FLORA OF AUSTRALIA

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Section 4: Management

Utilisation of the Australian Flora

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UTILISATION OF THE AUSTRALIAN FLORA

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The Australian vascular flora, with in excess of 20 000 species, a very high proportion of which are endemic, would be expected to yield a large number of useful products. Certainly, before 1770 the Aboriginal inhabitants used a large number of plants for food, tools, weapons and remedies, and many still do. Yet with colonisation by Europeans, and the development of large scale farming and horticulture, little use was made of the native flora, with the exception of timber. Until very recently, the only Australian species grown extensively for food were *Macadamia integrifolia* and *M. tetraphylla*, and even here, the first major plantations were developed in Hawai'i, not Australia (O'Neill, 1996).

A number of accounts of useful plants were written in the 19th century, although most concentrated on plants of use to industry, particularly timber and related products. One of the most comprehensive references from this period, and one which discussed a number of indigenous as well as industrial uses for plants, was Maiden (1889).

Belatedly, the potential of the Australian flora to provide useful products has been recognised. A number of recent books give an overview of useful native plants (e.g. Cribb & Cribb, 1982; Bindon, 1996), while others deal with particular subjects, particularly bush foods. This chapter surveys some of the more important of these products, without pretending to be comprehensive. Some large industries such as ecotourism and bushwalking, built substantially but not entirely on the native flora and vegetation, are beyond the scope of this account, but cannot be discounted in any account of the contribution of the native flora to Australia's economic activity.

Aboriginal use of native plants

The indigenous inhabitants of Australia used many hundreds of native plants for food, shelter, weapons, implements, medicines, stimulants, adornment, fibre, rope, canoes and much more. Numerous books have been written on this subject, particularly in the last decade or two. While some traditional knowledge of the properties of the native flora has undoubtedly been lost, a surprising amount has survived. Documentation of traditional usage is gathering pace, with traditional peoples recording knowledge of their traditional plants, and others providing cross-cultural surveys of the amazing numbers of plants that have been used, and the diverse uses to which they have been put.

No attempt will be made here to try to provide a comprehensive account of this subject. A few subjects, such as food plants and medicinal plants will be discussed in some detail below, but for other uses only a selection of source materials can be quoted.

General books on indigenous use of plants include Bindon (1996), Cribb & Cribb (1982) and Isaacs (1987, 1996). More regional guides include Edgar *et al.* (1987), Goddard & Kalotas (1988), Latz (1995), Levitt (1981), Roberts *et al.* (1995), Smith (1991), Smith *et al.* (1993), Smith & Wightman (1990), Symons & Symons (1994), Turner & Henderson (1994), Wightman *et al.* (1991), Wightman *et al.* (1994), Wightman, Dixon *et al.* (1992), Wightman, Roberts & Williams (1992), Wightman & Smith (1989) and Zola & Gott (1992).

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Bush foods

The last decades of the 20th century have seen a growing interest in the native flora (and fauna) as a source of new and exotic foods. To a large extent this was triggered by a very successful television program *Bush Tucker Man*, narrated by Les Hiddins and screened by the Australian Broadcasting Commission in the late 1980s, although a specialist literature had been quietly building for some years (e.g. Cribb & Cribb, 1975; Jones, 1985; Low, 1988, 1989, 1991).

Until the 1990s only one commercial crop, macadamia nuts, had been developed from Australian native plants. This crop is discussed in more detail below. A few other species were used as minor food sources on a regional basis and almost entirely wild-collected. These included Quandong (*Santalum acuminatum*), Bunya nuts (*Araucaria bidwillii*) and Native Rosella (*Hibiscus heterophyllus*) (Keena, 1997).

Increasing interest in bush foods has led to the development of an incipient plantation industry to supplement wild collection. This supports a rapidly increasing boutique restaurant industry based on bush foods, either alone or as condiments for more traditional dishes. A specialist literature is quickly developing. A dedicated bi-monthly magazine, *Australian Bushfoods Magazine* was established in March 1997 to service both the grower and consumer markets. Books on growing, processing and cooking native food plants are appearing (e.g. Bruneteau, 1996; Cherikoff & Isaacs, 1989; Robins, 1996). Industry organisations such as the Australian National Bushfoods Industry Committee are being formed, and industry reports are beginning to appear. One of these reports (Graham & Hart, 1997) identified and discussed 15 taxa with particular potential for cultivation and development. These were *Acacia* spp. (Wattleseed), *Acronychia acidula* (Lemon Aspen), *Backhousia citriodora* (Lemon Myrtle), *Davidsonia pruriens* (Davidson Plum), *Eremocitrus glauca* (Wild Lime), *Hibiscus heterophyllus* (Wild Rosella), *Kunzea pomifera* (Muntries), *Podocarpus elatus* (Illawarra Plum), *Prostanthera rotundifolia* (Native Mint), *Santalum acuminatum* (Quandong), *Solanum centrale* (Bush Tomato), *Syzygium luehmannii* (Riberry), *Tasmannia lanceolata* (Native Mountain Pepper), *Terminalia ferdinandiana* (Kakadu Plum) and *Tetragonia tetragonioides* (Warrigal Greens). Phelps (1997) produced another report, on the bush foods industry in western Queensland. Geno (1997) provided an overview of bushfood organisations. A brief review of current CSIRO research on bush foods is given by Boland (1997), and research on *Acacia* was described by Morse (1997).

Articles on individual bush foods are numerous. The following are only a sample: *Acacia* (Gott, 1997; House & Harwood, 1992; B.King, 1997; Morse, 1997; Orr & Hiddins, 1992), *Araucaria* (J.R.King, 1997), *Backhousia* (Costin, 1997; Lake, 1998b), *Eremocitrus* (Phelps & Phelps, 1997; Sykes, 1997), *Kunzea* (B.King, 1998), *Microcitrus* (Birmingham, 1997; Sykes, 1997), *Santalum* (CSIRO Plant Industry Horticulture Industry, 1998; Fox, 1998; Matthews, 1997) *Solanum* (Cherikoff, 1998; Latz, 1998), *Syzygium* (Keena, 1998; Ringer, 1997), *Tasmannia* (Padbury, 1998). Note that *Eremocitrus* and *Microcitrus* are now often included in *Citrus*.

As well as literature on the bush foods industry, there is a growing literature on traditional use of native food plants. Recent books and articles include Bindon (1996), Brock (1993), Gott (1985), Latz (1995), Plomley & Cameron (1993), Roberts *et al.* (1995), Smith & Jumbun experts (1991), Stewart & Percival (1997), Zola & Gott (1992).

A number of studies have been made on the nutritional qualities of bush foods. A symposium in 1976 (Hetzel & Frith, 1978) discussed Aboriginal nutrition in Central Australia, including the food value of various native plant species. In 1984 a colloquium was held to discuss the food potential of seeds of Australian native plants (Jones, 1985). This workshop considered, among others, the food value of seeds of *Santalum* (Rivett *et al.*, 1985), *Erythrina*, *Canavalia* and other Fabaceae (Jermyn, 1985), *Acacia* (Kortt, 1985), *Athertonia* and *Elaeocarpus* (Irvine, 1985) and *Hovea* (Tucker *et al.*, 1985). A comprehensive summary of the nutritional qualities of over 500 foods (plant and animal) was presented by Miller *et al.* (1993). Devitt (1992) discussed the use of *Acacia* seeds as a traditional Aboriginal food, and Brand & Maggiore (1992) discussed the nutritional composition of a range of Australian *Acacia* seeds.

The farmgate equivalent gross value of the bush food industry was estimated at $10–12 million for 1995/96, and has about 200 'active participants' (Gare, 1997). The Australian Native Bushfood Industry Committee reported to a Senate inquiry (Woodley, 1998) that bushfood sales were $14 million in 1996, and expected to be $100 million by the year 2000. A modest amount of research funding is directed towards the industry: in 1997/98 the Rural Industries Research and Development Corporation (RIRDC) provided $82 000 in support of four projects on marketing and food safety for bush foods, and RIRDC is expecting to provide support of about $130 000 for similar projects in 1998/99 (RIRDC, 1998).

Macadamia

Macadamia integrifolia and *M. tetraphylla* are the source of macadamia nuts, an industry pioneered in Hawai'i (O'Neill, 1996), but now based on extensive plantations in South Africa, Zimbabwe, Malawi, Kenya, California, Central America, and, belatedly, in Australia, with smaller plantations elsewhere. Five other species produce inedible nuts with high levels of cyanide, and cyanide is produced even within germinating nuts and seedlings of the edible species (Dahler *et al.*, 1995; O'Neill, 1996). Doran & Turnbull (1997) provided silvicultural information for the two species yielding edible nuts.

Macadamia was introduced into Hawai'i experimentally in 1881 and 1892, but production expanded rapidly after widescale plantings of improved varieties in 1948. In Australia small plantings had been made by 1900, but it was not until 1965/66 that commercially viable areas were planted in this country. In the meantime many other countries had established plantations, and by 1987 world production amounted to 6 806 tonnes of kernels from 51 600 acres of plantations. Projections suggested that with new plantations coming on stream, production would rise to about 18 000 tonnes of kernel per annum within 5–10 years (Jodvalkis, 1987). At that time the market was dominated by Hawai'ian growers with 73% of world production. Australia had about 14%, but with extensive plantings coming into production, the projection was that, within 5–10 years, this would rise to about 20%. Nut production in 1987 is given in Table 29. The 1987 estimate of potential Australian production appears to have been pessimistic. O'Neill (1996) stated that Australian production had now exceeded that of Hawai'i, making Australia the leading world producer of macadamia nuts, and estimated that by the year 2000, some 2 million trees in northern New South Wales and southern Queensland would be coming into production, yielding crops worth more than $100 million annually.

Table 29. World macadamia nut production in 1987.
(Source: Jodvalkis, 1987).

Country	Acres	Bearing acres	1987 kernel production (tonnes)	Projected production, 5–10 years (tonnes)
Hawai'i	21 900	14 000	5000	9000
Australia	7100	2400	982	3570
South Africa	6200		240	1000
Kenya	2500		180	500
Malawi	1900		90	600
Costa Rica	5000	2000	180	2600
Guatemala	1000		134	180
Others*	6000			500
Totals	51 600		6806	17 950

*Brazil, Florida, Mexico, California, New Zealand, China

Wattleseed

Acacia seeds are a traditional Aboriginal food, particularly in Central Australia (Devitt, 1992), and have a high nutritional value (Brand & Maggiore, 1992; Miller *et al.*, 1993). Traditional methods of preparation were described by Orr & Hiddins (1987). Building on this tradition, the seeds of a number of Australian *Acacia* species are being investigated as a source of food for use in the growing bushfood industry (Gott, 1997; Harwood, 1994; House & Harwood, 1992; B.King, 1997; Maslin & McDonald, 1996; Maslin *et al.*, 1998; Morse, 1997).

Not all *Acacia* species yield edible seeds, and many are poisonous, or require special treatment to make them safe for consumption. Kortt (1985) described proteinase inhibitors in some *Acacia* seeds, while Maslin *et al.* (1988) surveyed a number of species for cyanogenesis.

For those seeds which are edible without requiring special treatment to eliminate toxicity, preparation involves grinding and sometimes roasting. The 'flour' is added to products such as bread and damper, pasta, biscuits, icecreams and drinks.

Acacia victoriae is currently the most important species in the wattleseed industry. Most seed is wild-collected, but experimental plantations have also been established (Maslin *et al.*, 1987). Considerable potential exists in a number of other species: Thomson (1992) discussed *A. colei*, *A. cowleana*, *A. tumida*, *A. adsurgens*, *A. oligophleba*, *A. coriacea* var. *pendula* and *A. glaucocaesia*; Maslin *et al.* (1998) listed *A. murrayana* and *A. victoriae* as the most promising species, followed by *A. jennerae*, *A. microbotrya*, *A. pycnantha*, *A. retinodes*, *A. rivalis* and *A. saligna*. Criteria for economic seed production include: regular, heavy, synchronised seed production, relatively large seed size, habit of plant in relation to ease of harvest (including potential for coppicing), ease of establishment, and longevity (Maslin *et al.*, 1998).

Experimental *Acacia* plantations have been established abroad, particularly in the Sahel of Africa (Cossalter, 1987; Souvannavong & de Framond, 1992), to provide a source of firewood and seed for food.

Medicinal plants

As for bush foods, there is a very large literature on the use of Australian native plants for medicinal purposes. Indigenous peoples are known to have used very many different plants to treat illness, to relieve symptoms, and as stimulants. Many of these remedies have been recorded in the literature, but a large number still survive only in oral tradition, while others have undoubtedly been lost. The subject is too varied to be treated in detail here. Useful sources of information include Barr *et al.* (1988, 1993), Bindon (1996), Cribb & Cribb (1981), Henshall *et al.* (1980), Isaacs (1987), Kyriazis (n.d.), Lassak & McCarthy (1983), Latz (1995), Low (1990), Stewart & Percival (1997), Wightman *et al.* (1994) and Zola & Gott (1992).

From the early 1940s until the late 1970s CSIRO was involved in a major screening program of Australian native plants, searching for medically active chemicals. A major target was alkaloids, but triterpenes, diterpenes, phytoecdysteroids, flavanoids and phenolics were also extracted and studied. This Australian Phytochemical Survey was conducted largely under the direction of L.J.Webb and J.R.Price, but involved field botanists such as W.T.Jones, T.G.Hartley and many others. In 1958 the screening was extended to Papua New Guinean plants. The results of the screening were published by Collins *et al.* (1990). A literature survey, preliminary to the Australian Phytochemical Survey, was carried out by Webb (1948). Other surveys have been undertaken, many associated with cancer research. The most recent major bioprospecting survey is that organised by the Australian Medical Research and Development Corporation (AMRAD), using the resources of herbaria in Tasmania, Victoria and the Northern Territory (Anonymous, 1996).

A number of Australian native plants have been developed as crop plants for the drug industry. One of the best known is *Duboisia*. Two species, *D. myoporoides* and *D. leichhardtii*, are major sources of the alkaloids scopolamine (hyoscine) and hyoscamine, used for pupil-dilation in ophthalmology, to prevent air- and sea-sickness, and in the treatment of stomach ulcers. An industry based on wild-collected material began in a small way in the late 1800s, expanding rapidly in the 1940s. Plantations on a broad scale were not established until the late 1950s. By the 1980s plantations of selected forms had been established in the South Burnett area of Queensland (Cribb & Cribb, 1981; Ohlendorf, 1996).

Two Australian *Solanum* species, *S. aviculare* and *S. laciniatum*, have also been grown as plantation crops for the extraction of solasodine, a steroid used in the manufacture of contraceptive pills and other products. Major plantations were established in southern Russia and Hungary from about 1958 (Swan, 1975; Cribb & Cribb, 1981; Symon, 1994). Plantation trials in Australia in 1978–1981 and in New Zealand in 1964–1982 were unsuccessful (Symon, 1994).

Cribb & Cribb (1981) and Lassak & McCarthy (1983) describe a number of other plants of minor pharmaceutical importance.

A special category of medicinal plants are those yielding essential oils and other aromatic compounds. Low (1990) records that extracts from various plants, particularly *Melaleuca*, *Eremophila* and *Callitris*, have been used for thousands of years to treat respiratory complaints, sores, diarrhoea, headaches and chest pains, and as a mosquito repellent. In the last 200 years an extensive essential oils industry has developed, and this is discussed in more detail below.

Horticulture and floriculture

The flora of Australia created enormous interest in Europe in the late 18th century, once the novelty of the many new plants collected by Banks and Solander, and those who followed them, was revealed. Although illustrations of the Banks and Solander collections were not published until the twentieth century, many others found their way into the illustrated journals of the period.

Cavanagh (1990) has provided a detailed account of Australian plants cultivated in England between 1771 and 1800, beginning with seeds and plants sent back in the ships of the First Fleet in 1789. The flood of novelties from Australia and South Africa in particular, during this period, were a major stimulus to the establishment of important periodicals such as Curtis' *The Botanical Magazine* (1787–) and Andrews' *The Botanist's Repository* (1797–). By 1800 170 species (84 genera), mostly from the vicinity of Sydney, were in cultivation in the nursery trade in England. Nelson (1990) documented the trade, both within England, and to and from continental Europe, in the period to 1840, and the extensive literature that was developed to describe and illustrate these novel taxa.

Many of the earliest settlers made a sparse but steady living from sending dried specimens, seeds and plants back to the nurseries of England. One of the first was James Caley in New South Wales (Currey, 1966); another was James Drummond in Western Australia (Erickson, 1969).

Like all fashions, the fascination with Australian flora faded, and by 1840 Australian plants in Europe were largely confined to botanic gardens (Nelson, 1990). This fall from popularity may have been partly due in changes to heating methods in European hothouses. The introduction of steam heating systems increased humidity in hothouses and conservatories and most of the Australian plants died (Hamilton & Bruce, 1998). Their place was taken by tropical plants from South America and South East Asia. The decline in popularity had been foreshadowed even earlier, however. The first books and journals describing Australian plants had sold well, but by 1810, when Robert Brown produced the first part of a planned 2-volume account of the plants that he had discovered in Australia between 1801 and 1805

(Brown, 1810), sales were so poor that the book was withdrawn from sale and the second part never completed.

Within Australia the native flora attracted only a passing interest for the next 150 years. Conspicuous taxa such as *Eucalyptus*, *Acacia* and *Banksia* were adopted by local authors and artists to lend authenticity to their works. The Coolabah (*Eucalyptus microtheca*, syn. *E. coolabah*) gained fame from A.B. (Banjo) Paterson's *Waltzing Matilda*, wattle gained informal acceptance as the national flower (with *A. pycnantha* becoming the official floral emblem in 1988), and gumnuts (*Eucalyptus* spp.) and *Banksia* spp., along with a few others, received popular recognition in May Gibb's *Snugglepot and Cuddlepie* books of 1918–1921. However, with the exception of some botanic gardens, and limited street plantings, Australian flora was little grown or appreciated until the mid-20th century. Symptomatic of this disregard is an article on Australian stamp design (McQueen, 1988) which barely mentions flora. Hewson (this volume) discusses in more detail the portrayal of the native flora in art, craft and literature.

The 1960s brought an increased national awareness of the Australian flora, coupled with a heightened interest in the environment. One manifestation of this was the establishment of the Australian National Botanic Gardens in Canberra, dedicated to the growing and display of Australia's native flora. The first plantings were made in 1945, but it underwent its major development in the 1960s, and opened to the public in 1967. It now displays some 90 000 plants representing about 5000 species, a quarter of Australia's vascular flora.

In 1958 the Society for Growing Australian Plants was established, and by the 1970s was thriving. It had branches in all States, and specialist study groups for popular families and genera. It continues to prosper, and has its own journal, *Australian Plants*.

The Nursery Industry

Australian native plants surged in popularity as garden plants in the 1970s, on a wave of national pride, and the continuing increase in environmental awareness. Native species were seen to offer advantages in terms of lower water requirements, as well as having novelty value and being useful to attract native fauna to gardens.

Horticultural use has led to the development of an enormous literature on the growing of Australian native plants. Examples include general and regional works (e.g. Blombery & Maloney, 1994; Brock, 1993; Doran & Turnbull, 1997; Elliot & Jones, 1980–; Harris, 1977, 1980; Langkamp, 1987; Newbey, 1968; Wrigley & Fagg, 1996). Works on particular groups, families and genera include those on ferns (Duncan & Isaac, 1986; Goudey, 1988; Jones & Clemesha, 1981), palms (Jones, 1987), climbing plants (Jones & Gray, 1988), *Acacia* (Simmons, 1981, 1988; Tame, 1992), *Grevillea* (Wrigley & Fagg, 1989; Olde & Marriott, 1994–1995), *Banksia* (George, 1984a; Wrigley & Fagg, 1989), *Eucalyptus* (Holliday & Watton, 1980), *Melaleuca* and related genera (Wrigley & Fagg, 1993), Proteaceae (Blombery & Maloney, 1992; George, 1984b; Wrigley & Fagg, 1989), Asteraceae (Salkin *et al.*, 1995) and Orchidaceae (Jones, 1988; Lavarack & Gray, 1985; Sharp, 1970). Many more could be cited. In addition, several monthly gardening magazines with national circulation carry regular articles on growing native plants.

The Australian nursery industry was estimated to be worth about $1.8–2 billion in 1992/1993 (Swane, 1995). Unfortunately, no figures appear to be available on what proportion of this trade involves native plants. Casual observation suggests that a figure of 20% or more would be a good approximation. Swane saw a bright future for the nursery industry, with increasing use of native plants as ground cover and feature plants, in low-maintenance, low water use gardens.

The Cut Flower Trade

Following from the renewed interest in growing native plants was a greatly increased acceptance, and demand, for native flowers in floriculture, and this triggered development of a new industry, the Australian wildflower trade.

The earliest production for the cutflower industry came from wild harvesting of a limited range of species. In the eastern States wild harvesting of Waratah (*Telopea speciosissima*, *T. oreades*) was the main target, while in Western Australia, *Banksia* spp., *Dryandra* spp., *Verticordia* spp., *Podocarpus drouynianus* and *Stirlingia* spp. were extensively picked. For example, in Western Australia in 1980/81 over 6 million stems of these 5 genera were bush-harvested. By 1995 the number had risen to 13 million stems (*Agonis* had displaced *Dryandra* in the top five genera), although an increasing proportion of production was from 'managed bush blocks' (Karingal Consultants, 1997). The impact of wild harvesing on natural populations was examined by Woodley (1998).

Since the early 1980s Australian native cutflower production has increasingly come from plantations. As this new aspect of the floriculture industry developed, workshops and conferences were held to shape and standardise production. In 1982 a National Technical Workshop on Production and Marketing of Australian Wildflowers for Export and a seminar on Production and Marketing of Wildflowers were held in Perth (University Extension, University of WA, 1983), and in 1989 a conference on The Production and Marketing of Australian Flora was sponsored by the Western Australian Department of Agriculture and Australian Special Research Fund (Western Australian Department of Agriculture, 1989).

A survey of the Australian native cutflower industry was conducted by Karingal Consultants for the Rural Industries Research and Development Corporation in 1993 (Karingal Consultants, 1994), and repeated in 1996 (Karingal Consultants, 1997). The 1996 survey revealed a total of 1926 hectares of Australian wildflowers cultivated for the cutflower trade (this figure excludes South African genera such as *Protea*, *Serruria*, *Leucospermum* and *Leucadendron* which are commonly included in 'Australian wildflower' statistics). The industry involved 445 growers, employed about 1362 people, and the most important genera cultivated were *Chamaelaucium* (767 hectares), *Banksia* (319 hectares), *Thryptomene* (251 hectares), *Eucalyptus* (132 hectares), *Blandfordia* (69 hectares), *Anigozanthos* (87 hectares), *Verticordia* (39 hectares), *Agonis* (39 hectares), *Ixodia* (38 hectares), *Boronia* (24 hectares), *Stenanthemum* (23 hectares), *Dryandra* (22 hectares), *Leptospermum* (21 hectares), *Telopea* (16 hectares), *Melaleuca* (15 hectares) and *Ozothamnus* (14 hectares). This compares with 312 hectares of *Protea*, 199 hectares of *Leucodendron*, and 68 hectares of *Leucospermum*. In depth studies are now starting to appear on specific crops. Examples are those of Lewis *et al.* (1997) on Rice flower (*Ozothamnus diosmifolius*) and Slater (n.d.) on *Baeckea* and *Scholtzia*. These are supported by magazine articles such as those of L.Turnbull *et al.* (1997) and Warfield (1997) on *Ozothamnus* and *Cassinia*, Slater *et al*. (1997) on *Ozothamnus diosmifolius*, Gollnow (1997) on *Blandfordia grandiflora*, *Ceratopetalum gummiferum*, *Telopea speciosissima*, *Anigozanthos* and *Macropidium* and Konig (1998) on *Schoenia* and *Rhodanthe*.

Exports of fresh and dried/preserved Australian native cutflowers and foliage in 1996 were worth about $20–25 million, with the biggest markets being Japan, North America and the EEC (Karingal Consultants, 1997; Lewis *et al.*, 1997). The domestic market is approximately equal to the export market. It is estimated that the worldwide trade in Australian native flowers is worth $440 million annually (Hamilton & Bruce, 1998). Australia's share of this is thus only about 10%.

Forestry

Australia has about 41 million hectares of native forest, predominantly *Eucalyptus*. About 6.9 million hectares is available for wood production (Lacey *et al.* (1990). This resource has been exploited for timber production, wood chip for the paper and fibre board industry, for plywood, and for firewood. The forestry industry is a major employer: in Queensland alone in 1998 it employed 17 000 people and had a turnover in excess of $1.7 billion (Department of Primary Industry, Forestry, 1998). The establishment of a forest industry in New South Wales after 1788, and the subsequent development of the industry in that State, and of

national training and management systems over the next 200 years was described by Grant (1989).

Traditionally, trees harvested for timber production have been removed from forests which are then allowed to regenerate, or have been harvested during the clearing of land for agriculture or other uses. From about 1910 however, commercial plantations of Californian *Pinus radiata*, established to provide the basis of a softwood industry, have led to replacement of native forests in some areas, and from the 1960s the commercial exploitation of native species for woodchips, principally for the paper industry, led to accelerating clear felling of forests. Concern at the rate of clearing and replacement led to a spirited debate (Routley & Routley, 1974; Woodgate & Black, 1988; Streeting & Hamilton, 1991; Dattner, 1993), which continues today.

In the 1990s the aim for Australia's native forests is sustainable management (McKinnell *et al.*, 1991). This still means different things to different people. To the forestry industry it means management of existing native forests for sustainable yield, supplemented by plantations (Florence, 1996). It means regeneration of forests *in situ* after clear felling, and selection of improved strains (Eldridge *et al.*, 1994). To conservationists, sustainable management means a phasing out of logging in native forests and replacement of the wild-harvested resource by plantation stock (Robins *et al.*, 1996). These concerns were addressed in the 1992 National Forest Policy Statement (NFPS) (Commonwealth of Australia, 1992), jointly developed by the Commonwealth, State and Territory Governments, in consultation with a wide range of individuals and organisations. The NFPS is designed to develop an ecologically sustainable forestry industry in Australia through:

- removal of unnecessary impediments to market efficiency and access to forests
- development of flexible timber allocation systems through competitive bidding arrangements
- security of supply through clearly defined and tradeable timber harvest rights.

Implementation of the NFPS is being achieved through the development of Regional Forest Agreements (RFAs) between the Commonwealth, State and Territory Governments, and export of hardwood woodchips beyond the year 2000 is conditional on having RFAs in place. The RFAs are negotiated through an open process involving a range of stakeholders, including scientists, economists, conservationists, industry and community groups and

Table 30. Production of various forest products in Australia (adapted from ABARE, 1997).

Timbers	1995/96 ('000 m^3)	1996/97 ('000 m^3)
Sawnwood (coniferous)	2053	2062
Sawnwood (broadleaf)	1391	1321
Railway sleepers	86	72
Plywood	131	151
Particleboard	826	790
Medium density fibreboard	377	434
Total	*4865*	*4830*
Papers & Paperboard	1995/96 (kt)	1996/97 (kt)
Newsprint	445	421
Printing & writing	351	364
Household & sanitary	180	181
Packaging & industrial	1344	1452
Total	*2320*	*2418*

political groups (Department of Primary Industry, Forestry, 1998). They are intended to deliver certainty of conservation outcomes, balanced by security of access to resources for industry. A major summary of the current state of Australia's forests is expected to be released in late 1998 (Commonwealth of Australia, 1998).

The Australian Bureau of Agricultural & Resource Economics produces a quarterly report, *Australian Forest Products Statistics*, giving details of various categories of forest production. According to a recent issue (ABARE, 1997), Australia in 1996/97 exported 57 200 cubic metres of sawn wood, and consumed 4 082 100 cubic metres, about one third coniferous and two thirds broadleaf. Production of sawn timber amounted to 1 954 600 cubic metres of exotic conifers, 101 300 cubic metres of Cypress Pine, 5900 cubic metres of Hoop Pine, 400 cubic metres of Tasmanian conifers, 1 314 300 cubic metres of *Eucalyptus* and 10 200 cubic metres of other broadleaf species. Imports of all types of sawn timber in 1996/97 was 756 300 cubic metres (ABARE, 1997). Production of various forest products in Australia for 1995/96 and 1996/97 is given in Table 30.

Eucalyptus

Eucalyptus species form the basis of the Australian hardwood timber industry. Various species are used for building and construction, furniture manufacture, railway sleepers and craft work, as well as in processed products ranging from plywood and particle board to paper.

Eucalyptus is extensively planted abroad as a timber crop. Eldridge *et al.* (1994) point out that at the beginning of the 1990s the largest *Eucalyptus* plantations in the world (3 million hectares) were in Brazil, with further large areas in India, Spain, Portugal, South Africa, Angola and China. Poynton (1979) provided details of the c. 200 species of *Eucalyptus* planted in southern Africa for timber, oil and pulp, and statistics on their performance in trials in different countries. In Australia the area of *Eucalyptus* plantations to 1989 was 55 000 hectares with another 30 000 hectares of reseeded harvested native forests (ABARE, 1990).

Recently, selected *Eucalyptus* clones have been re-imported to Australia to improve plantation timber yields. For example, Lake (1998a) described *Eucalyptus grandis*/*E.camaldulensis* hybrid clones imported from Brazil.

Paper

The earliest paper mills in Australia were based on locally grown *Pinus radiata* pulp, and imported pine pulp (Grant, 1989). Since the 1960s, with the development of methods to produce chemical Kraft pulp from the wood of *Eucalyptus* species, an increasing quantity of chipped timber from eucalypt forest has being going to paper production, both within Australia and overseas. The processes used are described by Higgins (1978). ABARE (1997) reported exports of 3 323 200 tonnes of woodchips in 1996/97, worth $543.5 million. Abroad, in addition to *Eucalyptus*, Australian *Acacia* species, particularly *A. mearnsii*, *A. saligna* and *A. mangium*, have been planted in over 70 countries, mainly as a quick source of pulp for paper making. J.Turnbull *et al.* (1997) reported that these plantations covered about 2 million hectares.

Hardboard

Eucalyptus spp. are also used in the manufacture of hardboard, usually referred to by its trade name of Masonite. The process, invented by W.H.Mason in Mississippi in 1926 to process pine waste into a composite board, has been used in Australia since 1939 to convert sawmill waste to board (Grant, 1989). Both wood and bark can be incorporated into the product. A different process, using an Asplund Defibrator, is used in some factories (Macmillan, 1978; Grant, 1989).

Timber

Eucalyptus is the basis of the Australian hardwood timber industry. The yield of sawn hardwood in Australia in 1996/97 was 1.3 million cubic metres, most of it *Eucalyptus*. Hillis & Brown (1978) provided an overview of the *Eucalyptus* timber industry. The total annual harvest of *Eucalyptus* wood in Australia in 1994 was 13 million green tonnes, of which only about 1% came from plantations (Eldridge *et al.*, 1994).

As well as *Eucalyptus*, other genera are or have been utilised for a range of purposes, and some of the most important are discussed briefly in the following paragraphs. A large number of Australian forest trees are used in small quantities in the craft industry and specialist furniture industry (e.g. *Allocasuarina fraseriana*, Jones, 1998). Many of these are discussed by Cribb & Cribb (1982) and Doran & Turnbull (1997). Bootle (1983) provided detailed data on the properties of Australian timbers.

Huon Pine

Huon Pine (*Dacrydium franklinii*) was the basis for a major timber industry in Tasmania from about 1816. It was recognised as an excellent construction timber, particularly for specialised uses such as boat and ship building. The timber is very fine-grained and is impregnated with an oil that makes it very resistant to rotting. The oil (methyl eugenol) was extracted from sawdust and scrap timber, and used as a disinfectant, insecticide, analgesic and skin treatment. Huon Pine is noted for being one of the most long-lived of plants. Individual trunks more than 2200 years old are known (Burrows, *et al.*, 1977), and individual clones are suspected of being very much older. However, it takes about 500 years for a tree to mature, making plantation growth impractical. Harvesting of the natural resource was intensive from 1816 until about 1880, and revived in 1890–1900. The last major harvest was in the 1970s when timber to be submerged by hydroelectricity dams on the Gordon River was salvaged and stockpiled. Small quantities of sub-fossil logs are still collected under licence from rivers and beaches. The species is well reserved in western Tasmania (Pedley *et al.*, 1980), but is unlikely ever again to be a major timber resource, other than in the craft industry.

Hoop Pine

Plywood production in Australia was originally based on *Araucaria cunninghamii* (Hoop Pine) but as supplies of this timber from native forests became scarce other rain forest timbers and imported species were substituted (Grant, 1989). More recently *Pinus radiata* from plantations has been used, and about 10% of plywood production now uses *Eucalyptus* spp. (Wade & Ksiazek, 1990).

Hoop Pine was recognised very early as a valuable timber, being used for joinery and shelving, and because of its odourless timber, for butter boxes. Plantations were established in New South Wales from the 1920s, with limited production from plantations being harvested from 1961. Extensive plantations of Hoop Pine were also established in Queensland, although exotic pines are now favoured for their quicker growth and ability to grow on poorer soils (Cribb & Cribb, 1982).

Cypress Pine

Callitris glaucophylla (syn. *C. glauca*, White Cypress Pine) was formerly widespread throughout western New South Wales and south-western Queensland, where it was prized for its high durability and resistance to termite attack. Minor stands occur in Victoria, South Australia, the Northern Territory and Western Australia. In New South Wales *C. glaucophylla* forests are primarily managed for timber production (Lacey, 1973), mainly for building construction, and some plantations have been established (Grant, 1989). About 102 000 cubic metres of *C. glaucophylla* timber was produced in New South Wales in 1987/88, about 5.5% of total sawlogs for that State (Grant, 1989). In Queensland, the harvest

has remained steady at about 180 000 cubic metres per annum since 1970 (Department of Primary Industry, Forestry, 1998).

Blackwood

Acacia melanoxylon (Blackwood) extends from Queensland through New South Wales, Victoria and Tasmania to South Australia. In Tasmania and Victoria it reaches 30 m tall, and is a prized cabinet making and craft timber, resembling teak (Cribb & Cribb, 1982; New, 1984). It is easy to work, although some people develop allergies to the dust. Production in Tasmania in 1990 was 16 000 cubic metres per annum, mainly from old growth forests (Allen, 1992). Blackwood has been grown as a plantation timber for some years in New Zealand (Nicholas, 1981, 1988; Gleason, 1986) and South Africa (De Zwaan & van der Sijde, 1990), and matures in 40 to 70 years. It is also grown in a number of other countries (Hawai'i, Sri Lanka, Pakistan, India, Kenya, Malawi, Zimbabwe, Uganda, Tanzania, Congo, Ethiopia, Spain, Portugal, Cyprus, Chile, Argentina and Uruguay) either for timber or pulpwood (Allen, 1992; Doran & Turnbull, 1997). In the late 1980s trials on plantation growth of Blackwood in Tasmania were conducted, with a view to making the entire industry plantation based within 35 years (Allen, 1992).

Other *Acacia* spp.

Acacia aulacocarpa is distributed from northern and eastern Australia to Papua New Guinea. Along with some closely related species it is being evaluated as a source of quality timber, pulpwood and fuelwood in subtropical and tropical regions. Plantations have been established in Australia, China, Fiji, Indonesia, Kenya, Laos, Malaysia, Philippines, Thailand, Vietnam and Zimbabwe (Gunn *et al.*, n.d.; Turnbull, 1987; Thomson, 1994; Maslin & McDonald, 1996; Doran & Turnbull, 1997).

Acacia mangium, another species of northern Australia and Papua New Guinea, is also showing promise as a reafforestation species for timber and pulpwood in subtropical and tropical regions (Turnbull, 1987; Maslin & McDonald, 1996; Doran & Turnbull, 1997).

Sandalwood

Two species of *Santalum* provide the basis of the Australian sandalwood industry. The major source is *Santalum spicatum*, found in Western Australia and western South Australia; smaller quantities of *S. lanceolatum* from northern and western Western Australia and northern Queensland are also exported. The wood is used for joss-stick manufacture, and Australia supplies most of the world market.

Western Australia is the major exporter, through a single company, the Australian Sandalwood Company. Exports in 1989 were 1960 tons, worth $11 480 875 (Statham, 1990). For a short overview of the international trade, see Coppen (1995).

Collection is by pulling out the whole tree, including the stump and larger roots. Roots and butts are the most valuable portion, with the greatest concentration of oils, but the upper trunk and branches are also processed. All supply comes from wild harvesting, on crown land and pastoral leases. Regulations control the size of trees to be harvested. *S. spicatum* takes up to 80 year to mature in the wild and 1985 estimates put the life of the industry at c. 25 years at the then current rate of harvesting.

Studies of sandalwood regeneration in the wild show that there is potential for reseeding to re-establish the species for harvesting in areas where it has been taken formerly (Loneragan, 1990). Limitations on re-establishment include the necessity for several years of good seasonal rains, and the availability of suitable host plants (*Santalum* is a root hemiparasite). Barrett & Fox (1996) suggested establishment of sandalwood as part of salinisation-reduction tree planting programs. Experimental plantations of both *S. spicatum* and *S. album* (high quality oil production) have been established (Statham, 1990).

Charcoal

Charcoal production is one of the more exotic industries based on forest products. Charcoal production from a range of genera (mainly *Acacia* and *Eucalyptus*) in New South Wales was described by Humphreys & Ironside (1980). The charcoal is used to make carbon bisulphide (viscose rayon industry), for case-hardening steel, metallurgy, as fuel for foundries and barbeques, and for the manufacture of briquettes and activated carbon for filters. Charcoal from *Eucalyptus* is used to a large extent in the Brazilian iron and steel industry (Humphreys & Ironside, 1980; Eldridge *et al.*, 1994).

Firewood

Wood for cooking and heating has been a traditional use for native timber for thousands of years. Indigenous peoples used relatively small quantities, but with European settlement usage increased rapidly. Grant (1989) reported that in New South Wales alone, firewood use peaked in the years 1924 to 1940, when up to 600 000 cubic metres of timber was used annually for firewood. Since 1968/69 usage dropped to below 50 000 cubic metres per annum (Grant, 1989). FORTECH (1989) estimated Australia's annual fuelwood collection (mainly *Eucalyptus*) at more than 4 million tonnes, air dried. The Resource Assessment Commission (1992) estimated that firewood collection in Australia had risen to 6.1 million tonnes per annum, and Low (1995) considered that this level of consumption of firewood exceeded ecologically sustainable levels. Neagle (1994a) suggested that 60 000 to 70 000 wood heaters were sold each year in Australia.

In South Australia, New South Wales and Victoria the use of the lignotubers of mallee *Eucalyptus* species as domestic fuel wood was a major industry in the late 19th and first half of the 20th century. These 'mallee roots' were ploughed up for many years after clearance of mallee woodland for agriculture, particularly in the Murray Mallee, Yorke and Eyre Peninsula areas of South Australia. While still used for this purpose, the supply is now dwindling.

Eucalyptus is frequently grown overseas as a source of firewood. *E. globulus* is one of the most usual fuelwood species, being quick growing and providing a good fuel. It is grown for this purpose in Portugal and the Nilgiri Hills of India (Cribb & Cribb, 1982). *Acacia* plantations have been established in many countries, including Kenya, Tanzania, Zimbabwe, People's Republic of China, Thailand, Malaysia and Sabah, principally as firewood sources, but also as food crops, for timber, and to enhance nitrogen fixation in soils (Turnbull, 1987). Midgley *et al.* (1986) provided information on fuelwood species for salt-affected areas.

Native pasture and fodder

A very large part of the Australian pastoral industry is based on native plants. The main taxa involved are Mitchell Grass (*Astrebla* spp.), Saltbush (*Atriplex* spp.), Bluebush (*Maireana sedifolia*), Wallaby Grass (*Austrodanthonia* spp.), Spear Grass (*Stipa* spp.), Tussock grasses (*Poa* spp.) and Kangaroo Grass (*Themeda triandra*).

Four species of *Astrebla* provide the main grazing resource for the summer rainfall area stretching from the black soil plains of western Queensland and north-western New South Wales through the Northern Territory to Western Australia. In the more temperate winter rainfall regions of southern Australia the main native pasture grasses are the danthonioids (particularly *Austrodanthonia*) and *Stipa*. *Themeda triandra* was once widespread throughout Australia, but is very palatable and susceptible to over-grazing and has now all but disappeared from much of its previous range. In subalpine areas of New South Wales, Victoria and Tasmania a substantial summer grazing industry was built on alpine tussock grasses, principally *Poa labillardieri* and *P. sieberiana*, but including many others. With reservation of much of the high country in recent decades, and exclusion of stock from mountain pastures, this part of the industry is now in decline. The contribution of grasses to Australia's economy is discussed in more detail by Lazarides (in press).

In semi-arid Australia, particularly on soils prone to salinisation, extensive shrublands of *Atriplex nummularia* and *Maireana sedifolia* support a major grazing industry. During wetter periods stock preferentially graze on ephemeral herbs and grasses, but in times of drought the chenopod shrubs provide a nutritious and moderately palatable substitute. However, the shrubs are susceptible to over-grazing and trampling, and in the past these shrublands have been degraded. Substantial research has now provided management techniques which can maintain the semi-arid shrublands in good condition. Lambs fed on these shrubs provide meat which is marketed as a specialty product in conjunction with the 'bush food' trade.

Cribb & Cribb (1982) list a number of shrubs and trees which provide a subsidiary resource for stock, either through browsing, or more usually, after lopping or felling to provide fodder during drought. These shrubs and trees include Mulga (*Acacia aneura* and related species), Myall (*Acacia pendula*), Red Ash (*Alphitonia excelsa*), Whitewood (*Atalaya hemiglauca*), Grey Mangrove (*Avicennia marina*), Bauhinia (*Lysiphyllum carronii*), Kurrajong (*Brachychiton populneus*), Bottle Tree (*Brachychiton rupestris*), *Capparis* spp., *Dodonaea* spp., *Ehretia saligna*, *Eremophila* spp., Leopardwood (*Flindersia maculosa*), Wilga (*Geijera parviflora*), Queensland Sandalwood (*Santalum lanceolatum*), Rosewood (*Terminalia volucris*) and Vine Tree (*Ventilago viminalis*). Other accounts of native shrubs and trees used for fodder are those of Wilcox & Morrissey (n.d.), Everist (1969), Askew & Mitchell (1978), Vercoe (1987) and Goodchild & McMeniman (1987).

Essential oils

An overview of aromatic oils extracted from native Australian plants was provided by Cribb & Cribb (1982). They pointed out that one of the first exports from Australia was oil distilled from *Eucalyptus piperita* by John White in 1790.

Currently, major oil production from Australian species is of *Eucalyptus* oil (mostly produced overseas) and Tea-tree oil (of which Australia is the major producer). Minor oil products for perfumes, after-shaves and other cosmetics come from *Backhousia citriodora* (Lemon Myrtle) (Archer, 1997; Costin, 1997; Lake, 1998b), *Boronia megastigma* (Peterson & Evans, 1996) and *Tasmannia lanceolata* (Peterson & Evans, 1996; Peterson, 1998). Sandalwood oil from *Santalum spicatum* was produced in Western Australia until 1971 (Loneragan, 1990). There is potential for this to resume if plantation production of *S. album* is successfully established (Statham, 1990). Other plants with essential oil potential have been tested but are not in commercial production.

One of the problems with production is the different chemotypes within a species, and wild production from plants of unknown chemotypes is a limiting factor. Plantation-grown clones or seedlings from selected seed reduces the variation in chemical composition and oil yields (Boland, 1991; Payne, 1998).

Bulk extraction is usually by steam distillation (*Eucalyptus* and Tea-tree). Solvent extraction is a more expensive method and is used mainly for smaller, high value production, particularly *Boronia* and *Tasmannia* (Peterson & Evans, 1996)

Eucalyptus Oil

Eucalyptus oils are obtained by distillation. Their main uses are in pharmaceuticals, confectionary, toiletries, fragrances, insect repellants and industrial solvents. Use as an additive to ethanol/petrol fuels is under investigation. For a history of the *Eucalyptus* oil industry in Australia, see Boland (1991).

World production is about 3000 tonnes per annum (Peterson & Evans, 1996), of which only 5–10% is produced by Australia (Boland, 1991). The major producer and exporter of oils is China (1600 tonnes/annum), mainly from *E. globulus*. Australia produced about 1000 tonnes/annum in 1939/48, but is now only producing about 110 tonnes/annum, mainly from *E. polybractea* plantations in Victoria and New South Wales. Other countries with a eucalypt

oil industry are Portugal, Spain, India, Brazil and South Africa, with minor production in Bolivia, Uruguay, Paraguay, Swaziland, Zimbabwe and Nepal (Coppen, 1995).

The main Australian commercial species is *E. polybractea*, followed by *E. dives* and *E. viridis*. Overseas *E. globulus*, *E. smithii* and *E. citriodora*, and lesser quantities of *E. camaldulensis*, *E. cneorifolia*, *E. dumosa*, *E. elata*, *E. exserta*, *E. goniocalyx*, *E. leucoxylon*, *E. macarthurii*, *E. olida*, *E. oleosa*, *E. radiata*, *E. sideroxylon*, *E. staigeriana*, and *E. tereticornis* are the main commercial crops (Boland, 1991; Coppen, 1995; Woodley, 1998). In overseas plantations oil can be a secondary product from trees grown for fuel, pulp or other purposes.

There is a continuing program of research into eucalypt oils, in search of new products and uses and for improved production. Brophy *et al.* (1991) provided a detailed analysis of the essential oil components of 111 northern and eastern Australian species of *Eucalyptus*, and Lassak *et al.* (1991) summarised the oils of most *Eucalyptus* species.

Tea-tree Oil

Tea-tree oil is produced principally from *Melaleuca alternifolia*, although *M. linariifolia* and *M. dissitiflora* are sometimes used (Colton & Murtagh, 1990; Drinnan, 1998; Woodley, 1998). *M. alternifolia* occurs naturally along coastal regions of northern New South Wales and southern Queensland, and was wild-harvested until the 1980s, when plantations began to be established. The oil has anti-bacterial and anti-fungal properties and is used in toiletries and healthcare products, especially in mouthwash, antiseptic creams, shampoos and soap.

Production of oil in 1989 was 55 tonnes, rising to approximately 150 tonnes in 1995 (Peterson & Evans, 1996). Australia consumed about 20 tonnes per annum in 1989–1991. About 80% of the crop is exported, mainly to the USA (Downing, 1994). The main plantations are in northern New South Wales where projected production is 500 tonnes by the year 2000. Smaller plantations have been established in Queensland, particularly in the Atherton Tablelands where the crop is seen as an alternative to tobacco (Kernot, 1994). See Stubbs & Davis (1992) and Drinnan (1998) for overviews of the industry in New South Wales and Queensland respectively. For industry overviews, planning and marketing strategies see Dean (1988), Murtagh & Southwell (1989) and Murtagh (1991).

Trial plantings of *M. alternifolia* for oil extraction have been established in China, Fiji, India, Indonesia, New Zealand, Thailand and the USA (Peterson & Evans, 1996).

Tropical Myrtaceae - *Asteromyrtus, Callistemon, Melaleuca*

Thirty six tropical Australian species from these three genera were surveyed for potentially valuable commercial essential oils by Brophy & Doran (1996). Among the species included in the survey were *Melaleuca leucadendra* (as *M. cajuputi*) used as the source species for the cajuput oil industry in Indonesia, and *M. quinquenervia*, the basis for the niaouli oil industry in New Caledonia.

Boronia

The oil of Brown Boronia, *Boronia megastigma*, is obtained from the flowers, mainly by solvent extraction. It is used mainly in flavouring (and to a lesser extent in perfumery). The industry was originally based on extraction from wild-collected material in Western Australia, but is now mainly centred on plantation-grown clones in Tasmania. Limited production occurs in New Zealand. Production was less than 0.5 tonnes in 1995 (Peterson & Evans, 1996) but the value of the absolute oil is over $10 000 per kg.

Tasmannia

Tasmannia lanceolata (Native (Mountain) Pepper) is primarily utilised as a bush food, but an oil extract has been produced and is being marketed as a flavouring in chewing gum and

toothpaste in Japan. Marketing research into other applications in the food industry is continuing (Peterson & Evans, 1996; Padbury, 1998).

Olearia

Olearia phlogopappa (Dusty Daisy Bush) is a variable, aromatic plant, grown mainly for its colourful flowers. Trial extractions of oil from this plant are currently being evaluated (Peterson, 1998).

Sandalwood

A small Sandalwood oil industry existed in Western Australia until 1971, based on *Santalum spicatum*. The oil of this species is inferior to that of *S. album* from east India, although *S. album* oil can be approximated by blending oil from *S. spicatum* and *S. lanceolatum* (Loneragan, 1990). *Santalum album* is native from India to Hawai'i and extends to coastal Northern Territory (George, 1984c). Investigations of the possibility of establishing plantations of *S. album* are underway (Statham, 1990)

Native plants for revegetation

Since European settlement of Australia, large areas of the natural vegetation have been cleared for agriculture, forestry, mining and urban development (see Cresswell, this volume; Fox, this volume; Glanznig, 1995). Increasing environmental concern has led to the expectation that mining areas (especially open-cut mines) will be returned to something approaching their natural state after the minerals have been extracted. In the case of degraded agricultural land, the emphasis is usually on returning the land to productivity, through agroforestry or pasture establishment.

In the case of mine-site rehabilitation there is often a requirement for selection of plants with high tolerance of heavy metals, extreme pH tolerance or other extreme ecological conditions. A new journal of the Australian Minerals and Energy Environment Foundation (AMEEF), *Groundwork*, was established in 1997 to disseminate information in this field.

It is estimated that there are c. 32.4 million hectares of saline land in Australia, 28.2 million hectares of which is natural (salt lakes, coastal marshes etc), with the remaining 4.2 million hectares being created by agricultural practices since European settlement. About 3.8 million hectares is referred to as 'scalded', where the loss of topsoil has exposed the saline subsoil; the rest is affected by seepage salinity, where the watertable has risen after clearing of vegetation, particularly trees (Robertson, 1996). An additional 250 000 hectares of land is salt-affected in irrigation areas of New South Wales. To repair areas subject to salinisation requires selection of strains and species that are salt tolerant (Fraser *et al.*, 1996; Barrett & Fox, 1996), and adoption of new methods of land management (Beal, 1993; Gomboso *et al.*, 1996; Hamilton & Bathgate, 1996). Replanting of trees (preferably of local provenance) will reduce recharge of watertables and related salinisation (Hamilton & Bathgate, 1996).

Doran & Turnbull (1997) provided descriptions and horticultural details for a wide range of native trees and shrubs suitable for land rehabilitation in the Australian tropics. Marcar *et al.* (1995) and Midgley *et al.* (1986) provided additional information for salt-tolerant tree species for tropical and temperate areas. Socioeconomic aspects of maintaining native vegetation on agricultural land were examined by Price (1995).

In the last decade a number of State, Territory and Commonwealth Government programs have been established to rehabilitate and revegetate degraded areas. Most of these programs involve a large community component, and seek to work with landowners for mutual benefit. These programs include national and State Landcare programs, various State Remnant Vegetation Protection and Revegetation schemes, One Billion Trees, Save the Bush, and several programs under the Natural Heritage Trust, including Bushcare.

Miscellaneous uses

Honey

Honey from native bee nests was a sought-after delicacy of the indigenous peoples. The techniques for gathering it are described by Isaacs (1987). Indigenous peoples also extracted nectar directly from a range of flowers, by sucking inflorescences or dipping them in water. *Grevillea*, *Banksia* and *Hakea* were the main sources of nectar (Isaacs, 1987; Latz, 1995).

Use of the native Australian flora as a source of nectar and pollen for honey production by the introduced honey bee, *Apis mellifera*, is 200 years old. From a cottage craft it has expanded into a sizeable industry, supplying both commercial bulk honeys and specialist products based on particular species. Among the latter are Leatherwood honey (derived from Tasmanian *Eucryphia* spp.), River Red Gum honey (*Eucalyptus camaldulensis*) and Yellow Box honey (*Eucalyptus melliodora*). Both native and introduced plants contribute to the honey industry, although the native species predominate. The number of taxa involved is quite high. For New South Wales alone, Clemson (1985) listed over 300 species, about two thirds of which are native. The most important are numerous species of *Eucalyptus*; of somewhat lesser importance are *Angophora*, *Lophostemon*, *Melaleuca*, *Callistemon*, *Leptospermum*, *Banksia*, *Acacia* (pollen only), *Casuarina*/*Allocasuarina* (pollen), *Eucryphia* and some mangroves.

In 1994/95 honey production in Australia was 19 000 tons, worth $24 621 000 (McLennan, 1997).

There is a very large literature on the honey flora. The following are just a sample of recent and older works: Australia: Rayment (c. 1917), Cribb & Cribb (1982); New South Wales: Goodacre (1958), Clemson (1985); Queensland: Blake & Roff (1988); Victoria: Department of Agriculture (n.d.); South Australia: Purdie (1968).

Wattle Bark

One of the first industries established in Australia after European settlement was a tanning industry to produce leather. The industry was built on tannins extracted from the bark of a number of native taxa, principally *Eucalyptus* spp. A Government tan yard was established in Parramatta in 1801, and by the following year sample shipments of tan bark were being sent to England for evaluation. By 1814 *Acacia* spp. had been identified as an excellent source of tan bark, and by 1828 *Acacia mearnsii* or Black Wattle (then known as *A. decurrens* or Green Wattle) was established as a high quality and abundant source.

In the period 1840 to 1905 large bark stripping and processing industries were established in southern New South Wales, in south-western and north-eastern Victoria and in eastern Tasmania. At the peak of this industry, up to 20 000 tonnes of wattle bark per annum were exported. A Board of Inquiry into the industry in Victoria in 1878 found that at that time about 12 000–15 000 tonnes of wattle bark was harvested annually to support the Victorian tanning industry. As all of this had come from wild-harvesting, and killed the trees involved, widescale destruction of the resource had occurred. From 1883 a number of Government-sponsored plantations were established in Victoria, South Australia and New South Wales and these continued to be established until about 1920. Private plantations continued to be established until about 1943. However, fires, a declining market, competing land uses, high stripping and transport costs, and a lack of a market for the wood, all contributed to their eventual failure.

South Africa established more successful plantations of *Acacia mearnsii* from the 1880s, and by the 1940s was a major exporter. Plantations totalled about 400 000 hectares (Cribb & Cribb, 1982). Even Australia imported tannin extracts from *A. mearnsii* from South Africa, with a peak of 16 887 tonnes of bark and extract in 1944. Brazil also became a major exporter from *A. mearnsii* plantations in the 1980s. Since 1984 China (in collaboration with Australia's CSIRO) has also established plantations of this species, to service its domestic

tanning industry. Other countries growing *A. mearnsii* for tan bark are Kenya, Tanzania, Zimbabwe, Indonesia, the Philippines and Sri Lanka (Cribb & Cribb, 1982).

Chromium salts, either alone or in combination with tannin, were increasingly used as a faster and cheaper tanning method during much of the 20th century. This contributed to the decline of the tan bark industry. From the 1950s, leather production declined sharply, as synthetics were increasingly used for furniture and shoes, and demand for other leather products, such as harnesses, declined.

From the 1960s, however, there has been something of a resurgence in the tan bark industry. Concerns about heavy metal contamination have reduced the popularity of chromium-based tanning processes, and a new industry has developed: the production of waterproof glues based on phenol-formaldehyde fortified *A. mearnsii* tannins. These are used increasingly in the production of water resistant plywoods and particle boards.

In 1984 a major research project on *A. mearnsii* biology, silviculture, properties, chemistry, production and use of tannin extract and prospects for its development as an industry in China, was established between the Chinese Academy of Forestry and the Australian Centre for International Agricultural Research. The major outcomes of this research were described in a Chinese-language publication in 1991. This was reissued in abridged form, in English, in 1997 (Brown & Ho, 1997). New (1984) provided a history of the industry in Australia and abroad, and information on chemistry, plantation sizes, and yields. Grant (1989) traced the history of the wattle bark industry of New South Wales, and Luyt *et al.* (1987) described the production of wattle bark from *A. mearnsii* in Zimbabwe. A comprehensive history of the Australian *A. mearnsii* wattle bark industry was written by Searle (1991). Doran & Turnbull (1997) provided detailed silvicultural information for the species, both within Australia and abroad.

Cribb & Cribb (1982) listed other taxa used as a source of tan bark as *Acacia pycnantha*, *Bruguiera spp.*, *Callitris* spp., *Casuarina* spp., *Eremophila longifolia*, *Eremophila oppositifolia*, *Eucalyptus alba*, *Eucalyptus astringens*, *Eucalyptus calophylla*, *Eucalyptus diversicolor*, *Eucalyptus gomphocephala*, *Eucalyptus wandoo* and *Rhizophora stylosa*.

Brush Fencing

The construction of domestic fencing from bundles of 'brush' has been popular in South Australia (particularly Adelaide) since at least the 1940s. From about the mid-1970s, the practice spread to the eastern States. Brush fencing is a prestige product, costing at least 30% more than the most expensive sheet metal product, but about half the price of a reinforced brick fence of comparable height.

Brush fencing is made from the thin flexible stems of *Melaleuca uncinata*, sometimes with the addition of *Baeckea behrii*. Fences are typically 1.5 to 2 m tall, and weather to an attractive dark grey. If well constructed they have a life of 20 years or more, and because of their high oil content, are resistant to rot and termites. On the other hand, they are very flammable, and can harbour insect pests.

Supplies of brush for Adelaide come from wild harvesting, principally in the Murray Mallee and South East of South Australia (mainly the Pinnaroo–Lameroo area) and from western Victoria. Supplies for the Sydney market are cut near West Wyalong in New South Wales. Lewis (1979) estimated that at that time about 1800 tonnes of brush were used in Adelaide per annum, and this figure was supported by another study by Bastin *et al.* (1982). These figures translate to the harvest of about 6000–9000 plants per week, or 100 to 300 hectares per annum. Woodley (1998) set usage at the equivalent of 30–50 km of fencing per annum. More than 70% of plants regenerate after harvesting, mimicking their behaviour after fire. Regeneration periods of 10 years after fire or harvesting are required to produce commercial-sized stems, and individual plants may therefore be capable of providing 3 or 4 crops in an estimated lifespan of 50 years. The continuing supply of material is largely dependent on natural regeneration. Very small trial plantation plantings near Monarto by the South Australian Woods & Forests Department were reported by Bastin *et al.* (1982), and others at Dimboola, Lameroo and other sites in south-eastern South Australia were reported by

Bulman *et al.* (1998), but no commercial plantations appear to have been established. Bulman *et al.* (1998) examined the economics of plantation farming of *M. uncinata*, and reported a usage rate of about 100 000 bundles (each of 23 kg) per annum for Adelaide alone.

The economic value of the industry has not been estimated, although Bastin *et al.* (1982) reported 24 brush fence companies operating in Adelaide in 1982, mostly family businesses. The value of the brush used was $156 000 to $468 000 per annum to the cutters. Construction costs were 2–3 times this amount, making the industry worth perhaps $2 million per annum in South Australia alone in 1982. Woodley (1998) cited concerns that the industry was not sustainable, although the South Australian Government disagreed.

Dye Plants

In the early years of European settlement many plants were investigated as sources of dyes for cloth, but following the development of aniline dyes in the 1860s, and the subsequent replacement in industrial use of most natural dyes by synthetic ones, the search was largely abandoned (Cribb & Cribb, 1982). Some plants of historical interest, including some traditional Asian dye plants, are discussed by Cribb and Cribb (1982).

Since the 1960s an increased interest in fibre crafts, especially spinning and weaving, has revived the interest in native plants as dye sources. In addition to the information collected in the nineteenth century, Spinners and Weavers Guilds in several States have coordinated tests of local plants and several books are available, e.g. Lloyd, 1971; Handspinners & Weavers Guild of Victoria, 1974; Carman, 1978; Trendall, 1981. Hundreds of native plants produce useful dyes, in particular species of *Eucalyptus* and *Acacia*.

Gums, Resins and Kinos

A number of native plants produce exudates, and many of these were used by indigenous peoples as foods, cements and gums. Relatively few have been exploited commercially, the one exception being the resin from *Xanthorrhoea* spp. This resin is produced copiously at the base of the leaves, and has been used in the manufacture of picric acid (for explosives), as an (inferior) substitute for shellac, as a varnish for metal instruments, and in stove polish, incense, perfumery, soap, sealing wax, paper sizing and in gramophone record and linoleum manufacture. An industry to collect this resin, based on *X. resinosa* (New South Wales and Victoria), *X. preissii* (Western Australia and *X. tateana* (Kangaroo Island, South Australia), previously existed, and at its peak in about 1940 over 2500 tonnes of resin per annum was being exported (Neagle, 1994b). The Kangaroo Island industry still exists, with production also resuming recently on a very small scale in Western Australia (Neagle, 1994b). In 1994 exports of Yacca (*Xanthorrhoea*) resin from South Australia were about 153 tonnes, with a further 30 tonnes being produced in Western Australia. The industry was estimated to have a life of about 20 years (Neagle, 1994b). However, Woodley (1998) reported that the industry on Kangaroo Island had now ceased. Cribb & Cribb (1982) provide descriptions of other species yielding gums, resins and kinos of minor importance. Cribb & Cribb (1975) and Low (1991) describe *Acacia* gums which were and still are used as food or in drinks. Isaacs (1987) and Latz (1995) mentioned that gum from *Casuarina*/*Allocasuarina* is also eaten, and Latz also identified *Crotalaria eremaea* as a source of edible gum. New (1984) provided information on the chemical constituents of *Acacia* gum.

Soap Making

Various species have been burned to produce the alkaline ash or barilla necessary as an ingredient in soap making (the other ingredient is fat or oil). Cribb & Cribb (1982) described the use of *Avicennia marina* and *Casuarina paludosa* for this purpose. Bird (1981) described the Australian barilla industry based on *Avicennia marina* in Victoria, New South Wales and South Australia in the 1840s and 1850s, and a similar industry based on unspecified mangroves in Moreton Bay during the same period.

Whinray (1981) described the barilla industry in Tasmania. This industry existed from at least 1819, and was based at first on barilla produced by burning kelp. Later, about 1822, *Acacia mearnsii*, *Allocasuarina verticillata* (syn. *Casuarina stricta*) and *Eucalyptus* spp. were used. From 1823 to about 1830 a barilla industry based on chenopod shrubs (particularly *Atriplex cinerea*, *Rhagodia baccata* and *Arthrocnemon arbusculum*) from the east coast of Tasmania and islands of Bass Strait serviced a soap manufacturer called Roberts on Bruny Island, and others in Hobart. By the 1850s chemically produced alkali was available in quantities and of a quality that made the barilla industry uneconomic.

Sphagnum Moss

Woodley (1998) reported on a tiny sphagnum moss harvesting industry that operates in Tasmania, yielding about 125 cubic metres per annum.

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