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AcaciaSearch

Evaluation of *Acacia* as a woody crop option for southern Australia

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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.

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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

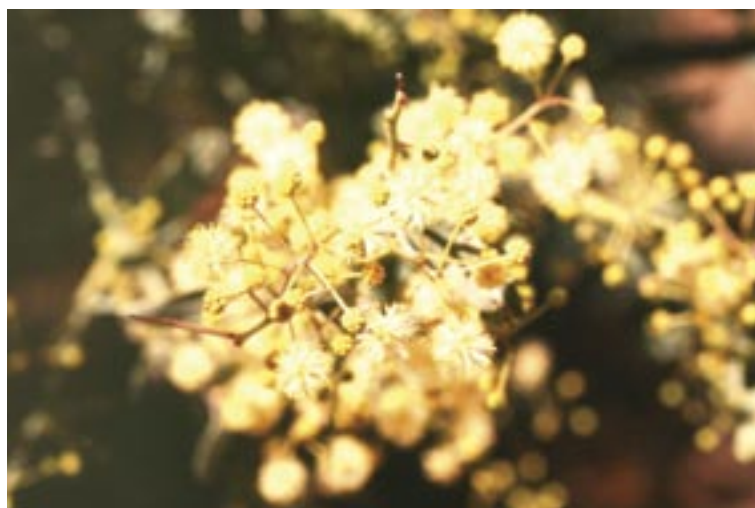
Acacia crops could provide suitable feedstock. Therefore, the most important plant characteristic was the ability for rapid production of commercial volumes of harvestable wood biomass, particularly low density wood .

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.

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.



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



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. nerüfolia (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. wattiana (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. watsiana*). 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



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

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.

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. nerüfolia* 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 <i>Acacia</i> |
| 8: | Lianes with prickles on stems | Subgenus <i>Aculeiferum</i> |
| 7: | Plants without prominent stipular spines, prickles absent | Section Pulchellae |

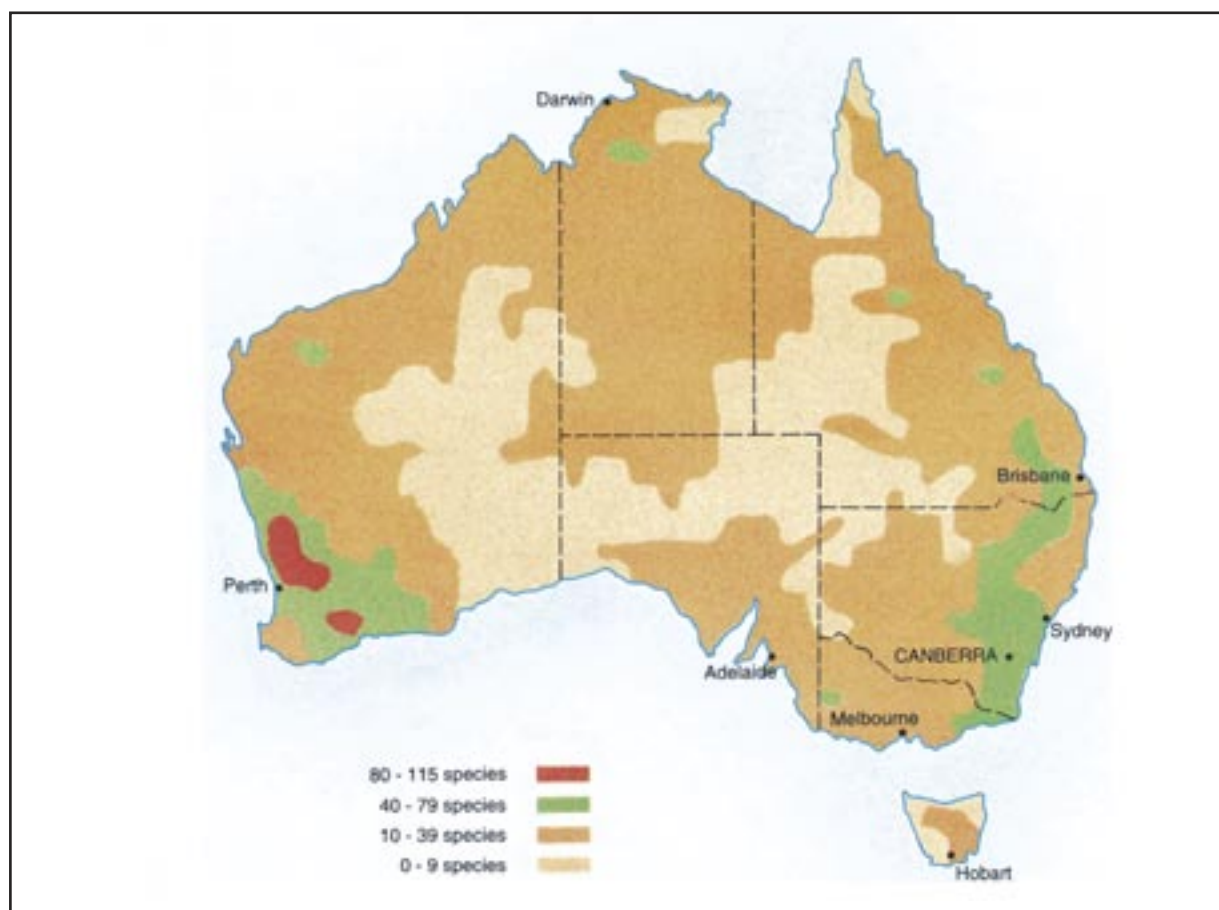
Simplified key to the major infrageneric groups (subgenera and sections) of Acacia. This key was originally published in Maslin (1995).

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 Australia 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 pereginalis*, *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 *Landscape*, 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 <i>in situ</i> 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).

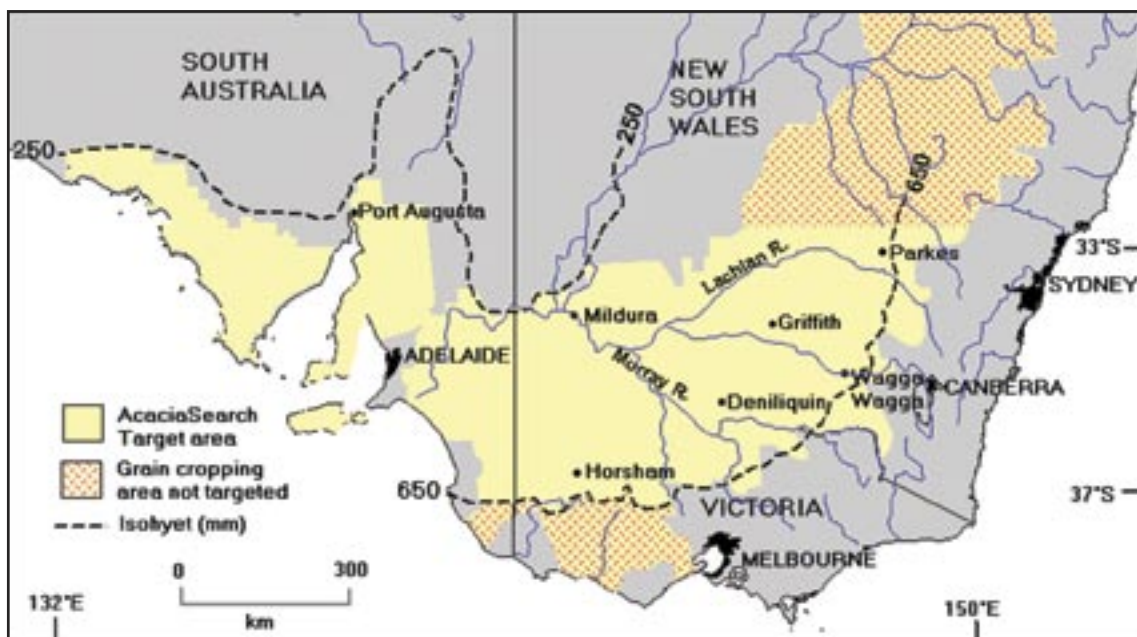
The *inland boundary* (in all States) is represented by the limit of grain cropping which corresponds fairly well with the 250 mm isohyet in eastern Australia and the 300 mm isohyet in Western Australia.

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 isohyet 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** 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 ESOCIM (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. wattiana* (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. wattiana* (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. microbotrya*, *A. retinodes* (all variants) *A. rivalis*, *A. watsiana*.
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. leuoclada*, *A. mearnsii*, *A. parramattensis*) are probably reasonably closely related to one another. However, the five species of section *Plurinerves* (*A. cyclops*, *A. implexa*, *A. melanoxydon*, *A. aff. 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 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. melanoxydon* 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. leuoclada*, *A. linearifolia*, *A. mearnsii*, *A. melanoxydon*, *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. watsiana*). 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. melanoxydon* 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. rostelifera* 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*.

<i>A. alcockii</i> 1	<i>A. cowaniana</i> 2,3	<i>A. inceana</i> 1,2,3
<i>A. aneura</i> 2,3	<i>A. crassa</i> 1,2	<i>A. inophloia</i> 2,3
<i>A. anthochaera</i> 2?,3	<i>A. cretacea</i> 1	<i>A. iteaphylla</i> 1
<i>A. beauverdiana</i> 2,3	<i>A. deanei</i> 1	<i>A. jibberdingensis</i> 1
<i>A. blakelyi</i> 1	<i>A. difformis</i> 1,2	<i>A. leiocalyx</i> 1,2
<i>A. burkittii</i> 2,3	<i>A. enervia</i> 1,2,3	<i>A. leiophylla</i> 1
<i>A. burrowii</i> 2,3	<i>A. eremaea</i> 1,2,3	<i>A. ligulata</i> 1
<i>A. caesiella</i> 1	<i>A. fauntleroyi</i> 2,3	<i>A. loderi</i> 2,3
<i>A. caroleae</i> 1	<i>A. gillii</i> 1	<i>A. longifolia</i> 1,2
<i>A. cheelii</i> 1	<i>A. harpophylla</i> 2,3	<i>A. melvillei</i> 2,3
<i>A. coolgardiensis</i> 2,3	<i>A. heteroclita</i> 1	<i>A. mollifolia</i> 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. melanoxydon* 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 propagate 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
<i>A. acuminata</i>	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
<i>A. argyrophylla</i>	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
<i>A. baileyana</i>	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
<i>A. bartleana</i>	W	SWA	Low hills on brown sandy loam.	200-275	450-600	w	6-8	32-33	6-7	11-24	Low to moderate
<i>A. cyclops</i>	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
<i>A. dealbata</i> subsp. <i>dealbata</i>	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
<i>A. decurrens</i> *	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
<i>A. dodonaeifolia</i>	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
<i>A. doratoxylon</i>	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
<i>A. euthycarpa</i>	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
<i>A. filicifolia</i> *	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
<i>A. hakeoides</i>	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 rock ranges.	2-550	250-875	u,w	0-12	24-37	1-7	10-23	Moderate
<i>A. implexa</i>	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
<i>A. lasiocalyx</i>	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
<i>A. leucoclada</i> subsp. <i>leucoclada</i>	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
<i>A. linearifolia</i>	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
<i>A. mearnsii</i>	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
<i>A. melanoxylon</i>	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
<i>A. microbotrya</i>	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
<i>A. murrayana</i>	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
<i>A. nerifolia</i> *	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
<i>A. parramattensis</i>	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
<i>A. pycnantha</i>	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
<i>A. redolens</i> affn.	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
<i>A. retinodes</i> 'typical variant'	S (S)	FLB, KAN	Rocky hillides or plains on clay loams or loams.	100-510	340-940	w, u	3-12	27-30	3-6	8-20	Moderate
<i>A. retinodes</i> '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
<i>A. retinodes</i> 'Normanville'	S	KAN	Creekbanks of coastal dune system on sandy loam.	20	500-600	w, u	4-6	25	7	15-23	Low
<i>A. retinodes</i> var. <i>uncifolia</i>	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
<i>A. rivalis</i> *	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
<i>A. rostellifera</i>	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
<i>A. salicina</i>	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
<i>A. saligna</i>	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
<i>A. stenophylla</i>	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
<i>A. victoriae</i>	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
<i>A. wattiana</i>	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/m³). 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**.

^ASubject to coppicing ability being acceptable; ^BBut 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
<i>A. acuminata</i>	3	Absent (or very low frequency)	Unlikely	Moderate	Low	899-1171	Perhaps > 50	Long cycle	Shrubs/trees 2-7(-10)m
<i>A. argyrophylla</i>	3-4	Present (but probably low frequency)	Unlikely	Moderate	Low	Unknown	Perhaps to 30	Phase	Shrubs 2-3 m
<i>A. baileyana</i>	3	Unlikely	Absent	Fast	High (especially in wetter areas)	Unknown	10-20(40)	Phase	Shrubs/trees 5-10 m
<i>A. barileana</i>	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
<i>A. cyclops</i>	4	Absent or rare	Unlikely	Moderate	High	780-826	Unknown	Phase	Shrubs/trees 1-4(-8) m
<i>A. dealbata</i> subsp. <i>dealbata</i>	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
<i>A. decurrens</i> [*]	2	Absent or poor	Absent (or poor)	Fast	High	457-520 (air-dry density c.720)	10-15	Phase	Trees 5-10(-22) m
<i>A. dodonaeifolia</i>	4	Unknown (but likely)	Occasional	Fast	Low or (wet areas) moderate	Unknown	About 20	Phase	Shrubs/trees 2-6 m
<i>A. doratoxylon</i>	3	Unknown	Absent	Moderate	Low	720	Long-lived	Long cycle	Shrubs/trees 3-12 m
<i>A. euthycarpa</i>	4	Unknown	Unlikely	Moderate	Low	Unknown	About 30	Phase	Shrubs/trees 2-6(-10) m
<i>A. filicifolia</i> [*]	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
<i>A. hakeoides</i>	3	Unknown	Vigorous	Moderate to fast	Moderate	Unknown	Several decades	Phase ^b	Shrubs/trees 1-4(-6) m
<i>A. implexa</i>	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
<i>A. lasiocalyx</i>	2	Unknown (but unlikely)	Unlikely	Moderate to fast	Low	593-912	20-40	Phase, ?long cycle	Shrubs/trees 2-5(10-15) m
<i>A. leucoclada</i> subsp. <i>leucoclada</i>	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
<i>A. linearifolia</i>	1-2	High	Absent (apparently)	Fast	Low	Unknown	Unknown (but probably several decades)	Phase, ?coppice, ?long cycle	Shrubs/trees 5-10 m
<i>A. mearnsii</i>	2	Absent	Absent	Fast	High	550-750 (air dry density)	10-20(40)	Phase	Shrubs/trees 5-10 (-20)m
<i>A. melanoxylon</i>	3	Present but variable frequency	Vigorous	Moderate	Moderate	390-670	Long-lived	Long cycle ^b	Trees 10-20(-40) m
<i>A. microbotrya</i>	2	Unknown (but likely)	Vigorous	Fast	Low	654-959	20-30	Phase ^b , ?coppice ^{a,b}	Shrubs/trees 2-4(-7) m
<i>A. murrayana</i>	2-3	High	Vigorous	Fast	Low - moderate	522-850	10-25	Phase, ?coppice ^a	Shrubs/trees 2-6(-8) m
<i>A. nerifolia</i> *	2-3	Poor to fair	Unlikely	Fast	Low	Unknown	Perhaps 10-15 (sometimes more)	Phase	Shrubs/trees 2-8(-15) m
<i>A. parramattensis</i>	3	Unlikely	Probably low to moderate	Fast	Low (presumably)	606	Probably 10-20	Phase	Shrubs/trees 2-7(-15) m
<i>A. pycnantha</i>	2	Absent or (in older plants) poor	Absent	Moderately fast	High	Unknown	15-30 typically	Phase	Shrubs/trees 4-10 m
<i>A. redolens</i> affin.	4	Unknown	Unlikely	Unknown	Low	732-835	20+	Phase	Trees 4-7(-10) m
<i>A. retinodes</i> 'typical variant'	1-2	Present (but vigor unknown)	Moderate	Moderately fast	Low	Unknown	30-40	Phase, long cycle	Trees 5-6 (-10) m
<i>A. retinodes</i> 'swamp variant'	2	Absent (or low frequency)	Absent	Very fast	Low	Unknown	10-20	Phase	Trees 5-6 (-10) m
<i>A. retinodes</i> '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
<i>A. retinodes</i> var. <i>uncifolia</i>	3	Unknown	Present and absent	Fast	Low	Unknown	Unknown	Phase	Shrubs/trees 5-10 m
<i>A. rivalis</i> *	2-3	Absent (or low frequency)	Absent (seemingly)	Moderate - fast	Low	Unknown	10-15	Phase	Shrubs/trees 3-5 m
<i>A. rostellifera</i>	3	Unknown (but possible)	Vigorous	Moderate	Low - moderate	727-948	About 20	Phase ^B	Shrubs/trees 2-5 m
<i>A. salicina</i>	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
<i>A. saligna</i>	1	High (at least in some plants)†	Moderate or vigorous	Fast to very fast	High	469-735	10-20	Phase, coppice	Shrubs/trees 2-10 m
<i>A. stenophylla</i>	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
<i>A. victoricae</i>	3	Present (but variable)	Vigorous	Fast	Low to moderate	739 - 890	10-15	Phase ^B	Shrubs/trees 2-5(-9) m
<i>A. wattiana</i>	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.

