Department of
Primary Industries and Regional Development

GOVERNMENT OF WESTERN AUSTRALIA

Environmental weed risk assessment

Leucaena (*Leucaena leucocephala*)

Family: *Fabaceae*

Synonyms: *Acacia leucocephala*; *Leucaena glauca; Mimosa glauca; M. leucocephala*

Common names: Leucaena, Coffee bush

Cultivars: the older varieties in Australia are Peru and Cunningham; newer varieties are Wondergraze, Tarramba and Redlands (psyllid resistance)

Assessment prepared by: Chris Munday and Geoff Moore

Assessment reviewed by: Greg Keighery, Bruce Cook

Date completed: June 2017

Species summary:

Leucaena is a tropical legume, originating from Central America and the Yucatan Peninsula of Mexico. It is a long-lived shrub or small tree (usually 5-10m, rarely to 20m) which is used for multiple purposes around the world including: firewood, timber, paper pulp, human food, green manure, shade, erosion control and forage.

Leucaena can grow in a wide range of humid and sub-humid environments where the annual rainfall varies from 650 to 3,000mm and can tolerate moderate dry seasons up to 4-6 months (Shelton and Brewbaker 1998; Brandon and Shelton 1997). However, in lower rainfall environments the biomass yields are low and Brewbaker *et al*. (1985) estimate yields increase linearly from 800 to 1,500mm, assuming other factors are equal. Leucaena requires fertile, well drained soils with a neutral or alkaline reaction for good growth. It is frost sensitive and until it is well established also has a low tolerance to waterlogging. Both seedlings and established plants are very drought tolerant (Shelton and Brewbaker 1998). Leucaena requires warm temperatures (25-30°C) for growth and effectively stops growing when night temperatures fall below 15-17°C (Brandon and Shelton 1997; Pratchett and Triglone 1989).

There are over twenty species in the genus, although none is native to Australia. *Leucaena leucocephala* has three sub species of which two, *L. leucocephala* subspecies (ssp.) *leucocephala (*common leucaena*)* and *L. leucocephala* ssp. *glabrata* (commercial forage varieties), are present in Australia. Shelton and Brewbaker (1998) report that *Leucaena leucocephala* is self-pollinating; however it can also be crossed with other species from the genus to produce hybrids with improved characteristics for agriculture.

L. leucocephala ssp. *leucocephala*, or ‘common’ leucaena (also referred to as the ‘Hawaiian’ strain) was deliberately introduced to Australia in the late 19th century and had become naturalised by 1920 (Shelton and Dalzell 2007). This shrubby free-seeding form or 'common' leucaena tends to be low yielding and weedy (Jones 1979) and is now a visible ruderal weedy shrub, mostly of roadsides, disturbed sites and creeks (Walton 2003). Commercial varieties of the second subspecies, *L. leucocephala* ssp. *glabrata* have been developed in Queensland for use in productive forage tree−perennial grass systems for cattle production. There are now more than 200,000ha under leucaena in Queensland, but only small areas were grown commercially before the 1980s (Walton 2003; Shelton and Dalzell 2007).

Leucaena is a contentious species as it is highly regarded for its feed quality (e.g. Garcia *et al*. 1996) and animal production (e.g. Pratchett and Triglone 1989; Shelton and Dalzell 2007), but in certain situations it can also be a serious environmental weed (e.g. Walton 2003; PIER

2002). In Queensland, the 'Leucaena Network' has developed a voluntary code of practice to limit spread from planted areas (Shelton and Dalzell 2007).

The leucaena psyllid (*Heteropsylla cubana*) which was first recorded in Australia in April 1986 is a major pest, especially in humid environments which may limit spread in humid environments. There is also a bruchid seed beetle (*Acanthoscelides macrophthalmus*) which only feeds on the genus leucaena and is now found wherever leucaena is grown in Australia (Middleton *et al*. 1995; Walton 2003).

Leucaena (cv. Cunningham) was commercially grown (>2,000ha) on the Ord River Irrigation Area in the 1980-90s for beef production. A cattle grazing trial on irrigated leucaena-pangola grass pasture produced 1,500kg of liveweight gain per hectare (Pratchett and Triglone 1989). However, over-irrigation of flood-irrigated leucaena paddocks on the ORIA resulted in seed being moved into the waterways where downstream it has become a weed along the Ord River (Walton 2003). Leucaena has also been planted for shade around homesteads and roadhouses in the Kimberley and Pilbara and is also present in highly disturbed environments like townsites (Walton 2003). Western Australian Herbarium (1998–) describes leucaena as an alien species with reports of its presence in the central and northern Kimberley, Murchison and Pilbara.

'Leucaena in Queensland' by Walton (2003) is a comprehensive review of leucaena as a 'conflict tree'.

Figure 1 The distribution of leucaena (*Leucaena leucocephala*) in Australia from the Australasian Virtual Herbarium (https://avh.ala.org.au/)

Section 1: Invasiveness

1. Does the species have a documented environmental weed history?

a) Is an environmental weed in Australia

b) Is an environmental weed overseas

c) Species not known to be an environmental weed but there are environmental weed species in the genus

d) Genus has no known environmental weeds

Leucaena leucocephala is widely reported to be an environmental weed in both Australia and overseas. Walton (2003) in a Pest Status Review of leucaena for the Queensland Government reports that ssp. *leucocephala* is a visible ruderal weedy shrub of roadsides, disturbed sites and creeks. This subspecies is widespread and known as a weed in over 25 countries across all continents, except Antarctica (Walton 2003). *L. leucocephala* ssp. *glabrata* which includes the

commercially available varieties is less weedy, although there are reports of spread from commercial plantings (Walton 2003; Shelton and Dalzell 2007).

Csurhes and Edwards (1998) nominate leucaena as a potential environmental weed with a weed history overseas. Lowe *et al.* (2000) include it in a list of 100 of the world's worst invasive alien species. Richardson and Rejmánek (2011) include leucaena as one of only six trees or shrubs known to be invasive in ten or more regions of the world (12 regions including Australia). Randall (2007) reports it as a weed of the natural environment, escaping from cultivation and an invasive species in Australia.

PIER (2002) lists leucaena as among the most prevalent invasive species in the Pacific and a serious problem in several islands, including Tonga. Gordon *et al*. (2011) investigated bioenergy crops for Florida and the US using weed risk assessment and found leucaena to have a high probability of becoming invasive. It is found as a weed throughout the sub-tropical areas of South Africa and under their Conservation of Agricultural Resources Act, 1983 it is a Declared weed in the Western cape and a Declared invader plant with a value, in the rest of South Africa (Bromilow 2001).

Leucaena has naturalised throughout many areas of the Australian mainland and on a number of off-shore islands. In Queensland it has been seen to invade many disturbed sites and creek lines and may have suppressed the regeneration of native species (Anon 2016). The Northern Territory weed management system found leucaena to be a very high risk species and suggested that it should be nominated for declaration in that state (Ferdinands *et al*. 2010).

2. What is the ability of the species to successfully establish and compete with other plants, especially amongst intact native vegetation?

a) High - species can establish and displace intact native vegetation

b) Moderate - species can establish amongst intact native vegetation, but may not displace the native vegetation

c) Low - species can only establish where there is little or no competition or in areas where the native vegetation is in poor condition or has been disturbed

d) Very low - species can only successfully establish in vegetation which has been highly disturbed (e.g. roadsides, degraded or cleared areas)

e) Don't know

Leucaena may spread along riverine habitats as it invades riparian areas—both undisturbed and disturbed but does not readily invade other undisturbed vegetation types such as woodland (Walton 2003). "It is not known to have invaded undisturbed closed forests" – overseas (Walton 2003).

In a case study of leucaena used in mine site rehabilitation at Weipa the leucaena had spread from a planted area of 172ha to infest 1,000-1,200ha of rehabilitated areas, but had not invaded undisturbed eucalypt woodland surrounding the rehabilitated areas (Walton 2003).

Under favourable conditions leucaena can spread and Hussey *et al.* (1997) report that leucaena has become a common weed of wetlands and riverine sites in the Kimberley and Pilbara in northern Western Australia and has been recorded south to Exmouth.

In the tropics and sub-tropics leucaena poses a threat to most coastal wetlands and in inland riparian zones particularly where extreme weather events cause flooding or alter watercourses.

Shading may reduce the growth of mature leucaena plants, but seeds will germinate and establish satisfactorily under established leucaena hedgerows or other species (Shelton and Brewbaker 1998).

Leucaena has formed thickets in the tropics (Darwin, Bowen) and subtropics (Brisbane) along roadsides and other areas protected from livestock.

3. Grazing tolerance and palatability

a) Unpalatable (or toxic), rarely grazed

b) Will persist under heavy continuous grazing due to plant structure (like rhizomatous grasses) or has limited palatability

c) Tolerant of grazing as, usually, only young growth (annuals) or young re-growth (perennials) is grazed, for example after fire or early in wet season; or plants are occasionally browsed

d) Readily grazed during the wet season with some preferential grazing, during the dry season. Some plants are grazed while others are left ungrazed

e) Comparatively good feed quality and preferentially grazed at all growth stages; or has low tolerance to grazing and plants are easily killed. Plant numbers decline over successive years if overgrazed.

f) Don't know

Leucaena is highly palatable and only left ungrazed if beyond the reach of livestock. It is grazed all year round, particularly in the dry season when animals seek higher feed quality and is also grazing tolerant.

Volunteer seedlings may establish outside managed areas, but will be preferentially grazed and the spread limited when domestic or native animals have access (Walton 2003). Bray (1986) reports it is necessary to control grazing of young plants by rabbits, hares, native animals and domestic stock to ensure successful establishment.

Cook *et al.* (2005) reports leucaena as extremely tolerant of regular defoliation by cutting or grazing once established. It is recommended that regular heavy grazing of leucaena does not commence until plants are mature and well established (1-3 years). Paddocks are normally rotationally grazed to avoid damage to the stems after the leaves have been removed. Grazing promotes branching and can remove flowers and pods which reduce vegetative growth rates (Shelton and Brewbaker 1998).

Plants may achieve a height where foliage is out of reach of grazing animals and plants can then flower and set seed in that environment.

4. What is the species' ability to persist as a long-term sward or stand without management?

a) Plant numbers increase substantially with successive reproductive cycles to form a near monoculture over a significant area

b) Plant numbers remain at a steady level, persisting as a significant component of a mixed sward/stand

c) Plant numbers decline slowly over successive years so that it becomes a minor component of the vegetation

d) Plant numbers decline rapidly over successive years so that only occasional plants can be found

e) Don't know

Leucaena is a long-lived (40+ years) shrub or small tree. Volunteer seedlings may establish outside managed areas. When domestic animals have access these may be preferentially grazed and the spread limited (Walton 2003). Over-grazing may also damage young established plants, but mature plants with woody stems may develop a canopy above grazing height and produce prolific seed which is the primary dispersal mechanism. In suitable conditions the plant habit, vigorous growth, early maturity and prolific hard seed can result in a rapid increase in plant numbers and a monoculture reducing plant diversity. Young plants can survive long periods of heavy grazing by cattle, kangaroos and hares, and established plants survive snapping off by bulldozers (B. Cook personal communication).

5. Is the plant likely to spread or rapidly colonise a site?

a) High risk – plants with a history of spreading rapidly with many plants successfully establishing under favourable conditions >200m from the sown area within 5 years for herbaceous perennials or 10 years for woody perennials

b) Medium risk – some plants will spread outside the planted area and successfully establish under favourable conditions >100m from the sown area within 5 years for herbaceous perennials or 10 years for woody perennials

c) Low – No or minimal spread of sown species. Outside the planted area a few plants will spread and successfully establish within 100m of the planted area under favourable conditions within 5 years for herbaceous perennials or 10 years for woody perennials

d) No spread of sown species more than 1m outside the planted area within 5 years for herbaceous perennials or 10 years for woody perennials

e) Don't know

The 'common' leucaena (*L. leucocephala* ssp. *leucocephala*) has been naturalised in Queensland for over 80 years and the estimated area infested across the state was up to 9,000ha in 2003 (Walton 2003). Spread is generally slow as most seedlings are controlled by grazing animals or from grass competition (Walton 2003).

Leucaena has considerable weed potential in ungrazed situations due to its high levels of hardseed and the large amount of seed produced (Cook *et al.* 2005). It can readily colonise disturbed areas such as roadsides and stream banks, particularly where the soils are calcareous (i.e. limestone based). Under suitable conditions and where leucaena is ungrazed, established plants can mature quickly and produce large amounts of seed which then has the potential to form dense thickets – with seedlings establishing below mature plants (Walton 2003; Hussey *et al*. 2007).

6. Will the species establish and reproduce in low-nutrient Australian soils without the addition of fertiliser or inoculant?

a) Establishment and reproductive ability uninhibited in low-nutrient soils

b) Establishment and reproductive ability reduced in low-nutrient soils

c) Establishment and reproductively severely diminished in low-nutrient soils

d) Establishment and reproduction not likely in low-nutrient soils without soil additives

e) Don't know

In its native range leucaena grows on shallow limestone soils, coastal sands and seasonally dry, self-mulching vertisols with a pH 7.0-8.5 (Cook *et al*. 2005). It is often found naturalised on the rocky coralline terraces of Pacific islands.

Under cultivation leucaena requires deep, fertile well drained soils with a neutral to alkaline soil reaction with high levels of phosphorus and calcium for good production and grows poorly on infertile or acid soils (Dalzell *et al.* 2006; Cook *et al*. 2005; Shelton and Brewbaker 1998). However, leucaena can grow on a wide variety of soil types including clay soils and mildly acid soils (pH >5.2), but is intolerant of low pH, low P, low Ca, high aluminium saturation, high salinity and waterlogging (Cook *et al*. 2005; Shelton and Brewbaker 1998).

Leucaena has a highly specific Rhizobium requirement (Cook *et al*. 2005) for effective nodulation. Cook *et al* (2005) state that leucaena is not usually fertilised when planted under rain-fed conditions, however on infertile, acid soils it is essential to add lime, P and K at planting and after each cut. In field trials in northern WA, the growth of leucaena seedlings on infertile sandy soils has been very slow even with added fertiliser (G. Moore unpublished data).

7.1 How likely is long-distance dispersal (>100m) by flying animals (birds, bats)?

a) Common

b) Occasional

c) Unlikely

d) Don't know

Walton (2003) has reported that animals, including birds, may be seed vectors.

7.2 How likely is long-distance dispersal (>100m) by stock, native and/or feral animals?

a) Common

b) Occasional

c) Unlikely

d) Don't know

The comparatively large leucaena seed is smooth and has no features to aid attachment to animal coats or feet unless it has been incorporated into the soil. Once the seeds mature, the pods shatter by opening along both margins and seed dispersal is largely passive with seed spread generally less than 20m, if unaided.

Watson (2003) reported that animals including rodents and cattle may be seed vectors. Cattle are commonly observed only to eat green seeds which may not be viable or survive excretion. In a controlled experiment 80% of leucaena seed placed directly into the rumens of cattle was excreted in faeces; 6% of the excreted seed was germinable, while 92% remained hard-seeded and 2% was rotten (Gardener *et al*. 1993).

However, leucaena is being reported more frequently around Perth, suggesting it may be transported with stock (G. Keighery personal communication, Department of Parks and Wildlife, WA).

7.3 How likely is long-distance dispersal (>100m) by water?

a) Common

b) Occasional

c) Unlikely

d) Don't know

Long distance seed dispersal by water is the main mechanism for the spread of leucaena. Leucaena thrives and has been reported widely as being invasive in riparian environments where it spreads readily by seed (Walton 2003; Hussey *et al*. 2007).

7.4 How likely is long-distance dispersal (>100m) by wind?

a) Common

b) Occasional

c) Unlikely

d) Don't know

Dispersal by wind (>100m) is unlikely due to the seed size (6-10mm) and as a result seed dispersal is largely passive, by gravity, with spread usually much less than 20m. In unusual circumstances, wind-assisted movement of leucaena pods has been recorded over 100m from leucaena plants on coastal cliffs in the Northern Territory (reported in Walton 2003), but generally any dispersal by wind would be much less.

8.1 How likely is long-distance dispersal (>100m) accidentally by people and vehicles?

a) Common

b) Occasional

c) Unlikely

d) Don't know

The comparatively large leucaena seed is smooth and has no features which would aid attachment to clothing.

Shelton and Dalzell (2007) state that unintentional spread of common leucaena via contaminated soil and machinery used in road maintenance is a dispersal mechanism. Walton (2003) report of a case study of mine rehabilitation at Weipa where leucaena had spread along access roads, possibly carried on muddy vehicles and from movement of seed contaminated topsoil. Ansong and Pickering (2013) found one study where leucaena seed was transported on a vehicle.

8.2 How likely is long-distance dispersal (>100m) accidentally in contaminated produce?

a) Common

b) Occasional

c) Unlikely

d) Don't know

Leucaena is not usually grown in situations where it would be accidentally included in other produce. Leucaena is usually grown in widely spaced alleys with perennial grasses in the inter-row and being a woody shrub is not usually cut for fodder production. Overseas it is used in cut and carry systems, but this is not the case in Australia.

9.1 What is the species' minimum generation time?

a) 1 year

b) 2-3 years

c) >3 years to never

d) Don't know

There are varied reports of the minimum generation time for leucaena. In the literature it is reported that seedling growth can be very rapid with plants attaining a height of 2m within 14 weeks of sowing, but usually seedling growth is very slow.

> "The genus *Leucaena* has a short juvenile phase for a woody species and can commence flowering 3–4 months after planting. Plant maturity of *Leucaena leucocephala* follows this pattern. …..Although ssp. *glabrata* is generally noted not to set seed until the second year, time to first flowers for 'Taramba' was recorded at 246 days" (Walton 2003 p. 31).

In field trials established under irrigation in northern WA leucaena ssp. *glabrata* plants took more than 12 months to produce their first flowers. At some sites 'Taramba' plants have not flowered 2 years after they were seeded, while some 'Wondergraze' plants flowered 12-15 months after seeding (G. Moore unpublished data).

9.2 What is the species' average seed set in a favourable season?

a) High (e.g. >1000 seeds/m^2 per year for woody species, >5000 seeds/m^2 per year for herbaceous species)

b) Moderate – low seed production

c) None (or seed is sterile)

d) Don't know

All subspecies will flower and set seed throughout the year providing soil moisture and temperature are adequate. *L. leucocephala* ssp. *leucocephala* is particularly precocious and free seeding (Cook *et al*. 2005; Walton 2003). Flowers are largely self-fertilised and self-compatible, which promotes seed production even on isolated individuals. Seed production is affected by plant maturity, soil fertility and stand density, but is often prolific (Pier 2002). Hutton and Grey (1959) reported 2 year old *L. leucocephala* ssp. *leucocephala* trees produced between three and six thousand seeds per plant in Queensland.

9.3 What is the species' seed persistence in the soil seedbank?

a) >5 years

b) 2-5 years

c) <2 years

d) Don't know

Leucaena seeds are hard-seeded and can persist in the soil for extended periods, with reports of seed longevity 7 years after the parent plants were removed from a site (Jones and Jones 1996 cited in Walton 2003) and other reports of seed viability after 20 years (Walton 2003).

9.4 Can the species' reproduce vegetatively?

a) Yes – rapid vegetative reproduction

b) Yes - slow

c) No

d) Don't know

In cultivation leucaena can be planted as seed, 'bare stem' seedlings or cuttings (Walton 2003, Shelton and Brewbaker 1998). Leucaena can regenerate rapidly from basal shoots after fire or cutting and this may result in denser stands (Pier 2002), but this does not constitute vegetative reproduction.

Section 2: Impacts

1. Could the species reduce the biodiversity value of a natural ecosystem, either by reducing the amount of biodiversity present (diversity and abundance of native species), or degrading the visual appearance?

a) The species could significantly reduce biodiversity such that areas infested become low priorities for nature conservation and/or nature-based tourism

b) The species could have some effect on biodiversity and reduce its value for conservation and/or tourism

c) The species would have marginal effects on biodiversity but is visually obvious and could degrade the natural appearance of the landscape

d) The species would not affect biodiversity or the appearance of natural ecosystems

e) Don't know

Under favourable conditions leucaena can form monocultures shading out native species and in some cases reducing biodiversity. A statewide survey of leucaena spread in Queensland found that most reports were where leucaena had invaded ungrazed sites, riparian zones, roadsides and most of these sites were partially to highly disturbed (>50%), or artificial habitats (23%); however there were also some reports of leucaena in undisturbed natural habitats (Walton 2003).

Leucaena is also a conspicuous species and visually obvious and it is reported in Walton (2003) that one of the comments often made about leucaena is that of being an 'unsightly weed'.

2. Does the species have a history of, or potential to reduce the establishment of other plant species?

a) The species can significantly inhibit the establishment of other plants (e.g. regenerating native vegetation) by preventing germination and/or killing seedlings, and/or the species forms a monoculture over a large area

b) The species can inhibit the establishment of other plants and/or does/will become dominant.

c) The species can cause some minor displacement by inhibiting establishment, but will not become dominant.

d) The species does not inhibit the establishment of other plants.

e) Don't know

The competitiveness of leucaena varies widely depending on the environment, especially the rainfall (soil moisture), soil fertility and presence of grazing animals, insect pests and termites (Brandon and Shelton 1997).

In general, leucaena seedlings are slow growing and compete weakly with perennial grasses and annual forbs and grasses. The seedlings are also highly susceptible to grazing, insect attack and once the stems become woody they are also susceptible to attack by termites (Brandon and Shelton 1997). On acid, infertile sandy soils leucaena did not inhibit the establishment of other plants in field trials in the west Kimberley and Pilbara (G. Moore unpublished data).

However, leucaena has a well-documented history of spreading from cultivation and invasion of disturbed and sometimes intact vegetation. In certain conditions it can form dense monocultures and therefore exclude or reduce the establishment of other species.

Chou and Kuo (1986) report that leucaena is allelopathic. They found that exudates from leucaena leaf litter and fallen seeds inhibited the growth of many species, but not leucaena seedlings. This may contribute to the ability of the species to form monocultures.

3. Could the species alter the structure of any native ecosystems at risk of invasion from this species by adding a new strata level?

a) Will add a new strata level, and could reach medium to high density

b) Will add a new strata level, but at low density

c) Will not add a new strata level

d) Don't know

Leucaena has a reputation of predominantly spreading along riparian zones in other environments (Walton 2003), In northern WA the waterways are usually lined with distinctive white-trunked Eucalypts (*Eucalyptus camaldulensis*), so if leucaena was to spread into these environments it could add a new strata.

Leucaena is a perennial woody species which can reach 5–18m and under favourable conditions can form monocultures shading out native species. It can invade native ecosystems, particularly along waterways and adjacent to wetlands and could add a new visually conspicuous strata level in native grasslands and other low growing native communities.

4. Could or does the species restrict the physical movement of people, animals, and/or water?

a) Species infestations could become impenetrable throughout the year, preventing the physical movement of people, animals and/or water

b) Species infestations could significantly slow the physical movement of people, animals and/or water throughout the year

c) Species infestations could slow the physical movement of people, animals and/or water at certain times of the year or provide a minor obstruction throughout the year.

d) Species infestations have no effect on physical movement

e) Don't know

In some environments leucaena can rapidly develop to form dense impenetrable stands with canopy closure which shade out other species (Jones *et al.* 1992). Dense stands can develop from individual plants (self-compatible) or by coppicing where many stems are produced from a single base after fire or cutting.

Leucaena is particularly invasive in riparian environments and may alter these environments. In Queensland leucaena forms dense thickets, hindering movement of wild life and excluding all other plants (Queensland Department of Agriculture and Fisheries 2016)

5. Does the species have, or show the potential to modify the existing behaviour and alter the fire regime?

a) High - major effect on frequency and/or fire intensity. May greatly increasing the dry season fuel load

b) Moderate effect on frequency or fire intensity

c) Minor or no effect

d) Don't know

In suitable conditions leucaena can grow rapidly and may provide a large fuel load. Smith (2001) noted that cool fires thicken up stands due to coppicing, but a hot fire can kill adult plants. Monitoring after the fire showed that some plants quickly regrew, either at or below ground level, reaching just under a metre within 2 months of the fire. Scarification of the seed from the heat of the fire may also increase germination rates. On the other hand, shading by dense stands may reduce the fuel loads of the understorey.

Walton (2003) reports that fire may be a useful tool for controlling leucaena as an early summer hot fire in a dense stand of leucaena and guinea grass resulted in 75% of the plants being killed including 94% of small plants (<2m).

Overall, leucaena itself would rarely carry a fire and the grass underneath would be suppressed by the tree and heavier grazing pressure.

6.1 Is the species toxic to animals, have spines or burrs, or host other pests or diseases that could impact on native fauna and flora?

a) Yes – plant poisonous or other adverse factors present

b) No – plant is not poisonous, does not produce burrs or spines or harbour pests or diseases

Leucaena plants do not have any spines or thorns, however leaves and seeds contain an amino acid (mimosine) which is toxic. The mimosine content in growing tips and young leaves can be up to 12%, but is generally lower in edible dry matter (3-6% of dry matter) (Jones 1979; Cook *et al.* 2005). Mimosine is usually converted to DHP (3 hydroxy-4-(1H)-pyridone) on ingestion (Cook *et al.* 2005).

Where leucaena is a high proportion of the diet and the appropriate rumen micro-organisms are not naturally present (i.e. Australia) DHP toxicity in ruminants causes goitre (enlargement of the thyroid gland) with listlessness, loss of appetite, excess saliva production, hair loss and loss of weight. However, this only occurs when leucaena constitutes a high proportion of the animal's diet (>30%) for an extended period (Shelton and Brewbaker 1998). Domesticated ruminants can be inoculated with the bacteria *Synergistes jonesii* which can break down DHP in the rumen to non-toxic compounds (Jones 1985; Jones and Megarrity 1986). Livestock only need to be inoculated once as the bacteria are readily passed to any new animals that join the mob (Jones *et al.* 2009).

6.2 Could the species provide food and shelter for pest animals?

a) Yes – could provide more shelter or greater nutritional value than the native vegetation

b) No – could provide similar or less shelter or nutritional value than the native vegetation

c) Don't know

Leuceana is highly nutritious fodder and can form dense thickets which could provide food and shelter for pest animals, however no reports were found to support this.

7.1 Does the species have, or show the potential to have, a major effect on nutrient levels in intact native vegetation?

a) Will significantly increase soil nutrient levels

b) Will significantly decrease soil nutrient levels

c) Will have minimal effect on soil nutrient levels

d) Don't know

Under ideal conditions and when the suitable Rhizobia are present in the soil and effective nodulation occurs then leucaena could increase the soil nitrogen below dense stands from N fixation and the leaf and pod litter. In commercial stands very high levels of N fixation have been reported (Garcia *et al.* 1996; Shelton and Dalzell 2007). In general, effective nodulation is unlikely in the soils of northern WA, as leucaena has a specific rhizobia requirement (Cook *et al.* 2005) which is not present in the soils of northern WA, but in certain environments the rhizobia could be transported.

Shelton and Brewbaker (1998) found leucaena is particularly susceptible to phosphorus deficiency and dependent on vesicular arbuscular mycorrhizae (VAM) to extend the capacity of its root system to access immobile nutrients such as phosphorus. Leucaena was also sensitive to calcium deficiency which may reduce nodulation.

7.2 Could the species reduce water quality or cause silting of waterways?

a) Could significantly reduce water quality or cause silting or alteration of flow of waterways

b) May have some effect on water quality or silting of waterways in a small number of ecosystems

c) Minor or no effect on water quality

d) Don't know

Leucaena leucocephala is a significant invasive weed in some riparian systems where it can form dense impenetrable stands with the potential to affect water quality and flow, however it is intolerant of prolonged flooding (>3 weeks) and waterlogging (Cook *et al.* 2005).

7.3 Does the species have, or show the potential to have, a major effect on the soil watertable below intact native vegetation?

a) Will significantly lower the water table and/or reduce groundwater recharge to the watertable.

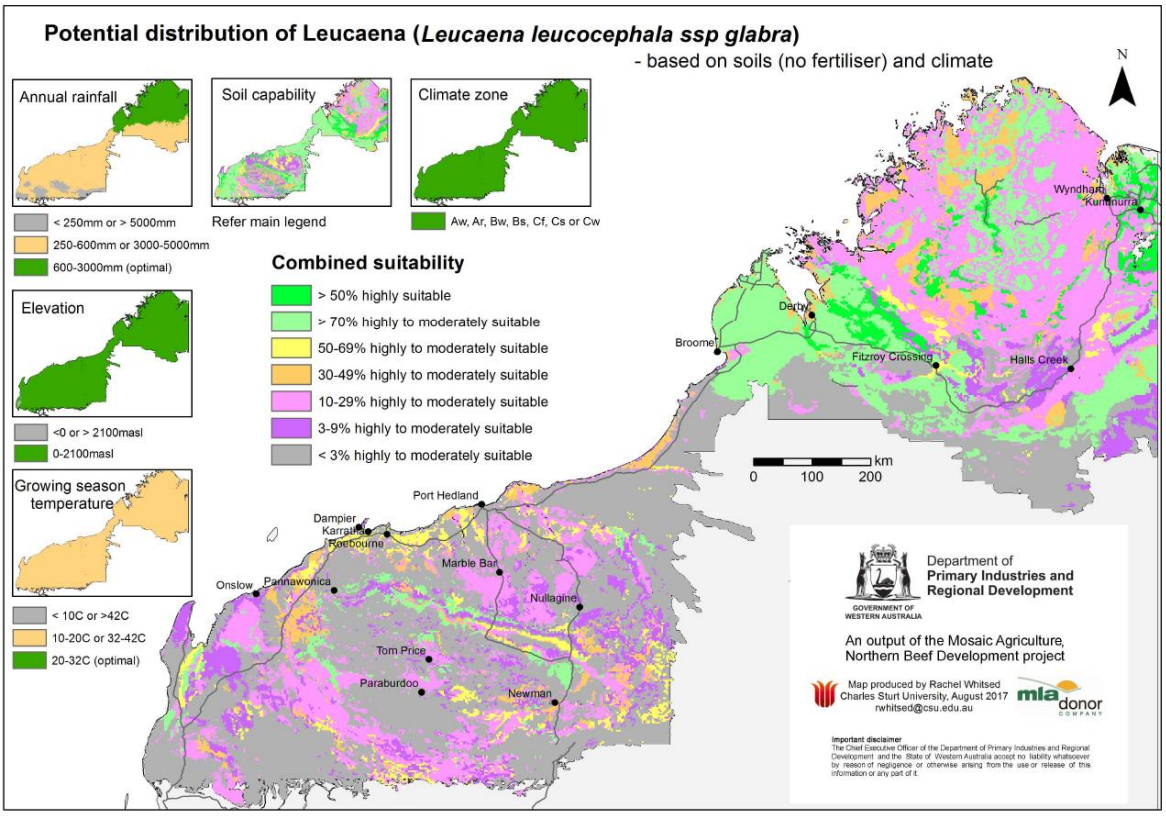
b) Will have little or no impact on hydrology

c) Don't know

Mature leucaena plants can develop deep root systems with a taproot that may reach a depth of 5-6m which was similar to the native vegetation in two Queensland studies (Shleton and Dalzell 2007). Where it is well adapted on fertile soils in riparian zones leucaena may use more water than the native vegetation.

In a replicated trial at Wallal Downs on red-brown deep sand the leucaena plants were moisture stressed over the 2016 dry season, while the native shrub (*Acacia stellaticeps*, poverty bush) was actively growing with fresh growth, indicating they were accessing soil moisture deeper in the soil profile (G. Moore unpublished data).

Potential distribution



Region	Area of suitable soils and climate	Potential distribution score
Kimberley	12.4Mha	8.0
Pilbara	3.0Mha	5.0
Gascoyne – Goldfields	N/A	–

Overall weed risk assessment

The overall weed risk assessment (WRA) is calculated from Equation 1.

Equation1: Invasiveness (0-10) x Impacts (0-10) x Potential Distribution (0-10) = Weed risk score (0-1000)

Region	WRA calculation*	Overall score	WRA rating
Kimberley	6.4 x 7.0 x 8.0	**358.4**	**Very high**
Pilbara	6.4 x 7.0 x 5.0	**224.0**	**High**
Gascoyne – Goldfields (>250mm AAR)	6.4 x 7.0 x ?		**TBD**
Gascoyne – Goldfields (<250mm AAR)	6.4 x 7.0 x 0.5	**22.4**	**Negligible to low**

* Invasiveness (0-10) x Impacts (0-10) x Potential Distribution (0-10) = Weed risk score (0-1000)

References

Anon (2016). Invasive plant: *Leucaena leucocephala.* Biosecurity Queensland, Department of Agriculture and Fisheries.

Ansong M, Pickering C (2013) Are weeds hitchhiking a ride on your car?: A systematic review of seed dispersal on cars. PLoS ONE 8(10): e80275.doi:10.1371/journal.pone.0080275 (11p).

Brandon NJ, Shelton HM (1997) Factors affecting the early growth of *Leucaena leucocephala*. 1. Effects of nitrogen, phosphorus, lime and irrigation at three sites in south-east Queensland. *Australian Journal of Experimental Agriculture* **37(1)**, 45-53.

Bray RA (1986) Leucaena in northern Australia—a review. *Forest ecology and management* **16(1-4)**, 345-354.

Brewbaker JL, Waimanalo HI, MacDicken K, Withington D (1985) Leucaena: Forage production and use. Nitrogen Fixing Tree Association, FAO.

Bromilow C (2001) Problem plants of South Africa. Interpak Books, Published by KwaZulu-Natal, South Africa.

Chou CH, Kuo YL (1986) Allelopathic research of subtropical vegetation in Taiwan. *Journal of Chemical Ecology* **12**, 1431.

Csurhes S and Edwards R (1998) Potential environmental weeds of Australia: candidate species for preventative control*.* Biodiversity Group, Environment Australia, Canberra.

Ferdinands K, Setterfield S, Ibbett M (2010) Developing a WRM system in the Northern Territory, Australia. *In* Kakadu National Park Landscape Symposia Series 2007–2009. Symposium 2: Weeds management. Ed. S Winderlich, 27–28 November 2007, Jabiru Field Station, Supervising Scientist Division, Kakadu National Park. Internal Report 565, January, Supervising Scientist, Darwin, pp. 29–31.

Garcia GW, Ferguson TU, Neckles FA, Archibald KAE (1996) The nutritive value and forage productivity of Leucaena leucocephala. *Animal Feed Science and Technology* **60(1-2)**, 29-41.

Gardener CJ, McIvor JG, Jansen A (1993) Survival of seeds of tropical grassland species subjected to bovine digestion. *Journal of Applied Ecology* **30**, 75-85.

Gordon DR, Tancig KJ, Onderdonk DA, Gantz CA (2011) Assessing the invasive potential of biofuels species proposed for Florida and the United States using the Australian weed risk assessment. *Biomass and Bioenergy* **35**, 74-79.

Hutton EM, Grey SG (1959) Problems in adapting *Leucaena glauca* as forage for the Australian Tropics, *Empire Journal of Experimental Agriculture* **27**, 187–96.

Hussey BMJ, Keighery GJ, Cousens RD, Dodd J, Lloyd SG (1997) Western weeds, A guide to the weeds of Western Australia. 2nd Edition. Plant Protection Society of Western Australia (Inc.) and the Gordon Reid Foundation for Conservation. 245p.

Jones RJ (1979) The value of *Leucaena leucocephala* as a feed for ruminants in the tropics. *World Animal Review* **31**, 13-23.

Jones RJ (1985) Leucaena toxicity and the ruminal degradation of mimosine. *In*: eds. AA Seawright; MP Hegarty; LF James; RF Keeler. Plant Toxicology. Proceedings of the Australia-USA Poisonous Plants Symposium, Brisbane, May, 1984; Brisbane: Poisonous Plants Committee; p.111-119.

Jones RJ, Coates DB, Palmer B (2009) Survival of the rumen bacterium Synergistes jonesii in a herd of Droughtmaster cattle in north Queensland. *Animal Production Science* **49(8)**, 643-645.

Jones RJ, Megarrity RG (1986) Successful transfer of DHP-degrading bacteria from Hawaiian goats to Australian ruminants to overcome the toxicity of Leucaena. *Australian Veterinary Journal* **63(8)**, 259-262.

Jones RJ, Brewbaker JL, Sorensson CT (1992) *Leucaena leucocephala* (Lamck) de Wit, *Plant Resources of South-East Asia No 4: Forages*, in L Mannatje and R J Jones (eds),Pudoc Scientific Publishers, Wageningen.

Lowe S, Browne M, Boudjelis S, De Poorter M (2000) 100 of the world's worst invasive alien species. A selection from the global invasive species database. Published by The Invasive Species Specialist Group, World Conservation Union (IUCN), 12p.

Middleton CH, Jones RJ, Shelton HM, Petty SR, Wildin JH (1995) Leucaena in northern Australia. *In* ACIAR Proceedings (pp. 214-219). Australian Centre for International Agricultural Research.

Pier (Pacific Islands Ecosystems at Risk) (2002) *Leucaena leucocephala* http://www.hear.org/pier/species/leucaena_leucocephala.htm Accessed 7.2.2017.

Queensland Department of Agriculture and Fisheries: Biosecurity Queensland (2016) Leucaena factsheet https://www.daf.qld.gov.au/__data/assets/pdf_file/0019/73450/IPA-Leucaena-PP85.pdf Accessed 7th December 2016.

Randall R (2007). The introduced flora of Australia and its weed status. Cooperative Research Centre for Australian Weed Management, University of Adelaide, SA.

Richardson DM, Rejmánek M (2011) Trees and shrubs as invasive alien species – a global review *Diversity and Distributions* **17**, 788-809.

Shelton HM, Brewbaker JL (1998) 2.1 *Leucaena leucocephala* – the most widely used forage tree legume, FAO. Accessed January 2017.

Shelton M, Dalzell S (2007) Production, economic and environmental benefits of leucaena pastures. *Tropical grasslands* **41(3)**, 174-190.

Smith N (2001) Not from here: Plant invasions on Aboriginal lands, Tropical Savannas CRC, Darwin, NT.

Walton CS (2003) Leucaena (*Leucaena leucocephala*) in Queensland. Pest status review series – Land protection. Published by the Queensland Government Department of Natural Resources and Mines.

Western Australian Herbarium (1998–). FloraBase—the Western Australian Flora. Department of Parks and Wildlife. https://florabase.dpaw.wa.gov.au/ Accessed 15th February 2017.

Important disclaimer

The Chief Executive Officer of the Department of Primary Industries and Regional Development and the State of Western Australia accept no liability whatsoever by reason of negligence or otherwise arising from the use or release of this information or any part of it.

Copyright © Department of Primary Industries and Regional Development, 2022