

# Pongamia

*Millettia pinnata* syn. *Pongamia pinnata*



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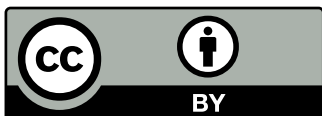
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Front cover: *Pongamia pinnata* flowers and leaves at Shamirpet, Andhra Pradesh, India. (Source: *Pongamia\_pinnata\_(Karanj)\_near\_Hyderabad\_W\_IMG\_7634.jpg*. Author: JM Garg (2009). Licensed under GNU Free Documentation License, Version 1.2)

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# Summary

*Pongamia* (*Millettia pinnata*), formerly known as *Pongamia pinnata*, is a tree/shrub with a broad distribution from India, through central and south-eastern Asia, Indonesia and into northern Australia. Its native range is uncertain, with conflicting information in the published literature. However, the Queensland Herbarium currently considers *pongamia* native to northern Australia (Queensland and the Northern Territory).

The seeds of *pongamia* are rich in oil, which might be a new source of 'biofuel'. Research and field trials to assess the species' capacity to produce biofuel are currently underway in Queensland and the Northern Territory.

Preferred habitats include coastal and riverine habitats, primarily in humid tropical and subtropical areas (500–2500 mm rainfall per annum).

This study assessed the risk of *pongamia* invading bushland and grazing land outside its native range in Queensland. While it has naturalised in several countries (with evidence of sporadic naturalisation in south-eastern Queensland), this study was unable to find evidence that *pongamia* has significant negative impacts as a weed anywhere in the world. When combined with the fact that it is considered native to northern Australia, this study concludes that *pongamia* poses a low risk in Queensland.

*Pongamia* tolerates a wide range of soils, including saline soils. It also produces large numbers of water-dispersed seeds. Its leaves and seeds are toxic to herbivores. These attributes have led some people to recommend its restriction outside its native range in Australia, particularly if cultivation is proposed close to national parks or waterways. The IUCN's 'Guidelines on biofuels and invasive species' recommends that 'environmental management plans' are drawn up for biofuel plantations so that adequate planning and funding is in place to ensure, among other things, that seedlings are eradicated outside of designated plots.

# Identity and taxonomy

**Species:** *Millettia pinnata* (L.) Pierre (syn. *Pongamia pinnata* L. Merr).

**Other synonyms:**

*Cajum pinnatum* (L.) Kuntze

*Cytisus pinnatus* L.

*Dalbergia arborea* Willd.

*Derris indica* (Lam.) Benn.

*Galedupa indica* Lam.

*Galedupa pinnata* (L.) Taub.

*Galedupa pungum* J.G. Gmel.

*Millettia novo-guineensis* Kaneh. & Hatus.

*Millettia pinnata* (L.) Panigrahi

*Pongamia glabra* Vent. (nom. Illeg.)

*Pongamia mitis* (L.) Kurz

*Pongamia xerocarpa* Hassk.

*Pterocarpus flavus* Lour.

*Robinia mitis* L.

**Varieties:**

*Pongamia glabra* Vent. var. *xerocarpa* (Hassk.)Prain.

*Pongamia glabra* Vent. var. *minor* Benth.

*Pongamia mitis* (L.) Kurz var. *xerocarpa* (Hassk.)Merr.

*Pongamia pinnata* (L.) Pierre var. *hannii* Domin

*Pongamia pinnata* (L.) Pierre var. *minor* (Benth.) Domin

*Pongamia pinnata* (L.) Pierre var. *pinnata*

*Pongamia pinnata* (L.) Pierre var. *typica* Domin [nom illeg.]

*Pongamia pinnata* (L.) Pierre var. *velutina* CT White [renamed *Millettia velvetina* Adema (Adema, 2000)]

*Pongamia pinnata* (L.) Pierre var. *xerocarpa* (Hassk.) Alston

**Common names:****Pongamia, native wisteria, Indian beech (Australia)**

Arbre de pongolote (French), bangkong (Indonesian, Javanese), Báni (Filipino), biansu (Indonesian, Malay), Coqueluche, dalkaramcha (Tamil), day lim (Vietnamese), d[aa]y m[aa]s u (Vietnamese), d[aa]y kim (Vietnamese), day mau (Vietnamese), dok kom koi (Lao), Gal-karanda (Singhala), honge tree (Cantonese), Indian beech (English), kacang kayu laut (Malay), kanji (Hindi), karanda (Sinhala), karanj (Hindi, Bengali, Sanskrit), karanja (Hindi, Bengali, Sanskrit), karauini (Nepali), karum tree (English), kerong, khayi (Thai), kh[oor] (Vietnamese), ki pahang laut (Indonesian), ko:m ko:y (Thai), kona (Singhala), kranji (Indonesian), magul-karanda (Singhala), malapari (Malay), melapari (Indonesian), mempari (Malay), mullikulam tree (English), naktamala (Sanskrit), papar (Hindi), pari- pari (Malay), pongam (Tamil, English), pongam oil tree (English), pongu (Malay), poona (Tamil), poonga-oil-tree (English), pungai (Tamil), pungam (Tamil), punka (Tamil), punku (Tamil), s[aa]m hoa (Vietnamese), saw, seashore mempari (English), shui huang pi (pinyin, China), thinwin (Indomal.), thiuwia (Burmese), um al shuur (Arabic), vesi ne wai, vesivesi, yinam (Thai)

**Trade names:**

Kanji, pongam, karanga

Sources: Orwa et al. (2009); Mabberley (2000); APC (2010); APNI (2010); GRIN (2010); ILDIS (2010); IPNI (2010); Tropicos (2010).

**Family:** Fabaceae or Leguminosae-Papilionoideae

**Nomenclature:**

Pongamia is currently placed in the genus *Millettia* (see reviews by Acharya et al. 2004; Adema 2000; Geesink 1984). Prior to the latter reviews it was known widely as *Pongamia pinnata*.

Pongamia appears to be a variable species and a number of varieties have been listed (refer to list above and GBIF 2010). However, there is little published information describing the varieties, their distribution or genetic relationships. For example, *P. Pinnata* (L.) Pierre var. *pinnata* is represented in China and *P. pinnata* var. *xerocarpa* (Hassk.) Alston occurs in southern and south-eastern Asia (Flora of China, Tropicos). The synonym *P. Pinnata* var. *velutina* was cited as a possible distinct species and has now been revised to *Millettia velutina* Adema (Adema 2000).

## Description

*Pongamia* is a medium-sized, fast-growing tree or shrub (15–25 m tall). It has been described as briefly deciduous or evergreen with a drooping or spreading branching habit and broad crown (Orwa et al. 2009). The bark is grey or grey-brown and smooth or with faint vertical fissures.

The branchlets are hairless with pale stipule scars evident. The leaves are arranged alternately along the stems. Each leaf is composed of 5–9 leaflets with the terminal leaflet being largest. The leaves are hairless, pinkish-red when young, darkening to a glossy green above and a dull green with prominent veins below as they mature. The leaflets are ovate elliptical or oblong (5–25 cm x 2.5–15 cm), obtuse-acuminate at the apex, rounded to cuneate at the base, not toothed at the edges and slightly thickened. Stipules are caducous.



**Figure 1.** A flowering shoot of *Millettia pinnata* (Source: Derrispinnata.jpeg; Author: L. Shyamal (2007), licensed under a GNU Free Documentation License, Version 1.2).

The inflorescence is raceme-like, 6–27 cm long, axillary, pendant and has pairs of strongly fragrant flowers. The flowers are clustered (2–4 together), short-stalked and pea-shaped (15–18 mm long). The calyx is campanulate, truncate (4–5 mm long) and finely pubescent. The corolla is white to pink, purple inside and brownish-veined on the outside and five-toothed. The lowermost lobe is sometimes longer. The standard is sub-orbicular (1–2 cm), broad, with basal auricles often with a green blotch and thin silky hairs on the back. The wings are oblong, oblique, with a slightly adherent to obtuse keel (keel petals are coherent at the apex). The stamens are monadelphous; vexillary stamen free at the base but joined with others into a closed tube. The ovary is subsessile to short-stalked and pubescent. There are usually two ovules (rarely three). The style is filiform (with its upper half incurved) and glabrous. The stigma is small and terminal (description modified from Duke 1983; Orwa et al. 2010).



**Figure 2.** Close-up of *Millettia pinnata* inflorescence, Shamirpet, Andhra Pradesh, India (Source: *Pongamia\_pinnata\_(Karanj)\_near\_Hyderabad\_W\_IMG\_7631.jpg*; Author: JM Garg (2009), licensed under a GNU Free Documentation License, Version 1.2).

Pods are smooth, flattened but slightly swollen, oblique-oblong to ellipsoid (3–8 cm x 2–3.5 cm x 1–1.5 cm), slightly curved with a short, curved point (beaked). They are 1–2 seeded, brown, thick-walled and leathery to sub-woody, hard and indehiscent; borne on short stalks in quantities. Seeds are elliptical or compressed ovoid, bean-like, with a brittle coat (1.5–2.5 cm x 1.2–2 cm x 0.8 cm), flattened, dark brown and oily. It has an extensive lateral root system and a long taproot. *Pongamia* does not appear to require specific inoculation with *Rhizobium* bacteria (Daniel 1997; Orwa et al. 2009).



**Figure 3.** *Millettia pinnata* seed pods (Source: *Pongamia\_pinnata* Seeds.jpg; Licensed under a Creative Commons Attribution 3.0 License).

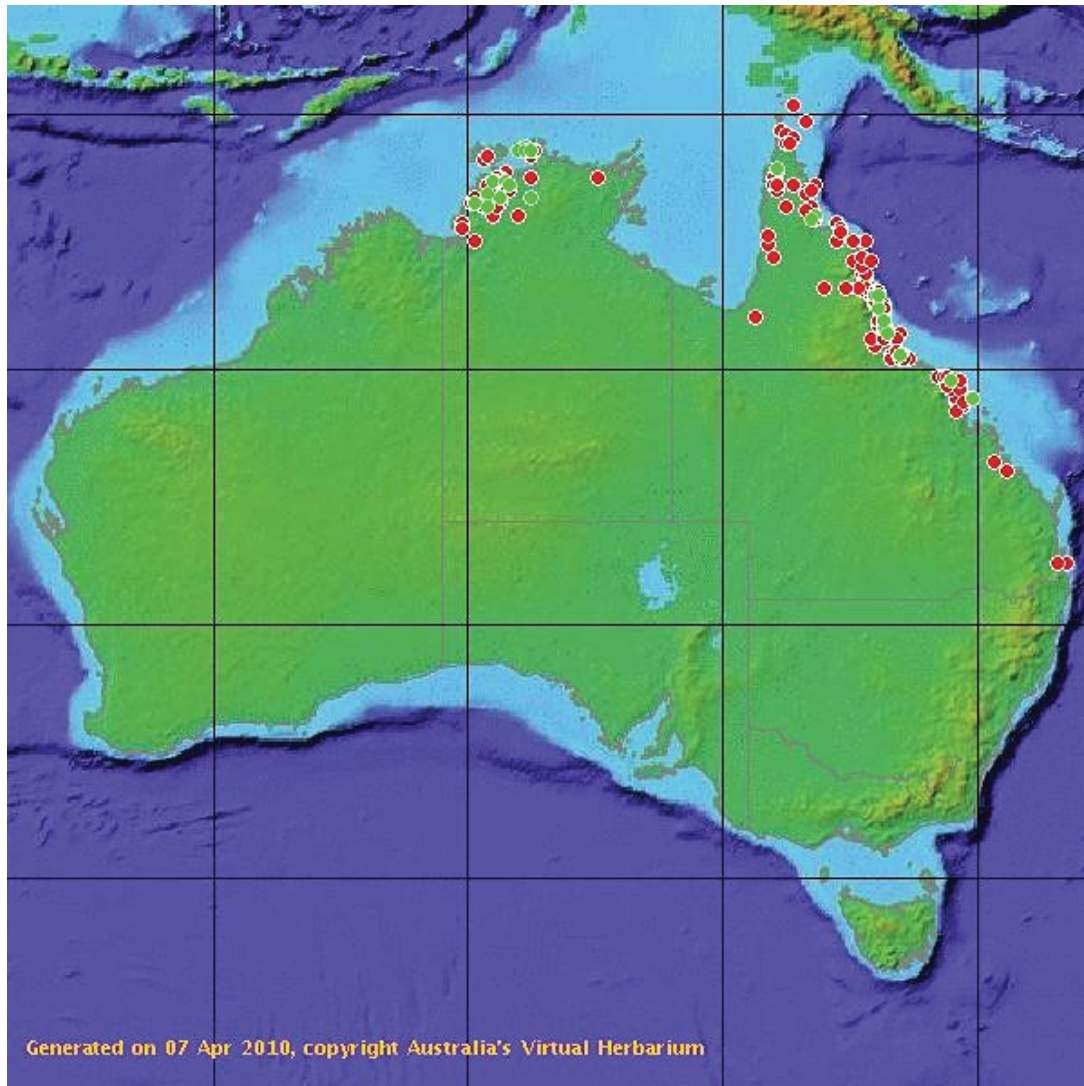


## Native range and distribution

*Pongamia* has a broad distribution across the Indian subcontinent, Asia, Africa, Pacific and America including the Caribbean (area includes India, Bangladesh, Pakistan, Nepal, Sri Lanka, Burmar, Thailand, Vietnam, Malaysia, Brunei, Irian Jaya, Java, Kalimantan, Lesser Sunda Islands, Sumatra, Singapore, Philippines, China (Fujian, Guangdong), Taiwan and Japan (Kyushu, Ryukyu Islands)). Within India, *pongamia* occurs in the following states: Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Dadra and N. Haveli, Delhi, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Pondicherry, Punjab, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh, West Bengal. It is also found on the Andaman and Nicobar Islands, northern Australia (including Christmas Island), Bismarck Archipelago, Papua New Guinea, Mauritius, Reunion, Seychelles, Fiji, Tonga, Samoa, Northern Marianas, Solomon Islands, New Zealand, Sudan, Egypt, Djibouti, Tanzania, Zaire, Uganda, New Zealand, Caribbean, Nicaragua and the United States of America. Across this range, its status as either native or introduced (naturalised) is unclear, due to a long history of cultivation and transportation spanning back to at least the 19<sup>th</sup> Century. For example, it is considered naturalised in the United States (Florida), Puerto Rico (USDA, NRCS 1999), Hawaii (Morton 1990) and Africa. *Pongamia* was introduced to Hawaii in the 1860s and the US Department of Agriculture received seeds from Sri Lanka, Mauritius, Egypt and India in the first two decades of the 20<sup>th</sup> Century (Morton 1990).

Sources: Duke (1983); Orwa et al. (2009); CAB International (2000); GRIN (2010); ILDIS (2010).

There is uncertainty regarding the native/naturalised status of *pongamia* in Australia. A number of publications consider *pongamia* to be naturalised (non-native) in Australia—for example, the AgroforestryTree Database (Orwa et al. 2009), CAB International (2000) and the Centre for Integrative Legume Research (undated). Other literature considers it native (e.g. Hnatiuk 1990; Morton 1990; Low & Booth 2007). The Queensland Herbarium currently lists *pongamia* as native to Queensland (from Mackay north) (T Bean, Queensland Herbarium, pers. comm. 2010), with a considerable number of specimens being collected over coastal eastern and northern Queensland and the Top End of the Northern Territory (Figure 4). There are relatively few records south of Mackay and it is suggested that the species was planted in recent times as an ornamental south of Mackay.



**Figure 4.** Locations where specimens of *Millettia pinnata* have been collected and identified by state herbaria (red circles represent collection locations labelled as *Pongamia pinnata* and green circles collections labelled as *Millettia pinnata* (AVH 2010).

The earliest herbarium record of pongamia in Queensland is dated 1818.

The Central Queensland University, The University of Queensland (UQ) and Pacific Renewable Energy (in collaboration with UQ) have established trial plantations of pongamia in central Queensland (including Roma), Gatton and Caboolture.

## Preferred habitat and climate

Pongamia prefers humid tropical and subtropical climates. However, it can tolerate a range of different conditions with mean annual rainfall between 500–2500 mm and temperatures of 0–16 °C minimum and 27–50 °C maximum. Mature trees can cope with light frosts, but require a dry period of 2–6 months (Duke 1983; Daniel 1997; Orwa et al. 2010).

Pongamia can tolerate a wide range of soil types including saline, alkaline, sandy, heavy clay and rocky soils (including oolitic limestone) and waterlogged soils. However, Orwa et al. (2009) suggest it performs best in deep, well-drained, sandy loams with adequate moisture. It does not grow well in very dry sands.

Pongamia can grow at altitudes from sea level to approximately 1200 m (Orwa et al. 2009). It has been described as a ‘maritime species’ since it tends to occur naturally along coasts and riverbanks in India, Bangladesh and Burma (Daniel 1997; CAB International 2000). In Australia, it shows a preference for coastal areas and waterways (T Bean, Queensland Herbarium, pers. comm. 2010).

## Reproduction and dispersal

Flowering occurs throughout the year in some parts of the world (Wikipedia 2010) but in late spring and summer in Florida and Queensland (Orwa et al. 2010; CILR n.d.). In the Northern Territory, seed production occurs from September to October (Bennett 2009). Seed longevity has not been formally researched but may exceed 60 years (Milletia Plantations 2010). Seeds tolerate salt concentrations equivalent to sea water (Royal Botanic Gardens Kew 2002).

Growth is rapid, with specimens reaching adult height in 4–5 years and producing seeds in 4–7 years. Seed production is prolific, with a single tree yielding 9–90 kg of seeds per annum, indicating a yield potential of 900–9000 kg seeds/ha assuming a plant density of 100 trees/ha (Duke 1983). Gresshoff (Rural Diversity 2010) suggests individual trees are capable of producing 30 000 seeds per annum in Australia.

In India, research is underway to develop high-seeding varieties with an emphasis on selecting varieties that will yield maximum quantities of biofuel (oil extracted from the seeds) (Sahoo et al. 2009; Mukta Sreevalli 2010; Sunil et al. 2010). One early rural development project—the ‘Seeds of Hope’ project in southern India—found that wild types are unpredictable in cropping (number of pods per tree) and trees can take up to 10 years to mature. The practice of grafting helped reduce time to maturity to three years in some cases (Tigunait 2006).

Trial plantations at Katherine in the Northern Territory were found to flower profusely but did not set large numbers of pods. In contrast, Queensland varieties were found to produce fewer flowers but more pods. Highest yielding individuals are reported from Queensland and these superior lines have now been introduced to the Northern Territory for trials (Bennett 2009). Clonal material is being produced in Queensland (Walkamin) for bulk sale and individual lines have been selected for superior early flowering, crop canopy, yield and oil content (Clonal Solutions 2010).

Pods do not dehisce or open naturally and need to decompose before the seeds can germinate (Morton 1990; Orwa et al. 2010). Seeds are unpalatable to herbivores. In riverine and coastal habitats, the pods are dispersed by flowing water (T Bean, Queensland Herbarium, pers. comm. 2010; Bennett 2009).

Vegetative propagation can occur from cuttings and root suckers (new plants growing from lateral roots of the parent tree). At times, root suckers may be prolific (Orwa et al. 2009).

Pongamia is an outbreeding diploid, with a diploid chromosome number of 22.

## History as a weed overseas

Pongamia is listed as a weed in Puerto Rico and Florida (Randall 2007; Llamas 2003). Llamas (2003) describes it as a 'noxious pest' in gardens and invasive in native environments in Florida. In Hawaii, where pongamia has naturalised, it is considered to be 'high risk' and outside its native range (PIER 2009; Buddenhagen et al. 2009).

In a review of invasive woody plants of the tropics, Binggeli et al. (1998) concluded that pongamia is 'moderately invasive' and that it was 'spreading but still occurs at low densities and is not considered an immediate problem'.

When cultivated, it can be persistent, due to its ability to tolerate coppicing and produce suckers. For this reason it is considered unsuitable for agroforestry (Daniel 1997).

## Current impact in Queensland

Pongamia does not appear to have any significant negative impacts in Queensland.

It is being cultivated outside its native range in south-eastern Queensland but there is little evidence of spread, with only a very small number of sporadically naturalised populations. Herbarium records from the 1930s indicate that a population had established at Hercules Bank (now part of the Fisherman's Island Port of Brisbane complex) at the mouth of the Brisbane River. This population may have developed from pods drifting downriver from cultivated specimens in Brisbane (T Bean, Queensland Herbarium, pers. comm. 2010). Stanley and Ross (1986) also reported its spread, on a small scale, into native bushland in southern Queensland.

## Potential impact in Queensland

There is considerable concern over the potential for biofuel crops, in general, to become invasive pests (e.g. IUCN 2009; Low & Booth 2008; Buddenhagen et al. 2009; Mauremootoo 2009). Buddenhagen et al. (2009) suggest that the likelihood of biofuel plants becoming weeds in the tropics is 2–3 times greater than other introduced flora.

As mentioned earlier, there is evidence from tropical areas overseas that pongamia can escape cultivation and naturalise outside its native range (Binggeli et al. 1998; Randall 2002). However, pongamia is considered native to Queensland (earliest record dated 1818) and has an extensive distribution across eastern and northern Queensland. As such, it seems reasonable to suggest it has already spread over most of its potential range, with limited potential for range expansion into marginal habitats. Large-scale plantations established outside the species' native range might result in local naturalisation, especially in coastal (humid) south-eastern Queensland.

Due to a propensity to produce root suckers, and the toxic nature of leaves and pods, neighbouring landholders may not want this species. For this reason, precautions to limit spread and a willingness by plantation owners to undertake ongoing control on neighbouring properties may be wise. Based on the evidence collected in this study, and in comparison to a large suite of invasive plant species currently in Queensland, pongamia is considered 'low risk'. Moreover, the cultivation of pongamia is considered a lower risk than other non-native biofuel species, such as *Arundo donax*. A similar suggestion was made by Mauremootoo (2009).

Low and Booth (2008) recommend not growing pongamia next to national park boundaries or waterways outside its natural range. Plantations established in the Northern Territory are recommended to be located away from waterways and cropping is usually undertaken prior to the wet season to avoid water dispersal (Bennett 2009). The IUCN's 'Guidelines on biofuels and invasive species' (IUCN 2009) recommend that 'environmental management plans' be drawn up for each introduction, ensuring control of seedlings outside of the plantation areas and provisions (financial and otherwise) for rapid and effective control.

Finally, there is a risk that import of pongamia varieties from overseas might introduce new genetic material into the Australian pongamia population, possibly enhancing its fecundity, adaptability and general invasive potential. More vigorous biotypes may hybridise with native genotypes, with unpredictable results. As a precaution, genetic material sourced from existing Australian stocks should be used.

## Use

There is significant interest in developing pongamia as a new source of biofuel in Australia (RIRDC-CSIRO 2007). Its reputation in India as a sustainable rural fuel source, combined with its ability to establish on low fertility soils and status as a native Australian species led to research investment in Australia. Trial sites exist at Katherine and at Coastal Plains Research Station in the Northern Territory (Bennett 2009) and on degraded land in Central Queensland (Henry & Rice 2009). The Queensland Government has invested in research into the suitability of pongamia as a biofuel feedstock, via the ARC Centre for Excellence in Legume Research (CILR) at The University of Queensland, Caboolture and Gatton ('Australia's report to the Convention on Biological Diversity on the development and application of tools relevant to the sustainable production and use of biofuels' 2008; CILR n.d.; Scott et al. 2008). Cultivars are being selected that will yield seeds with up to 40% oil (CILR n.d.).

Development of pongamia as a biofuel crop has largely been centred in India, where scientists have been assessing new crops to support sustainable rural development since the 1990s. The plant has attracted research interest due to its reputation as a drought tolerant crop and its traditional use as a source of oil for lamp fuel (Tigunait 2006; Sarnaik et al. 2010).

Pongamia has a long history of use by people. Most of the tree is used either in indigenous medicine or for other purposes. The seed's oil is red-brown, bitter and thick. Its bitterness is due to flavonoids. In the past, the oil has been used for making soap, lamp oil and lubricants, and also for tanning (Duke 1983). The leaves are known to have antiseptic properties and the presscake leftover from oil extraction is used as a liniment. The roots are used to treat abscesses and as fish poison. The wood is not durable but is used for cabinet and tool-making. It is also an important source of firewood in arid areas (Orwa et al. 2009).

More recently, pongamia has been cultivated as a garden ornamental and for shade. However, it can be problematic due to its toxicity (induced vomiting if ingested) and the fact that its flowers can irritate skin. The extensive lateral root system cause damage to pavements (Morton 1990).

Though not particularly palatable, it has been used as fodder in arid areas. The presscake can be used as fodder but should not be fed to animals alone since it contains a number of toxins including karanjin. The leaves and flowers are high in nitrogen and can be used to enrich soil (Morton 1990).

In India, pongamia is used in land reclamation and as a soil stabiliser. It is being trialled for 'phytocapping' landfill waste in Rockhampton (Venkatraman & Ashwath 2009).

Pongamia can be imported into Australia (subject to conditions) as nursery stock and as seed stock (AQIS 2000).

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