation and reflecting these in a taxonomic classification is considered crucial for the effective management and development of this widely-utilized species. To this end a study of the native Western Australian populations of *A. saligna* was recently commenced by the first author and others. While preliminary results indicate that most of the variation can be accommodated within four main 'variants' these have not yet been adequately characterized or their taxonomic status resolved. Indicative distributions of the four variants are shown in Map 69 and synoptic details concerning them are as follows.


Map 68. Predicted area (blue) where *A. saligna* (all variants combined) is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 67), see also Table 5. Target area shown in yellow.

The 'typical' variant is widespread in inland regions (predominantly the wheatbelt) where it extends from east of Esperance to the Murchison River (extending inland to north of Yalgoo). It grows mainly along seasonally dry water courses and around the base of granite rocks but also occurs on coastal sand dunes around Esperance (which is where

Figure 33. *Acacia saligna 'cyanophylla'* variant

A – Large plant near Muchea, W.A. (Photo: B.R. Maslin)

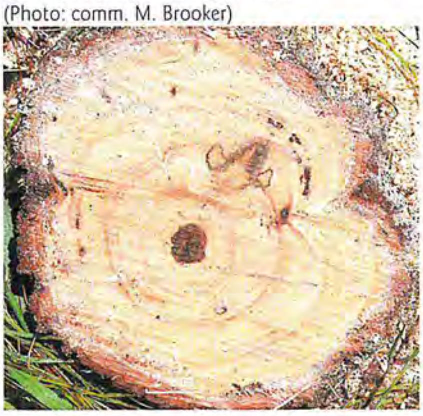
B – Branched stem base. (Photo: B.R. Maslin)

C – Un-branched stems. (Photo: B.R. Maslin)

D – 22 month old plants in trial at Coorow. (Photo: J. Carslake)

E – Coppice regrowth following cutting of main stem. (Photo: B.R. Maslin)

F– Phyllode base with characteristic, disk-like gland (arrowed) close to pulvinus. (Photo: comm. M. Brooker)



G (above) – Branch with large, golden heads in racemes. (Photo: B.R. Maslin)
H (right) – Stem section showing pale-coloured, low density wood. (Photo: W. O'Sullivan)

the original specimens of the species were collected in 1792). In places this variant extends to saline drainage systems such as the human-induced salt-affected, upper catchment of the Avon River (e.g. east of Brookton). The 'typical' variant is commonly a shrub 2–4 (–5) m tall with stout, straight to sub-straight main stems about 5–10 cm dbh, however, around granite rocks it may reach 10 m tall with stems to 20 cm dbh. The bark is smooth (longitudinally fissured towards base of main stems on oldest plants) and the phyllodes green. This variant suckers vigorously.

The 'cyanophylla' variant appears to have a restricted natural distribution in the vicinity of Perth where it occurs on the Swan Coastal Plain from near Yanchep to Mandurah, a distance of around 150 km. It is this variant to which the name A. *cyanophylla* was originally applied and it is the one that is probably most commonly planted around the world. The 'cyanophylla' variant is typically found on deep sandy soil, often near swamps. Because it has been so commonly used as an ornamental, in roadside and on-farm plantings, and in various revegetation programs, it is somewhat difficult to be certain of its true natural distribution (especially on the Swan Coastal Plain south of Mandurah). The 'cyanophylla' variant grows to a shrub or tree 3–10 m tall, it is either single-stemmed or has a short main stem which branches near the base, the stems are robust, straight to sub-straight and reach about 20–40 cm dbh. The crown is dense and bushy (phyllodes commonly sub-glaucous) and the bark is smooth (but longitudinally fissured towards the base of main stems on oldest plants). This variant does sucker but seemingly not as aggressively so as the other three variants; it coppices well.

The 'forest' variant is geographically located between the above two. It grows in the Jarrah–Marri forest from near Mount Barker to Augusta and north to New Norcia but extends to the Swan Coastal Plain south of Mandurah. It occurs on a variety of soils (sand to clay, but not laterite) and is most commonly found along water courses , but does extend to the coastal dunes in places. This variant grows as a shrub or tree 3–8 (–10) m tall (spindly forms occur in places), it is single-stemmed or has a few main stems from the base, the stems are commonly sub-straight to rather crooked (sometimes straight) and reach 10–20 cm dbh. This variant seems to be most readily identified by its bark which is friable (crumbly) and breaks with a rectangular fracture. It appears to sucker very aggressively.

The 'Tweed River' variant is seemingly uncommon with a scattered distribution in the Bridgetown–Manjimup–Kojonup area. It grows to a tree 3–10 m tall with either a single-stem or with a few main stems from the base, the stems have an erect aspect, are straight to rather crooked and reach 35 cm dbh on the oldest plants. The bark is similar to that found on the 'forest' variant. This variant is most readily identified by the white pruinose stems and distinctly glaucous phyllodes that are found on juvenile plants. It suckers aggressively.

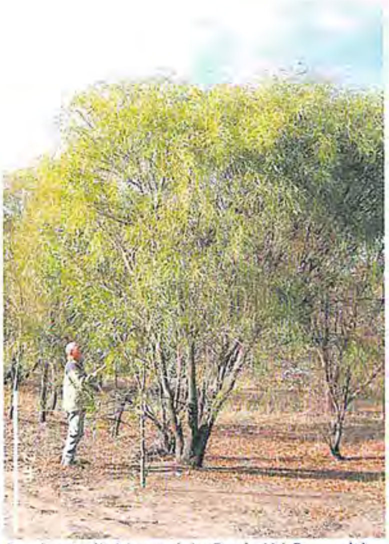
Given the current inadequate knowledge of these variants it is not possible to confidently ascribe the large body of previously published information concerning A. *saligna* to one or other of them. Therefore, the information presented below refers to A. *saligna* in the broad sense.

At present it is not possible to ascertain with certainty any close relatives for A. *saligna*. There are, however, some indications that the species may not be too far removed taxonomically from certain members of the A. *bivenosa* group (see Chapman & Maslin 1992 for review of this group) or to A. *blakelyi* and A. *scirpifolia*. It may superficially resemble, and is sometimes confused with, A. *pycnantha* (see profile above) but these two species are not particularly closely related (Maslin 2001).

Distribution and habitat

Acacia saligna is widespread and often locally abundant in southwest Western Australia where it extends from near Kalbarri southeast to near Mount Ragged; there are outlying populations about 200 km east-northeast of Kalbarri on Meka, Murgoo and Jingemarra Stations. Much of this distribution falls within the target area. See above under **Taxonomy** for discussion of the distribution of the four variants currently recognized within this species (indicative distributions of these variants are shown in Map 67). *Acacia saligna* is naturalized (and often weedy) in parts of eastern Australia and also in some countries abroad (see below under **Weed potential**). This species has been introduced to Chile, Libya,

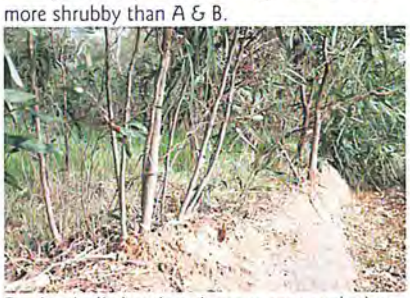
Figure 34. *Acacia saligna* variants



A – 'typical', Muntadgin Rock, W.A., multi-stemmed.

B – 'typical', Muntadgin Rock, W.A., single-stemmed.

C – 'typical', dry site near Mingenew, W.A., more shrubby than A & B.



D – 'typical' showing vigorous root suckering

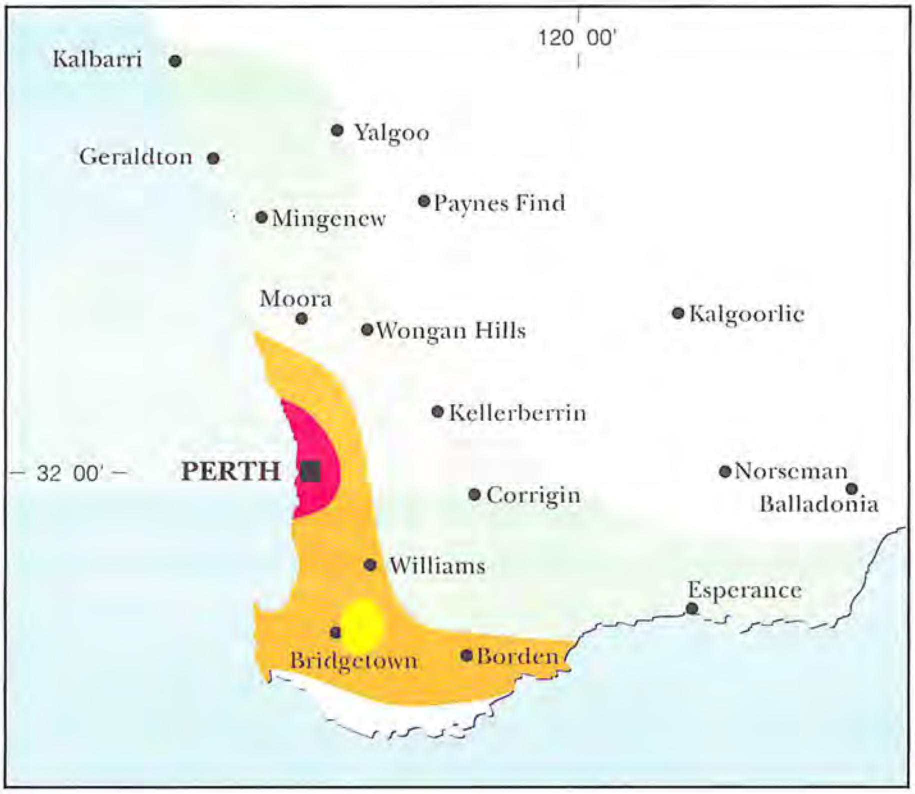
E – 'forest', crooked stems.

F – 'forest', crooked stems.

G – 'forest' variant, vigorous root suckering

H – 'forest', vigorous root suckering

I – 'Tweed River', mature tree (right) & adolescent plant (left).
(All photos: B.R. Maslin)



Map 69. Indicative distribution of *A. saligna* variants: 'typical' – green *'cyanophylla'* – red 'forest' – orange 'Tweed River' – yellow

Tunisia, Iran, Morocco, Algeria, Egypt and elsewhere (see CAB International 2000 for details). Maslin (2001) provides maps of both the native and naturalized distributions of A. *saligna* within Australia.

As noted by Doran & Turnbull (1997) A. *saligna* occurs on many soil types, especially poor and calcareous sands, but also on moderately heavy clays and a range of podzolics; in its natural habitat the species is normally found near water courses and other wet areas. Simmons (1987) reported that it is tolerant of alkaline and saline soils. Marcar *et al.* (1995) advise to expect reduced growth at EC_{se} about 5 dS/m when growing A. *saligna* on saline soils. House *et al.* (1998) report 80–100% survival at age 4.5 yrs at soil salinity up to 20 dS/m EC_{se}.

Details of the ecology of A. *saligna* is provided in Hall & Turnbull (1976a), Fox (1995), Doran & Turnbull (1997) and CAB International (2000).

Flowering and fruiting

In southern Australia A. *saligna* flowers mostly from late July to October; plants can flower precociously, within 2–3 years of planting (Maslin *et al.* 1998). Mature seeds are present between November and January. In southern Australia A. *saligna* sets moderately heavy seed crops in most years; in cultivation it sets profuse seed crops from about 6 years of age (Goor & Barney 1968). The mature pods can be rapidly harvested manually by shaking/threshing, and the seeds readily detach from the mature pods. For further details on seed production see Maslin *et al.* (1998) and Fox (1995).

Toxicity

The seeds of A. *saligna* contain protease inhibitors (Kortt 1985), but such compounds are common to many grain legumes and can be deactivated by heat treatment or cooking.

Biological features

Acacia saligna is a hardy, fast-growing species that tolerates drought, waterlogging, light frost, alkalinity and salt (Simmons 1987). It is a relatively short-lived species with a life span of about 10–20 years.

This species is usually reported as suckering very readily. Preliminary field observations in Western Australia confirm that suckering occurs in all four variants; it is particularly vigorous in the 'typical', 'forest' and 'Tweed River' variants but appears to be less vigorous in the 'cyanophylla' variant (plants of this latter variant are often seen in plantations without suckering). It is not known if factors other than root disturbance promote suckering (perhaps some plants are genetically more disposed to suckering than others; it is not known if non-suckering provenances/plants exist). It is probable that all four variants coppice, however, coppicing may possibly be more vigorous in the 'cyanophylla' variant.

Plants of *A. saligna* nodulate with certain strains of *Rhizobium* (Roughley 1987). In common with many other acacias, they form associations with VA mycorrhizal fungi (Reddell & Warren 1987). Their efficiency in fixing atmospheric nitrogen as well as mycorrhizal associations is under investigation in Tunisia (Nasr 1986 cited in El-Lakany 1987). Nakos (1977) found that the ability of *A. saligna* to fix nitrogen was greatly reduced by drought, water-logging, shading or defoliation.

See Fox (1995) for further details on the biology and growth characteristics of *A. saligna*.

Genetics

Acacia provincialis was described from cultivated material and was said by its original authors to represent a hybrid between *A. retinodes* and *A. cyanophylla* (= *A. saligna*); having inspected these original specimens they appear to be *A. retinodes* 'swamp' variant (see species profile above) ; it very unlikely that hybrids between *A. retinodes* and *A. saligna* would occur.

Cultivation

The following information on the silviculture of *A. saligna* is taken largely from Doran & Turnbull (1997). Fox (1995) provides some additional information.

Establishment

Acacia saligna can be propagated from seed or cuttings (Elliot & Jones 1982). Direct seeding (750 g pre-treated seed/ha) has been used to establish plantations on better quality, well-cultivated soils in Cyprus (Michaelides 1979). In southwest Western Australia forage plantations of *A. saligna* also have been established by mechanised direct seeding and more recently from bare rooted cuttings. This species has been successfully micropropagated in tissue culture (Jones *et al.* 1990).

The seed requires a boiling or hot water treatment to break dormancy (see Fox 1995 for details of seed viability and germination techniques). There are 45 700 viable seeds/kg with an average germination rate of 74%. Seeds should be planted to a depth of 0.5 cm and the optimum temperature for germination is in the range of 15–20°C (Doran & Turnbull 1997). Raising seedlings in the nursery and field establishment presents few problems; a nursery phase of 10–12 weeks is recommended by Doran & Turnbull (1997). Although it may be grown under light-moderate shade, plants prefer full sun and seed production will be maximised under such conditions. Young plants require protection from grazing animals.

Management

The plants respond well to light pruning and may coppice strongly, but are rather short-lived, typically 10–20 years. At least some forms of the species regrow vigorously when pollarded at about 50 cm above ground level. It may be possible to rejuvenate declining stands by coppicing and/or shallow ploughing to induce root-suckering; Michaelides (1979) has recommended a short rotation of 5–10 years duration, with regeneration by coppicing. According to Hass (1993) irrigation can double height growth over the first 17 months from planting. *Acacia saligna* plants may be damaged by a wide range of insect pests and diseases (see below). Broad-scale cultivation of *A. saligna* in southern Australia may be expected to result in a build-up of one or more of these diseases. Such anticipated problems may be minimised by establishing mixed and/or dispersed small-scale plantings, and by maintaining plants in a healthy condition, e.g. by planting at wide spacing on more difficult sites.

Trials

Assessment trials of this species were recently established in plots on farmland at various locations in south-western Australia by the "Search" project (see Acknowledgements). At age 10 months plants of the best performing provenance of *A. saligna* showed an average survival of 66% and an average height of 106 cm. The 'best' plot was located on a downslope site with light soil on the Esperance Plains IBRA region, with plants averaging 178 cm high. In other trial plots, 22 month old plants of this species showed an average survival of 61% and an average height of 156 cm; the 'best' plot was located on an upslope site with light soil in the northern Avon Wheatbelt IBRA region, with plants averaging 311 cm high.

In trials in a subtropical area in southeast Queensland, *A. saligna* attained an average height of 6.2 m after only 41 months but slowed down substantially in the following year, averaging 6.7 m at 4.5 years (Ryan & Bell 1989, 1991). Further details of growth performance of this species in pot and field trials is summarized in Fox (1995).

Yield

As summarised by Doran & Turnbull (1997) *A. saligna* grows quickly in favourable conditions, often reaching 8 m tall with a spread as great as its height in 4–5 years. Annual wood yields vary from 1.5–10 m^3/ha (National Academy of Sciences 1980). In the arid zone of Tunisia and Libya, *A. saligna* produces fuelwood at a rate of up to 3500 kg dry-wood/ha/year in deep sandy loam alluvia receiving an average of 150 mm annual precipitation and some runoff (El-Lakany 1987). Annual harvesting for biomass production was found to be optimal in drip-irrigated trials near Cairo where production of foliage was 12–13 t/ha in the first year and increased with age (El-Lakany 1988). The wide variability between trees suggested that useful gains might be obtained through breeding.

Pests and diseases

As summarised by Doran & Turnbull (1997) older plants of *A. saligna* are susceptible to gall rust, *Uromycladium tepperianum*, and various gall-exploiting insects. In parts of Western Australia more than 90% of plants bear conspicuous woody galls (Berg 1978, Gathe 1971). The natural insect enemies of *A. saligna* in Western Australia have been studied by Berg (1980, 1980a and 1980b) in order to establish the importance of natural enemies with a view to biological control of these wattles in South Africa. Larvae of 36 species of *Lepidoptera* (moths and butterflies) were found on *A. saligna*. Those damaging the phyllodes were the most common. Adults or larvae of 55 species of *Coleoptera* (beetles and weevils) and adults and/or nymphs of 40 species of *Hemiptera* (cicadas, plant hoppers, plant lice, scale insects, and bugs) were also recorded. Those feeding on sap and twigs were most abundant. Plants of *A. saligna* have extrafloral nectaries at the bases of the phyllodes. These attract ants which are believed to reduce the numbers of leaf-eating insects (Majer 1978). Rodents sometimes attack the roots. Termites may cause serious problems in tropical countries (Michaelides 1979). The species has been shown to be susceptible to locust attack in trials in Western Australia (J. Carslake, pers. comm.).

Weed potential

Acacia saligna has become naturalized in temperate parts of southern and eastern Australia, from South Australia, Victoria, Tasmania, New South Wales and southeast Queensland. Virtue & Melland (2002) regard this species as posing a significant weed risk in parts of the agricultural region of South Australia. It is considered to be an invasive weed in Chile (Stephen Midgley pers. comm.), Spain and Portugal (De la Lama 1977, cited in Fox 1995), Cyprus (Pambos Christodoulou, pers. comm.) and, as discussed by Henderson (2001), in South Africa where it is a Declared Invader (category 2) species. Until recently *A. saligna* was regarded as the most important invasive weed in the Cape Fynbos floristic region of South Africa. However, the gall rust *Uromycladium tepperianum* has been used there with high success as a biological control agent (Selincourt 1992, Morris 1999). Unfounded concerns regarding possible negative social and environmental impacts of removing large stands of *A. saligna* in South Africa are discussed by Morris (1999). Interestingly, *A. saligna* is not considered a significant weed in north Africa, despite the fact that it has been grown there for about 100 years (for soil stabilization and fodder) and where there currently exists over 200 000 ha in cultivation (Le Houerou 2002).

Wood

The wood is described by Fahn (1959) as diffuse-porous with growth rings absent. Basic density values ranges from 469 kg/m^3 to 735 kg/m^3 (mean 596 kg/m^3) based on analyses of 38 wood samples by CALM's NHT-supported 'Search' project (unpublished data). Note: This study preferentially sampled young and adolescent plants. Anatomical details of wood structure are summarised by Fox (1995).

Utilisation

Acacia saligna is a versatile hardy plant that has been widely cultivated, not only in Australia but also abroad, for a variety of purposes (Crompton 1992).

The following information on the utilisation is largely taken from the summaries provided in Doran & Turnbull (1997) and CAB International (2000). Fox (1995) provides some additional information.

Wood

Acacia saligna can be used for fuelwood or charcoal; this species was amongst a group of acacias assessed as being reasonably satisfactory for these purposes by Hall (1939). The group gave a charcoal yield of 24% and had medium specific gravity and low tar yield (13.5–17%). According to Sale (1948) a firewood harvest can be taken from dune plantings of *A. saligna* at 10–15 years. It is likely, however, that many other species of *Acacia* would produce a better-quality fuelwood than this one. *Acacia saligna* wood has been successfully converted into particle board in Tunisia (El-Lakany 1987) and in the Mediterranean region it is used for vine stakes and for small agricultural implements (Michaelides 1979).

Fodder

Acacia saligna appears to have fairly good potential as a fodder plant if lines of higher potential feeding value are selected. The phyllodes, young shoots, pods and seeds, whether fresh or dry, are protein-rich and non-toxic and palatable to both sheep and goats (Anon. 1955, Michaelides 1979, Dumancic & Le Houerou 1981). El-Lakany (1987) summarised the results of fodder studies by Le Houerou and others, and reported that the composition of *A. saligna* was within the following ranges: dry matter (50–55%), crude protein (12–16%), crude fibre (20–24%), crude fat (6–9%), and ash (10–12%). Although the phyllodes are reported to have a high protein content, the presence of secondary compounds, including condensed tannins, may limit feeding value. They apparently have low or moderately low digestibility, at least in some situations (this matter requires further investigation, see Howard *et al.* 2002). For example, trial plantings of *A. saligna* in southeast Queensland showed its phyllodes to have high levels of crude protein (18.3%) but a very low predicted in vivo digestibility (36.5%) (Vercoe 1989). Over 200 000 ha of *A. saligna* has been planted in north Africa and a few thousand in West Asia and southeast Spain where the species is highly valued as food for sheep and goats (El-Lakany 1987, Crompton 1992, Le Houerou 2002: this last reference is particularly informative and is well illustrated with colour photographs). However, there are indications that the response of animals to grazing *A. saligna* is variable, depending upon breed. For example, based on work in South Africa, it appears that some breeds of sheep have a greater ability to digest *A. saligna* than others, possibly due to differences in gut flora (Lefroy, pers. comm.). Also, under trial conditions in Cyprus goats lost weight when fed on *A. saligna* only (Fox 1995). According to Lefroy *et al.* (1992) the advantage (in Western Australia) of using *A. saligna* is that it is easily established at relatively low cost, but a disadvantage is that the plants have to be cut regularly to make the foliage available to the animals; this study suggests that A. *saligna* is most effective as a fodder when used in combination with other plants such as Tagasaste (*Chamaecytisus palmensis*) and/or perennial grasses. Crushed seeds have been fed to a concentration of 95% of total ration to sheep without ill effects (but results with poultry were not encouraging) (Anon. 1955).

Recent studies by Howard *et al.* (2002) have examined the value of A. *saligna* as a fodder plant in Western Australia (see also Dynes & Schlinck 2002). The feeding value of Acacia is a function both of the amount of the material an animal will eat (voluntary feed intake) and the efficiency with which the animal can utilise nutrients. Being a leguminous plant, A. *saligna* will usually contain sufficient crude protein for grazing ruminants (minimum 6% CP). However the presence of secondary compounds, including tannins may limit voluntary feed intake through both preingestive (taste) and post ingestive (toxic) effects. Tannins suppress food intake by reducing macronutrient digestibility and cause illness. Tannins are potentially beneficial at low levels (<6%) but voluntary feed intake declines rapidly as tannin concentrations increase above that level.

The variability in predicted digestibility of A. *saligna* requires further research. Forage digestibilities of about 50% or higher are usually required for maintenance of liveweight in ruminants. Howard *et al.* (2002) found digestibility of 30–40% in their first experiment while in a second line of A. *saligna* digestibilities exceeded 50%. Digestibility differences probably accounted for most of the differences in animal performance. To have potential as a fodder, lines must be selected with phyllode digestibility exceeding 50%. Lower digestibility material may have a role in survival feeding, however, as Howard *et al.* (2002) reported, at very low digestibilities sheep will consume very small amounts of A. *saligna*, with little benefit.

Land use and environmental

Because A. *saligna* is highly variable in its growth form and displays a wide range of ecological tolerance it has excellent potential for use in salinity and soil erosion control, as a windbreak, visual screen and for shade and shelter for both stock and wildlife. In Australia it has been widely used for coastal sand dune stabilisation, and for minesite rehabilitation, for example, on Stradbroke Island and Saraji (north-east of Clermont) in Queensland and at Worsley and Collie in Western Australia (Barr & Atkinson 1970, Langkamp & Plaisted 1987). In southwest Western Australia it is a successful farm tree for reduction of water tables and mitigation of salinity, provision of shade and shelter and reduction in farm nutrient run-off. It is suited to heavy somewhat saline and waterlogged clay soils where it gives fast growth, excellent survival and large crown growth (Bennett & George 1993). *Acacia saligna* has been successfully established by direct sowing in regions with annual rainfall as low as 350–500 mm (Scheltema 1992). Wilcox *et al.* (1996) recommend its use for a variety of soil types in the Midlands and northern wheatbelt regions of the Western Australian wheatbelt, Clarke (1998) regards it as being suited to revegetating drainage lines in these areas and Lefroy *et al.* (1991) recommend its use for 'Grevillea' country (i.e. upland sandplain areas characterized by deep yellow, neutral to acidic sand over deep yellow sandy clay) in the central wheatbelt region. The tree is used extensively for coastal and inland sand dune fixation in North Africa, the Middle East and South Africa and for gully erosion control in Uruguay (see Fox 1995 for further details).

Human food

Acacia saligna is one of the promising species suggested by Maslin *et al.* (1998) for trialling in southern Australia as a source of seed for human food. The seeds had reportedly been consumed by Aborigines (Cherikoff & Isaacs 1989); they were probably ground into flour and eaten with pounded root bark from various eucalypts (P. Bindon, pers. comm.). As already noted, A. *saligna* seed contains protease inhibitors but these are deactivated by heat treatment or cooking.

Physiological stress or mechanical damage to the bark may induce copious gum flows: the acid-stable gum may have use in certain foodstuffs (Michaelides 1979). An analysis of the gum has been provided by Charlson *et al.* (1955) and Kaplan & Stephen (1967, cited in Anderson & Bell 1976).

Tannin

Acacia saligna was at one time the principal source of tan bark in southwest Western Australia, with a yield of nearly 30% tannins (Maiden 1889). It was also previously a major source of tannin in South Africa before being replaced by superior tanbarks (of *A. mearnsii*) (Boucher & Stirton 1980).

Other uses

This species has been widely cultivated (both within Australia and abroad) as an ornamental. Its phyllodes can be used to dye wool to a lemon yellow colour using an alum mordant (Martin 1974).

Potential for crop development

Acacia saligna is one of the most promising of all the species included in this report. It is ranked as a category 1 species and would seem suited to both a phase and coppice crop (Table 6). It is a fast growing, hardy, adaptable species that is drought tolerant, grows on a wide range of soils, generally develops a good growth form, produces good quantity of woody biomass and coppices well. However, as noted below there is variation for most of these attributes and not all are equally expressed in each of the four variants that are provisionally recognized for this species. Therefore, the selection of the appropriate provenance for utilisation will be an important factor in the development of *A. saligna* as a crop plant.

Acacia saligna has had a long history of multipurpose utilisation, both within Australia and abroad. It is widespread and common throughout its range in southwest Western Australia and is currently used in that region for revegetation and in a few agroforestry trial plantings. This species is therefore already quite well 'known' to people, some of whom are very enthusiastic about its potential for lowering water tables and its potential as a fodder plant. However, it is probably true to say that some of this enthusiasm is based on anecdotal or as yet unsubstantiated evidence.

Ahead of any extensive utilisation of *A. saligna* it is essential to develop a better understanding of its patterns of variation. This applies not only to well-known variable characters such as phyllode shape and size, but also to economically important biological attributes such as growth form, biomass production, suckering, coppicing propensity and fodder value which have a direct bearing on its utilisation potential. As discussed above preliminary taxonomic research indicates that four main variants can be recognized within the species, namely, the 'typical', 'cyanophylla', 'forest' and 'Tweed River' variants. Each of these variants has its own set of morphological, ecological and biological attributes, and a better understanding of these will provide a sounder basis for the effective management and utilisation of *A. saligna* worldwide. Taxonomic resolution of *A. saligna* and documentation of the variants will permit a more judicious selection of provenances for trialling as potential crop plants for large volume wood production.

All the variants of *A. saligna* are capable of producing a good growth form but they all have the capacity to develop an untidy, spreading shrubby habit. Furthermore, the 'forest' variant very often has crooked stems and branches and, along with the 'typical' variant in particular, may become very spindly under certain conditions. A similar range of variation is found among the variants for wood biomass production. The wood of *A. saligna* is pale coloured and its low basic density places it within the range of being suitable for reconstituted wood products. As noted above basic density values range from 469 kg/m^3 to 735 kg/m^3 so there is clearly variation for this character.

It is reported that *A. saligna* can flower within 2–3 years of planting and it is independently reported that plants set profuse seed crops from about age 6 years (see under **Flowering and fruiting** above). The age at which plants first set large seed crops has implications for their management as a phase crop because fruiting precocity may result in the creation of a soil seed bank which could lead to the species becoming a weed in adjacent and subsequent crops. One strategy for avoiding this weed problem is to harvest plants before they set seed, however, for this to be a viable strategy the plants will need to have produced sufficient wood biomass by that stage. A possible alternative is simply to treat the regenerating seedlings as a form of green manure. The propensity for A. *saligna* to root-sucker in nature may or may not be advantageous in cultivation, it depends whether or not this attribute is required (or expressed) for the system in which it is placed. Preliminary observations suggest that the 'cyanophylla' variant has the lowest suckering propensity of the four variants of A. *saligna*; indeed, in plantings of this variant sucker growth is rarely (if ever) seen. However, suckering propensity in this species requires further careful study.

Acacia saligna is reported to have a strong coppicing ability and we have observed this ourselves in a number of plantings. While all four variants probably have the potential to coppice most previous records are likely to have been derived from plants of the 'cyanophylla' variant. Unfortunately there is no reliable trial information available on coppicing in A. *saligna*. Therefore it is not known if resprouting occurs with sufficient frequency or vigor to sustain the species as a viable coppice crop, or indeed, which of the variants is most suited to such a regime. Research into this important attribute is recommended.

Additional benefit that might be derived from A. *saligna*, apart from its wood biomass production and use in landscape amelioration, may be its fodder potential and its provision of seed for human food. Apart from advantages that might accrue in Australia from using A. *saligna* the possibility of economic returns from exporting knowledge (and verified/improved seed) to overseas users should not be overlooked.

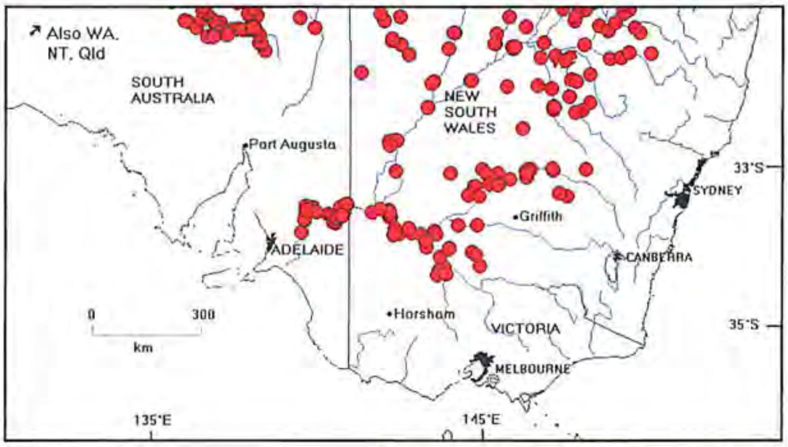
An issue associated with any development of A. *saligna* as a crop is its potential weediness. Under normal circumstances the species produces large quantities of seed and some plants at least display strong root suckering. *Acacia saligna* is reported to be an environmental weed in places outside its natural range in Australia (eg. South Australia, see Virtue & Melland 2002) and in a number of countries abroad (especially South Africa, see Henderson 2001). Therefore caution must be exercised in any wide-scale use of A. *saligna*, and such use must be accompanied by a thorough weed risk assessment. The potential weed risk associated with this species may constrain its use to its native geographic range (see also discussion on other possible weed reduction strategies under **Weed potential of *Acacia* in target area** in the introduction to the report).

The area predicted to be climatically suitable for the cultivation of A. *saligna*, based on its natural climatic parameters, is shown in Map 68. This analysis indicates that A. *saligna* has the potential to be grown throughout the winter rainfall zones in both the eastern and western target areas. However, because the analysis was based on rainfall seasonality in the species natural habitat, uniform and summer rainfall parameters were not included. Were these included then the area predicted as being climatically suitable for growth would be considerably larger, particularly in the eastern target area. Under cultivation in uniform and summer rainfall zones during the past 50 years, A. *saligna* has demonstrated vigorous growth performance. Considerable ecological plasticity and provenance variation is apparent in this species suggesting that it has the potential for cultivation on most soil types and a range of landforms throughout the entire target area.

Acacia stenophylla A. Cunn. ex Benth.

Common Names

River Cooba (Standard Trade Name), River Myall, Eumong, Gurley, and many more (see Cunningham *et al.* 1981).



Map 70. Distribution of *A. stenophylla*.

Habit

Somewhat bushy tall shrubs or trees mostly 4–12 m tall but can reach 20 m on very favourable sites (fide Hall *et al.* 1972), single-stemmed or divided into several stems about 1 m or more above the ground, the trunks may become mis-shapen (Cunningham *et al.* 1981), often with a weeping habit due to pendulous branches, freely root suckering. Bark dark grey-brown, rough and fissured.

Botanical descriptions and illustrations/photographs are provided by Cunningham *et al.* (1981), Simmons (1988), Whibley & Symon (1992), Tame (1992), Doran & Turnbull (1997), Cowan & Maslin (2001 & 2001a) and Kodela (2002).

Taxonomy

Acacia stenophylla is referable to *Acacia* section *Plurinerves* a diverse, and probably artificial, group of about 212 species (Maslin 2001) which are characterized by having plurinerved phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). Species of section *Plurinerves* are widespread in Australia with the main centres of richness located in the inland areas of the southwest and southeast of the continent (Hnatiuk & Maslin 1988, Maslin & Pedley 1988). Five species of section *Plurinerves* are detailed in this report, namely, *A. cyclops*, *A. implexa*, *A. melanoxylon*, *A. stenophylla* and *A.* aff. *redolens*

Close relatives unknown, however, *A. stenophylla* is frequently confused with and bears a superficial resemblance to the widespread arid zone species *A. coriacea* (Cowan & Maslin 1993).


Map 71. Predicted area (blue) where *A. stenophylla* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 70), see also Table 5. Target area shown in yellow.

Distribution and habitat

Very widely distributed in inland arid areas of Australia where it ranges from north-eastern Western Australia (with a disjunct occurrence in the Pilbara region), east through Northern Territory to Queenlsand (west of the Great Divide) and south to the Murray-Lachlan-Darling River system in New South Wales, Victoria and South Australia; it is disjunct in S.A. between Lake Eyre and the Murray River. *Acacia stenophylla* reaches the drier regions of the target area (along water courses) in South Australia, Victoria and New South Wales. It has not been widely introduced into countries abroad: CAB International

Figure 35. *Acacia stenophylla*

A – Suckering, roadside stand (sub-mature plants) near Condobolin, N.S.W.; insert showing mature stem base. (Photos: B.R. Maslin)

B – Adolescent plant in open site, Tambo-Barcoo River, Queensland. (Photo: Anonymous)

C – Adolescent stand (probably suckering), Wallamundry, N.S.W. (Photo: P. Macdonell)

D – Large spreading plant, Oodnadatta Track, S.A. (Photo: M. McDonald)

E – Stem core. (Photo: P. Macdonell)

(2000) lists those countries where it is grown. Usually grows in heavy alcaline clays along watercourses subject to periodic flooding. Comprehensive summaries of its habitat characteristics are given in Doran & Turnbull (1997) and CAB International (2000); see also Pedley (1978), Cunningham *et al.* (1981) and Whibley & Symon (1992).

Flowering and fruiting

Mostly reported to flower irregularly throughout the year, or from March to July. Pods mature from September to about December in Queensland (Pedley 1978) and February to May in South Australia (Bonney 1994). This species is capable of producing very large seed crops (Turnbull 1986) but because pods are indehiscent or tardily dehiscent this is one of the most difficult *Acacia* species from which to collect and process seeds. Parrots and galahs are known to eat seeds out of pods (Bonney 1994).

Biological features

Acacia stenophylla is highly salt-tolerant (expect significant growth reduction at EC_e about 10–15 dS/m with reduced survival above 15 dS/m) and tolerant of alkalinity and periodic flooding. It is adapted to a wide climatic range, is moderately drought tolerant and will tolerate moderate frosts. It has a moderate to fast growth rate. Coppicing and vigorous root suckering have been noted in natural stands (Searle 1989, Bonney 1994) and planted trees coppice well (Marcar *et al.* in prep.). The above information is taken from Turnbull (1986), Marcar *et al.* (1995), Doran & Turnbull (1997) and CAB International (2000).

Cultivation

The following information is taken from Doran & Turnbull ((1997) and CAB International (2000).

Establishment

Propagation is by seed that has been immersed in near-boiling water (90°C) for 1 minute. Manual and acid scarification are also effective seed pretreatments, but the standard boiling water treatment at 100°C is too severe (Doran & Gunn 1987). Germination rate averages 73% and there are 10 600 viable seeds/kg. *Acacia stenophylla* is typically planted as a seedling but can also be direct seeded. Planting should be done with tubed stock when the ground is moist, in late summer or early autumn (Brown & Hall 1968). The species may be amenable to micropropagation (Crawford & Hartney 1987).

Yield

Acacia stenophylla has given variable performance in trials, often surviving only poorly when planted on acid, freely draining sites to which it is poorly adapted (e.g. Chege & Stewart 1991, Kimondo 1991, Ryan & Bell 1991). Where survival has been good (about 80%), mean annual increments for height growth are in the range 0.8–1.7 m. The best growth reported was on a sodic site in Pakistan where trees averaged 2.3 m tall and individual trees were as high as 4.2 m at 16 months (Marcar *et al.* 1991). Ansari *et al.* (1998) report a mean (of two provenances) survival and growth of 45% and 3.75 m at 36 months on a highly saline site (EC_e range 5–40 dS/m) in Pakistan subject to seasonal flooding. On a degraded pasture site in south-east Queensland, Wilson (1998) reported that *A. stenophylla* grew only 2.9 m in 8 years. In a trial established on the northwest coast of Egypt, above-ground biomass of 3 year old *A. stenophylla* trees was amongst the highest of 17 tree species tested, with 13–28 kg/tree (El Osta & Megahed 1992).

Provenance variation

Marked variation in form of provenances has been noted (Marcar *et al.* 1995 and in prep.), indicating the need to test a range of provenances in introductory trials.

Pests and diseases

No major insect pests have been reported for *A. stenophylla* in Australia and susceptibility of foliage and stems to insect damage is considered low (Marcar *et al.* 1995), but seeds are sometimes heavily attacked by insects Doran &.Turnbull (1997). Symptoms of bunchy top (loss of apical dominance and development of a large number of side shoots from the axils of the condensed stem) due to the strawberry thrip (*Scirtothrips dorsalis*) were found in glasshouse-grown *A. stenophylla* (Ashwath & Houston 1990, cited in CAB International 2000). Whibley & Symon (1992) report a few records of mistletoes (*Lysiana exocarpi* and *Amyema preissii*) from this species.

Weed potential

Acacia stenophylla is considered a woody weed in parts of the Channel country in north-western Queensland. The best method of control has been by use of 2,4,5-T, however, the most practical is burning (Pressland *et al.* 1989).

Wood

According to Maiden (1889) the wood is very hard, heavy, close-grained, dark coloured, beautifully marked and takes a fine polish; it planes excellently and shows a very smooth surface. The basic density is given as 690–750 kg/m^3 by Ilic *et al.* (2000)*; Davis (1994) gives its air-dry density as 900 kg/m^3.

Utilisation

Wood

Acacia stenophylla produces an excellent fuel (Hall *et al.* 1972) and its timber is suitable for furniture and fenceposts (Marcar *et al.* 1995).

Land use and environmental

This attractive willow-like tree is useful for planting in inland areas as an ornamental, and because of its bushy crowns, for shade and as a windbreak. It is useful for soil stabilization, where its suckering propensity is an advantage (Stelling 1998). As noted in CAB International (2000) *A. stenophylla* has the potential to be grown in agroforestry combinations with pastures. Wilson (1998) reported that growth of green panic grass was not reduced by planting *A. stenophylla* trees at 5 m spacing, in contrast to *Eucalyptus argophloia*, and this was related to lower shading and water use.

Fodder

Rarely grazed by stock in western New South Wales (Cunningham *et al.* 1981), however, Everist (1969) reports that it is eaten fairly readily although it is not cut to any extend for drought feed. Vercoe (1987) estimated an *in vivo* dry matter digestibility of 43% and crude protein level of 11% for phyllodes in one trial, however, a second study on different material was less promising, suggesting variation between provenances (Vercoe 1989).

Other uses

Seeds and pods were roasted and used by Australian Aboriginal people as a food source (Cribb & Cribb 1976), however, it is not one of the species recommended by Maslin *et al.* (1998) for widescale planting as a source of human food. CAB International (2000) provides further details on the utilisation of this species.

Potential for crop development

Acacia stenophylla is regarded as having only moderate prospects as a crop plant for high volume wood production within the target area. Nevertheless, this hardy, long-lived, highly salt tolerant species has

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* The density range cited here represents a compilation of the Basic Density and the Estimated Basic Density from Air-dry (12%) MC values that are cited in Ilic et al. (2000).

a number of desirable attributes. It is ranked a category 3 species and has potential for development as both a phase and long cycle crop (Table 6). Although the species is reported to coppice well it remains to be seen if this growth is sufficiently vigorous to sustain it as a coppice crop. In the drier inland areas where the species grows naturally there are not that many crop options available. *Acacia stenophylla* has a moderate to fast growth rate but is only moderately drought-tolerant and plantings in arid areas should be limited to sites where supplementary water is available. It is capable of producing good quantities of woody biomass, however, there is much variation in stem form and stems with poor form are not uncommon. The wood is moderately dense which lowers its attraction for use in reconstituted wood products. However, the wood is attractively marked and takes a fine polish therefore it may have value in specialty applications such as furniture production; such uses increase the species appeal as a long cycle crop plant. *Acacia stenophylla* is capable of producing large quantities of seed and these would result in the creation of a soil seed bank that may lead to weed problems in adjacent or subsequent annual crops. (Alternatively young seedlings may possibly be treated as a form of green manure.) A strategy for avoiding soil seed build up would be to harvest plants before they set pods, but for this to be a viable option it would require that the plants will have produced acceptable quantities of wood by then. The propensity for A. *stenophylla* to vigorously root-sucker in nature may or may not be advantageous in cultivation, it depends whether or not this attribute is required (or expressed) for the system in which it is placed.

Acacia stenophylla has given variable performance in trials. Furthermore, there is variation in stem and growth form and in its fodder value. This indicates the need to test a range of provenances for this species in selecting those suitable for introductory crop trials. Although A. *stenophylla* produces large seed crops the pods are somewhat indehiscent so this may pose difficulties in collection of the germplasm.

The area predicted to be climatically suitable for the cultivation of A. *stenophylla,* based on its natural climatic parameters but excluding areas with <250mm mean annual rainfall, is shown in Map 71. This analysis indicates that climatic conditions exist throughout large parts of both the eastern and western target areas that are suitable for the cultivation of A. *stenophylla*. However, in its natural habitat the species has a strong preference for heavy clay soils, high watertables and it invariably grows in close proximity to water courses. If this habitat specificity is demonstrated in performance trials this may mitigate against its widespread use in cultivation.

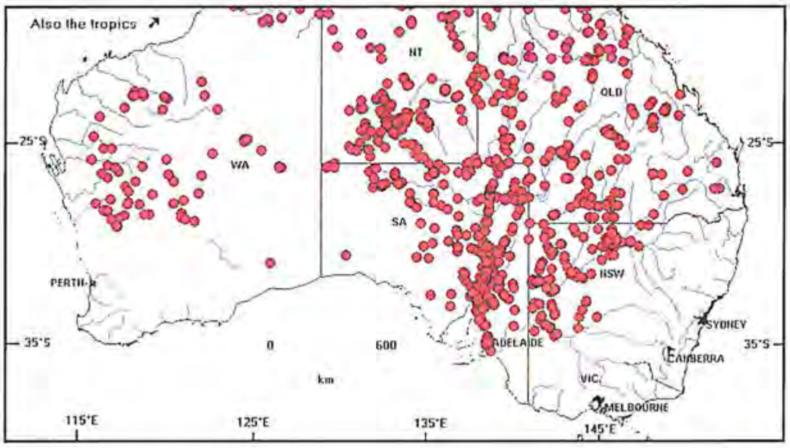
This very widespread species is considered a woody weed in parts of Queensland. Therefore, any wide-scale use of A. *stenophylla* should be accompanied by a weed risk assessment.

Because A. *stenophylla* has been tested and used abroad there exists a reasonable body of knowledge which should greatly facilitate any attempt to develop it as a crop plant in Australia.

Acacia victoriae Benth.

Common Names

Elegant Wattle, Gundabluey, Prickly Wattle, Bramble Wattle and more, see Cunningham *et al.* (1981).



Map 72. Distribution of *A. victoriae.*

Habit

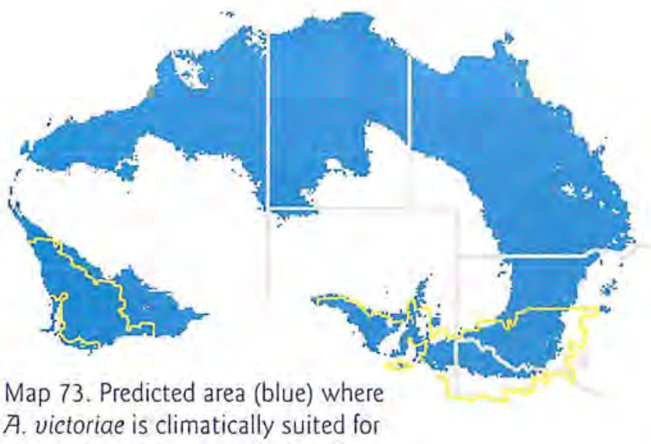
Spreading, often straggly or brambly shrubs or trees 2–5 (–9) m tall, with a short single trunk or sparingly divided at ground level, main stems rather crooked and commonly about 6 cm dbh but can reach 12–14 (–21) cm, branches often invested with spiny stipules (especially evident when young, commonly absent from mature plants), readily root suckering and sometimes forming thickets. Bark thin, smooth or (towards base of main stems) finely fissured. Root system reported by Maiden (1889) to be extremely deep, estimated to exceed 20 m (but this would need verification).

Botanical descriptions and illustrations/photographs are provided by Cunningham *et al.* (1981), Costermans (1981), Simmons (1987), Turnbull (1986), Whibley & Symon (1992), Tame (1992), Bonney (1994), Doran & Turnbull (1997), Maslin (2001 & 2001a) and Kodela (2002).

Taxonomy

Acacia victoriae is referable to *Acacia* section *Phyllodineae*, a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion).

Acacia victoriae along with nine close relatives comprise the '*Acacia victoriae* group' whose centre of diversity is located in Western Australia (Maslin 1992); only *A. victoriae* itself is included in the report. *Acacia victoriae* is not far removed taxonomically from *A. murrayana* (see above). Over its considerable geographic range *A. victoriae* is somewhat variable, especially in phyllode shape and size (Maslin 1992). The taxonomic status of a hairy variant, described as *A. victoriae* subsp. *arida*, requires further investigation: this variant occurs in a somewhat restricted geographic area in southern Northern Territory, northern South Australia, western New South Wales and southwest Queensland.



Map 73. Predicted area (blue) where *A. victoriae* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 72), see also Table 5. Target area shown in yellow.

Distribution and habitat

Widespread in arid and sub-tropical areas of all mainland States of Australia except Victoria (where it is confined to the extreme northwest of that State, near Mildura and in The Sunset Country). This species only just reaches the target area in the northern wheatbelt of Western

Figure 36. *Acacia victoriae*

A – Mature plant near Mildura (one of the largest specimens seen of this species). (Photo: B.R. Maslin)

B – Young pruinose stems with persistent stipular spines. (Photo: B.R. Maslin)

C – Section of stem. (Photo: B.R. Maslin)

D – Multi-stemmed shrub. (Photo: B.R. Maslin)

E – Fruiting branches (pods prolific & papery). (Photo: J. Morse)

F – 2 year old plants in trial at Morawa; juvenile plants brambly & spiny. (Photo: J. Carslake)

G – Flowering branch (heads pale-coloured & in racemes). (Photo: B.R. Maslin)

Australia but it is more common (in inland areas) of the region in the east. *Acacia victoriae* is one of only four species in this report that occur in both the eastern and westen target areas (the other three are *A. cyclops*, *A. hakeoides* and *A. murrayana*). Over its extensive range *A. victoriae* occurs in a variety of habitats but is commonly found in clay or loam on alluvial flats (subsp. *arida* occurs on sand, see Pedley 1980). Soils range from acid to alkaline or subsaline, and shallow to deep (Turnbull 1986). A comprehensive summary of its habitat characteristics is given in Hall *et al.* (1981a), Turnbull (1986) and Fowler & Fox (1995).

Flowering and fruiting

Phenology is variable. Flowering occurs from August to December (late winter to early summer) and appears to vary depending upon where the plants occur (Fowler & Fox 1995). Although flowering is sometimes irregular it does not appear to be dependent upon the incidence of rain (Askew & Mitchell 1978). Most sources record mature seeds occurring between about October and December, however, Pedley (1980) gives August to October and Bonney (1994) gives November to March. Pods are produced in great profusion and are easily collected by hand (shaking/threshing); they may be shed unopened or may open on the plant with the seeds remaining attached by the funicle.

Biological features

As summarised by Turnbull (1986) *A. victoriae* is an adaptable species that is moderately fast-growing, relatively short-lived (probably has a life-span of about 10–15 years) and moderately frost and salt tolerant. It is moderately drought tolerant but is killed by severe droughts, it recovers well after light grazing and is moderately fire tolerant when young (Askew & Mitchell 1978). It readily root suckers and has a large root system (Hall *et al.* 1981a); Maiden (1889) reported roots extend to more than 20 m. Its coppicing ability requires further investigation; according to L. Thomson (pers. comm.) coppicing may possibly be related to the age of the plant (with older plants not coppicing well) or varies with provenance. The report by Thomson (1991) that *A. victoriae* coppices may possibly include observations from plants that are now referred to *A. synchronicia*. Further details on the biology of the species are given in Fowler & Fox (1995).

Cultivation

There are few reliable growth data for this species. However, in Iran it is reported to have attained 1.5 m in one year, a similar growth rate to that of *A. stenophylla* (Webb 1973 unpublished, cited in Turnbull 1986). It has shown good survival and growth in Israel and India, but has been less successful in dry tropical West Africa (CTFT 1983 unpublished, cited in Turnbull 1986).

Trials

Assessment trials of this species were recently established in plots on farmland at various locations in south-western Australia by the "Search" project (see Acknowledgements). At age 22 months plants of the best performing provenance of *A. victoriae* showed an average survival of 53% and an average height of 64 cm. The 'best' plot was located on a downslope site with heavy soil in northern Avon Wheatbelt IBRA region, with plants averaging 110 cm high. This growth performance for *A. victoriae* was not as good as that achieved by *A. murrayana* and compared poorly with that of *A. saligna*.

Pests and diseases

Arboretum plants may be susceptible to root rot (Fowler and Fox 1995). Six species of Mistletoe have been recorded from this species in South Australia (Whibley & Symon 1992) and in central Australia there appears to be a relationship between mistletoe numbers and tree mortality (Reid *et al.* 1992).

Weed potential

In some areas plant numbers may increase markedly during a succession of wet seasons and the species can become a nuisance, especially around watering points (Everist 1969).

Wood

Basic density values range from 739 kg/m^3 to 890 kg/m^3 (mean 814 kg/m^3) based on analyses of 2 wood samples by CALM's NHT-supported 'Search' project (unpublished data). Note: This study preferentially sampled young and adolescent plants. Ilic *et al.* (2000) gives the air-dry density before reconditioning as 804 kg/m^3, based on 7 samples tested (note: this value was erroneously listed in the basic density column in this work). Based on our limited field sample this species produces a fair amount of sapwood relative to its dark brown heartwood and the wood is reasonably light relative to its volume; very minor end splitting occurred upon drying due to shrinkage in our wood sample.

Utilisation

Wood

Acacia victoriae is listed as highly suitable for the production of fuel wood and charcoal abroad by Thomson *et al.* (1994).

Land use and environmental

Useful as a low windbreak and for soil stabilisation in dry country (Turnbull 1986), especially as it can readily regenerate from suckers and sometimes forms thickets; however, as already noted, in some areas numbers may increase markedly during a succession of wet seasons and can become a nuisance, especially around watering points. Because of its moderate to fast growth rate and moderate salt tolerance *A. victoriae* has been used in land reclamation and mine site rehabilitation work in arid areas of Western Australia (Fowler & Fox 1995). Native stands of this species provide good protection for small mammals and birds; its seeds are a source of food for many birds (Bonney 1994), including emus (Davies 1976, 1978).

Fodder

Acacia victoriae is a useful species for providing valuable food supplement for stock in arid and semi-arid areas. However, it is killed by severe drought and, according to Petheram & Kok (1983), also by severe browsing, but recovers well following light browsing. The phyllodes have moderate palatability and digestibility (although foliage is usually not produced in particularly large amounts), and the seeds are a good source of protein for cattle. For further fodder details see Chippendale & Jephcott (1963), Askew & Mitchell (1978), Turnbull (1986) and Mitchell & Wilcox (1994).

Human food

The seeds of *A. victoriae* have good nutritional characteristics and they were commonly used as a food by aborigines; this is also the most important species in the emerging 'bush tucker' industry (see Maslin *et al.* 1998 for details). The branches exude a clear, tasteless gum which seems to have qualities for use in foods and industry (National Academy of Sciences 1979), however, under natural conditions the quantity of gum produced is not especially large. An analysis of gum characteristics is given in Anderson & McDougal (1988).

Medicinal

Results of studies by Mujoo *et al.* (2001) suggest that triterpenoid saponins from *A. victoriae* have potential as novel anticancer agents.

Other uses

It is a good source of pollen for bees, especially at Alice Springs (Boomsma 1972).

Potential for crop development

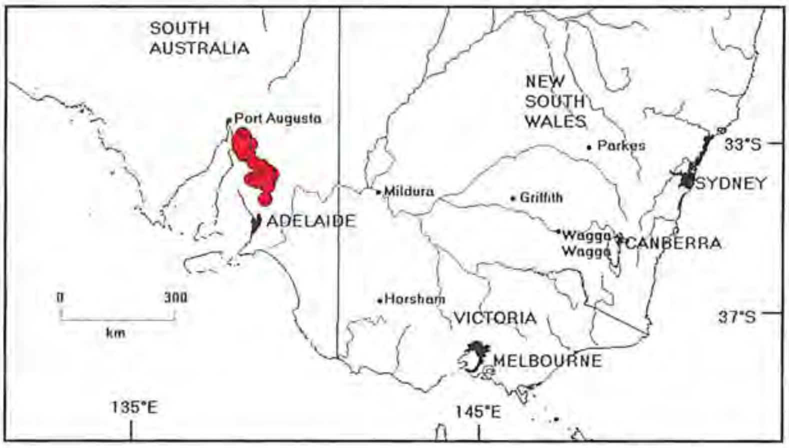
Acacia victoriae is regarded as having only moderate prospects as a crop plant for high volume wood production. However, in the drier inland areas where it grows naturally there are not that many options available. It is ranked as a priority 3 species and its growth characteristics suggest that it may have some potential for development as a phase crop (Table 6), although its vigorous suckering propensity may present difficulties for its management. *Acacia victoriae* is an adaptable, primary colonizer species characterized by having a fast to moderately fast growth rate, an extensive and deep root system and a fair degree of edaphic adaptability (including alkaline and subsaline soils). Its moderate fodder value and its importance as a source of seed for human consumption adds to its attraction as a potential crop plant. The main disadvantages of *A. victoriae* are its spiny nature (particularly the young plants), poor stem form (rather crooked) and the small dimensions of its wood (although some provenances, plants from near Mildura for example, do produce reasonable quantities of woody biomass, see Fig. 36A). Wood density values are moderately high which lowers the species attraction for use in reconstituted wood products. Because *A. victoriae* produces large quantities of seed (presumably at an early age) this would result in the creation of a soil seed bank that may lead to weed problems in adjacent or subsequent annual crops. (Alternatively young seedlings may possibly be treated as a form of green manure.) One strategy for avoiding soil seed build up is to harvest plants before they flower or fruit; however, for this to be a viable strategy the plants will need to have produced suitable quantities of wood by then. Under natural conditions *A. victoriae* relies on wet conditions for growth and it remains to be seen how well it will grow as water becomes limiting in cultivation (limited experience from dry area silviculture abroad has produced variable results). The propensity for *A. victoriae* to vigorously root-sucker in nature may or may not be advantageous in cultivation, it depends whether or not this attribute is required (or expressed) for the system in which it is placed. As noted by Everist (1969) if rainfall is high this species may regenerate rapidly and form undesirable thickets.

The area predicted to be climatically suitable for the cultivation of *A. victoriae*, based on its natural climatic parameters but excluding areas with <250mm mean annual rainfall, is shown in Map 73. This analysis indicates that *A. victoriae* is well suited to climatic conditions throughout large areas of both the eastern and western target areas. The prediction suggests cultivation is possible throughout the 250–500 mm rainfall zone. Within this zone the species would be probably be expected to perform best on heavy calcareous soils where its roots can access the watertable.

Acacia wattsiana F. Muell. ex Benth.

Common Names

Watt's Wattle, Dog Wattle.



Map 74. Distribution of *A. wattsiana.*

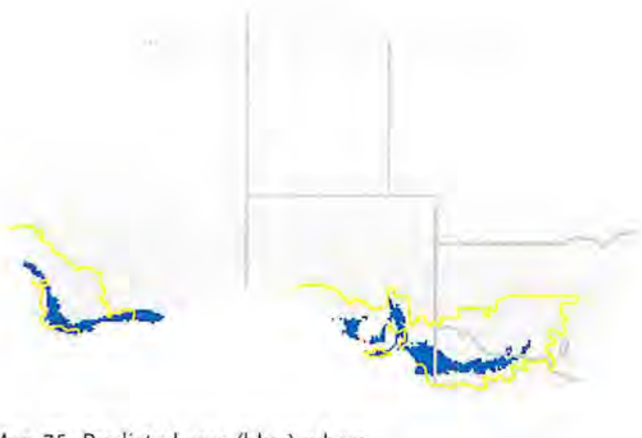
Habit

Erect, hardy, rounded to narrowly obconic shrubs mostly 1–4 m high (can reach 6 m in the Tothill Range, D. Kraehenbuehl pers. comm.), crowns rather bushy and spreading to 4 m across in open sites but narrower with more erect branches in dense stands, single-stemmed or dividing into a few main stems from near ground level, main stems straight to sub-straight and reach 6–9 cm dbh (it is estimated, based on a crude assessment of growth rings, that it would take 15–20 years to attain this diameter). Bark smooth, thin, grey.

Botanical descriptions and illustrations/photographs are provided by Costermans (1981), Simmons (1988), Whibley & Symon (1992) and Maslin (2001 & 2001a).

Taxonomy

Acacia wattsiana is referable to *Acacia* section *Phyllodineae,* a diverse, and probably artificial, group of about 408 species (Maslin 2001) which are characterized by having '1-nerved' phyllodes and flowers arranged in globular heads (see Maslin & Stirton 1998 and Maslin 2001 for discussion). More specifically this species is a South Australian member of the Australia-wide '*Acacia microbotrya* group' (Maslin 1995). A number of other species from this group are detailed in this report, namely, *A. bartleana, A. euthycarpa, A. microbotrya, A. retinodes* and *A. rivalis. Acacia wattsiana* is most closely related to *A. spooneri, A. quornensis* and *A. chalkeri,* none of which are considered prospective taxa for development as crop plants for wood production.



Map 75. Predicted area (blue) where *A. wattsiana* is climatically suited for cultivation; this area is derived from a bioclimatic analysis of the natural distribution (red circles, Map 74), see also Table 5. Target area shown in yellow.

Conservation status

This species is not regarded as having any State conservation significance for South Australia (Peter Lang, pers. comm.) despite having been listed in Lang & Kraehenbuehl (1987) as Rare.

Distribution and habitat

Confined to the target area in South Australia where it has a restricted distribution in the agricultural region from near Melrose in the southern Flinders Range, south to Clare and Tothill Ranges in the Northern Lofty region. Common in the places where it occurs. Grows in

Figure 37. *Acacia wattsiana*

A – Mature shrub in open site, with spreading, dense crown (insert showing stem base). (Photos: B.R. Maslin)

B – Mature shrub in dense roadside vegetation, erect habit & narrow crown. (Photo: B.R. Maslin)

C – Roadside stand, much sucker regrowth. (Photo: B.R. Maslin)

D – Section of stem (wood pale-coloured & dense). (Photo: B.R. Maslin)

E – Flowering branch (heads in short racemes, phyllodes short). (Photo: B.R. Maslin) alkaline clay or loam in low hilly country in woodland, open forest or tussock grassland, within the 500–600 mm rainfall zone.

Flowering and fruiting

Flowers from October to December and pods with mature seeds normally occur between December and February/March (but may continue producing seed if there is a wet summer) (Martin O'Leary, pers. comm.).

Biological features

Moderate suckering ability; coppicing unknown (but possible); moderate to fast growth rate. It is frost tolerant (Martin O'Leary, pers. comm.).

Cultivation

According to Whibley & Symon (1992), *A. wattsiana* grows well with a fast growth rate under cultivation in southern districts of South Australia. Direct seeded plants in a rather dry area near Adelaide attained 1.7 m height in two years, without supplementary watering (M. O'Leary, pers. comm.). This species is used in roadside plantings (with *A. victoriae*) near Wirralla, S.A.

In the one natural population examined many of the plants grew close together and developed a single, rather straight, erect main stem and relatively few, and short lateral branches. If this growth form could be attained in cultivation (perhaps by appropriate spacing of plants) then this would be conducive to harvesting for wood.

Weed potential

There are no records of this species presenting weed problems despite the fact that it grows naturally in highly disturbed agricultural areas. If widely grown outside its natural range, however, it may possibly have some weed potential on account of its suckering habit (could form clonal populations) and high seed production (P. Lang, pers. comm.).

Wood

Based on our field observations from one plant the wood is very dense and pale coloured (yellow-brown) with a relatively small development of darker heartwood. Shrinkage upon drying caused minor end fractures in the sample we collected.

Utilisation

Land use and environmental

Suitable for roadside and low shelter belt plantings. Bonney (1994) discusses the value of the species to wildlife.

Potential for crop development

Acacia wattsiana is regarded as only moderately prospective for development as a crop plant for high volume wood production. It is ranked as a category 3 species and would seem best suited for development as a phase crop (Table 6). This is a hardy, moderately fast-growing species with a reasonably good growth form. It produces a reasonable amount of woody biomass but the wood is seemingly very dense (albeit pale coloured) in which case it would lower its attraction for use in reconstituted wood products. Although *A. wattsiana* could have potential for crop development in parts of the target area in South Australia, species such as *A. rivalis* and *A. retinodes*, which occur in much the same region as *A. wattsiana*, are probably better prospects. Its moderate propensity for root suckering is unlikely to present difficulties for its management.

The area predicted to be climatically suitable for the cultivation of *A. wattsiana*, based on its natural climatic parameters, is shown in Map 75. This analysis indicates that the species has the potential to be cultivated beyond its natural range into parts of both the eastern and western target areas. While the predicted regions are restricted to winter rainfall areas this does not preclude *A. wattsiana* from potentially performing well in the uniform rainfall zone of the eastern target area. Within the areas predicted as favourable for its growth, this species would be a good candidate to trial on alkaline clays.

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Appendix 1.

Acacia taxa whose natural distributions occur within the AcaciaSearch target areas of eastern and western Australia (see Maps 2 & 3). Taxa that are naturalized within the target area and whose natural distributions fall outside area are not listed here. Species marked with an asterisk (*) are considered prospective for crop development and are discussed in detail above in this report.

acanthaster
acanthoclada subsp. *acanthoclada*
acanthoclada subsp. *glaucescens*
acellerata
acinacea
aciphylla
acoma
acuaria
aculeatissima
aculeiformis
* *acuminata* ('typical' variant)
* *acuminata* ('narrow phyllode' variant)
acuminata ('small seed' variant)
acutata
aemula subsp. *aemula*
aemula subsp. *muricata*
aestivalis
alata var. *alata*
alata var. *biglandulosa*
alata var. *platyptera*
alata var. *tetrantha*
alcockii
amblygona
ampliata
amputata
amyctica
anarthros
anceps
anceps x *nematophylla*
ancistrophylla var. *ancistrophylla*
ancistrophylla var. *lissophylla*
ancistrophylla var. *perarcuata*
andrewsii
aneura var. *intermedia*
anfractuosa
anthochaera
aphylla
applanata
aprica
arcuatilis
argutifolia
* *argyrophylla*
aristulata
asepala
ashbyae
aspera
assimilis subsp. *assimilis*
assimilis subsp. *atroviridis*
ataxiphylla subsp. *ataxiphylla*
ataxiphylla subsp. *magna*
aulacophylla
auratiflora
auronitens
ausfeldii
awestoniana
* *baileyana*
barattensis
barbinervis subsp. *barbinervis*
barbinervis subsp. *borealis*
* *bartleana* (ms)

baxteri
beauverdiana
beckleri
bidentata
bifaria
biflora
binata
blakelyi
blaxellii
botrydion
brachybotrya (appressed-hair variant)
brachybotrya (typical variant)
brachybotrya (Wirrabara variant)
brachyphylla var. *brachyphylla*
brachyphylla var. *recurvata*
brachypoda
bracteolata
browniana var. *browniana*
browniana var. *endlicheri*
browniana var. *glaucescens*
browniana var. *intermedia*
brownii
brumalis
burkittii
buxifolia subsp. *buxifolia*
caesariata
calamifolia
caleyi
camptoclada
campylophylla
cardiophylla
carens
carneorum
carnosula
cassicula
castanostegia
cavealis
cedroides
celastrifolia
centrinervia
cerastes
chamaeleon
chapmanii subsp. *australis*
chapmanii subsp. *chapmanii*
chartacea
chrysella
chrysocephala
chrysopoda
clydonophora
cochlearis
cochlocarpa subsp. *cochlocarpa*
cochlocarpa subsp. *velutinosa*
colletioides
comans
concolorans
congesta subsp. *cliftoniana*
congesta subsp. *congesta*
congesta subsp. *wonganensis*
conniana
consanguinea
consobrina
continua
coolgardiensis subsp. *coolgardiensis*
coolgardiensis subsp. *effusa*
coolgardiensis subsp. *latior*
costata
cowaniana
cracentis

crassistipula
crassiuscula
crassuloides
cremiflora
crenulata
cretacea
crispula
cultriformis
cummingiana
cuneifolia
cupularis
curranii
curvata
* *cyclops*
cylindrica
daviesioides
dawsonii
* *dealbata* subsp. *dealbata*
deanei subsp. *deanei*
deanei subsp. *paucijuga*
declinata
decora
deficiens
deflexa
delphina
dempsteri
densiflora
denticulosa
dentifera
depressa
dermatophylla
diaphana
diaphyllodinea
dictyoneura
dielsii
difformis
dilatata
diminuta
dissona var. *dissona*
dissona var. *indoloria*
disticha
divergens
* *dodonaeifolia*
dodonaeifolia x *paradoxa*
* *doratoxylon*
drewiana subsp. *drewiana*
drewiana subsp. *minor*
drummondii subsp. *affinis*
drummondii subsp. *candolleana*
drummondii subsp. *drummondii*
drummondii subsp. *elegans*
dura
durabilis
duriuscula
empelioclada
enervia subsp. *enervia*
enervia subsp. *explicata*
enterocarpa
epacantha
ephedroides
eremaea
eremophila var. *eremophila*
eremophila var. *variabilis*
ericifolia
ericksoniae
erinacea
erioclada
errabunda

* *euthycarpa*
euthyphylla
evenulosa
excentrica
exocarpoides
extensa
fagonioides
farinosa
farnesiana
fauntleroyi
ferocior
filifolia
flabellifolia
flavipila var. *flavipila*
flavipila var. *ovalis*
flexifolia
floribunda
forrestiana
fragilis
gelasina
gemina
genistifolia
gibbosa
gilbertii
gillii
glandulicarpa
glaucissima
glaucoptera
glutinosissima
gonophylla
gracilifolia
graniticola
grasbyi
grayana
grisea
guinetii
gunnii
hadrophylla
* *hakeoides*
halliana
harpophylla
harveyi
havilandiorum
hemiteles
heterochroa subsp. *heterochroa*
heterochroa subsp. *robertii*
heteroclita subsp. *heteroclita*
heteroneura var. *heteroneura*
heteroneura var. *jutsonii*
heteroneura var. *petila*
heteroneura var. *prolixa*
hexaneura
hopperiana
huegelii
hystrix subsp. *hystrix*
idiomorpha
imbricata
imitans
* *implexa*
improcera
inaequiloba
inamabilis
inceana subsp. *conformis*
incongesta
incrassata
incurva
ingrata
inophloia

inophloia x *lasiocalyx*
insolita subsp. *efoliolata*
insolita subsp. *recurva*
intricata
isoneura subsp. *isoneura*
isoneura subsp. *nimia*
iteaphylla
jacksonioides
jennerae
jibberdingensis
kalgoorliensis
kingiana
lachnophylla
lanceolata
lanei
lanigera var. *lanigera*
lanigera var. *whanii*
lanuginophylla
laricina var. *crassifolia*
laricina var. *laricina*
* *lasiocalyx*
lasiocarpa var. *bracteolata*
lasiocarpa var. *lasiocarpa*
lasiocarpa var. *sedifolia*
latipes subsp. *latipes*
latipes subsp. *licina*
leioderma
leiophylla
leptalea
leptopetala
leptospermoides subsp. *leptospermoides*
leptospermoides subsp. *obovata*
leptospermoides subsp. *psammophila*
* *leucoclada* subsp. *leucoclada*
leucolobia
ligulata
ligustrina
* *linearifolia*
lineata
lineolata subsp. *lineolata*
lineolata subsp. *multilineata*
lirellata subsp. *compressa*
lirellata subsp. *lirellata*
littorea
loderi
longifolia subsp. *longifolia*
longifolia subsp. *sophorae*
longiphyllodinea
longispinea
loxophylla
lullfitziorum
luteola
mabellae
mackeyana
maxwellii
* *mearnsii*
megacephala
meisneri
* *melanoxylon*
melvillei
menzelii
merinthophora
merrallii
merrickiae
microbotrya var. *borealis*
* *microbotrya* var. *microbotrya*
microcalyx
microcarpa

mimica var. *angusta*
mimica var. *mimica*
mitchellii
moirii subsp. *dasycarpa*
moirii subsp. *moirii*
moirii subsp. *recurvistipula*
mollifolia
montana
mucronata subsp. *longifolia*
multispicata
* *murrayana*
mutabilis subsp. *angustifolia*
mutabilis subsp. *incurva*
mutabilis subsp. *mutabilis*
mutabilis subsp. *rhynchophylla*
mutabilis subsp. *stipulifera*
myrtifolia
nanodealbata
nematophylla
nervosa
neurophylla subsp. *erugata*
neurophylla subsp. *neurophylla*
newbeyi
nigricans
nigripilosa subsp. *latifolia*
nigripilosa subsp. *nigripilosa*
nitidula
nivea
nodiflora
notabilis
nyssophylla
obesa
obovata
obtecta
octonervia
omalophylla
oncinophylla subsp. *oncinophylla*
ophiolithica
orbifolia
oswaldii
oxycedrus
oxycedrus x sophorae
oxyclada
pachyphylla
papulosa
papyrocarpa
paradoxa
* *parramattensis*
patagiata
pelophila
pendula
pentadenia
phaeocalyx
pharangites
phasmoides
phlebopetala var. *phlebopetala*
phlebopetala var. *pubescens*
pinguiculosa subsp. *pinguiculosa*
pinguiculosa subsp. *teretifolia*
pinguifolia
plicata
poliochroa
praemorsa
prainii
pravifolia
pravissima
preissiana
pritzeliana

profusa
pterocaulon
pulchella var. *glaberrima*
pulchella var. *goadbyi*
pulchella var. *pulchella*
pulviniformis
puncticulata
pusilla
* *pycnantha*
pycnocephala
pygmaea
quadrimarginea
quadrisulcata
quinquenervia
quornensis
recurvata
redolens
* *redolens* affin.
rendlei
repanda
resinimarginea
resinistipulea
resinosa
restiacea
* *retinodes* var. *retinodes* ('swamp' variant)
* *retinodes* var. *retinodes* ('Normanville' variant)
* *retinodes* var. *retinodes* ('typical' variant)
* *retinodes* var. *uncifolia*
retrorsa
rhamphophylla
rhetinocarpa
rhigiophylla
ridleyana
rigens
rigida
robinae
rossei
rostellata
* *rostellifera*
rupicola
* *salicina*
* *saligna*
saxatilis
scalena
sciophanes
scirpifolia
sclerophylla var. *pilosa*
sclerophylla var. *sclerophylla*
sclerophylla var. *teretiuscula*
sclerosperma subsp. *sclerosperma*
sedifolia subsp. *pulvinata*
sedifolia subsp. *sedifolia*
semicircinalis
sericocarpa
sertiformis
sessilis
sessilispica
shuttleworthii
sibina
siculiformis
signata
simmonsiana
simulans
singula
sorophylla
spathulifolia
spectabilis
sphacelata subsp. *recurva*
sphacelata subsp. *sphacelata*
sphacelata subsp. *verticillata*

sphenophylla
spilleriana
spinescens
spinosissima
spongolitica
spooneri
squamata
stanleyi
steedmanii
* *stenophylla*
stenoptera
stereophylla var. *cylindrata*
stereophylla var. *stereophylla*
subcaerulea
subflexuosa subsp. *capillata*
subflexuosa subsp. *subflexuosa*
subrigida
sulcata var. *planoconvexa*
sulcata var. *platyphylla*
sulcata var. *sulcata*
synoria
telmica
teretifolia
tetanophylla
tetragonocarpa
tetragonophylla
tetraneura
tetraptera
toondulya
torticarpa
tratmaniana
trigonophylla
trinalis
trineura
triptera
triptycha
triquetra
truculenta
trulliformis
truncata
tuberculata
tysonii
ulicifolia
ulicina
uncinella
undosa
unguicula
unifissilis
urophylla
varia var. *crassinervis*
varia var. *parviflora*
vassalii
verniciflua (typical variant)
verricula
verticillata subsp. *ovoidea*
vestita
* *victoriae*
viscifolia
vittata
volubilis
* *wattsiana*
websteri
whibleyana
wilhelmiana
willdenowiana
wilsonii
xanthina
yorkrakinensis subsp. *acrita*
yorkrakinensis subsp. *yorkrakinensis*

Joint Venture Agroforestry Program

RIRDC Publication No 03/017 Project No CAL-7A

AcaciaSea

Evaluation of *Acacia* as a woody crop op
for southern Aust

Acacia is a diverse and enormous genus with almost 1 000 species currently recognized for Australia. There are 462 Acacia species (comprising 538 taxa) that occur naturally within the target area for t study, which encompasses Western Australia, South Australia, Victo and New South Wales. This report identifies, evaluates and provides detailed information for Acacia species considered prospective as new woody crop plants in the agricultural region of southern Australia (wi the 250–650 mm rainfall zone). Large-scale commercial plantings wi perennial plants are in demand as a treatment for salinity control in these regions, and species were evaluated for their potential suitabilit feedstocks for selected products.

Agroforestry and Farm Fores

This program is funded by the Rural Industries R&D Corporation, Land & Water Australia, Forest and Wood Products R&D Corporation Murray-Darling Basin Commission Joint Venture Agroforestry Program (JVAP), with support from the Natural Heritage Trust, the Grains R&D Corporation and the Australian Greenhouse Office.

The Joint Venture Agroforestry Program works to develop practical agroforestry systems and strategies for the combined purposes of commercial production of tree products, increased agricultural productivity, and sustainable natural resource management within the agricultural environment. The JVAP is helping to provide the knowledg base that landholders need to invest with confidence in agroforestry. T program is managed by the Rural Industries R&D Corporation.

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