Department of
Primary Industries and
Regional Development

GOVERNMENT OF
WESTERN AUSTRALIA

Environmental weed risk assessment

Butterfly pea (*Clitoria ternatea*)

Family: Fabaceae

Common name: Butterfly pea, Blue pea, (also, Asian pigeonwings, bluebellvine, cordofan pea, kordofan pea, queen's shoe and Darwin pea)

Cultivars: Milgarra

Assessment prepared by: Geoff Moore and Nazanin Nazeri

Assessment reviewed by: Greg Keighery

Date completed: January 2022

Species summary:

Butterfly pea, also called blue pea, is a short-lived perennial legume with a semi-erect woody base with fine twining stems and pinnate leaves with 5–7 leaflets. Individual plants may persist for 2–4 years but, where well adapted, have good regeneration from seed, so reseeding is usually not required in permanent pastures. Its native distribution is obscure, now being pantropical due to naturalization from human cultivation (Cook et al. 2005).

Butterfly pea grows best in areas with average annual rainfall of 700-1500mm but is not suited to regions with severe cold or frequent frosts. It is well adapted to a range of soil types, but best suited to self-mulching heavy clay soils (Collins and Grundy 2005).

As well as being a pasture legume butterfly pea is also a garden ornament plant and has been widely used in agroforestry in tropical and subtropical regions of the world (Rojas-Sandoval 2016). In South and Central America, Caribbean, China and India it is used for human consumption as the flowers are used as a blue food dye, while the young pods are consumed like string beans (Gomez and Kalamani 2003).

In central Queensland, butterfly pea has been widely grown as a well-adapted legume for the fine-textured cropping soils of the region in both ley and permanent pasture systems (Collins and Grundy 2005; Conway 2005). In northern Western Australia, butterfly pea has been grown in experimental trials and to a very limited extent under commercial irrigation. However, it has also been planted as an ornamental on fencerows or trellises in towns in the Pilbara and Kimberley.

It is naturalised in many parts of northern Australia and is common in northern and central Queensland and in the northern parts of WA and the Northern Territory (NT) (Figure 1). Also widely naturalised throughout the humid and sub-humid lowlands of Asia, on several Pacific islands, in the Caribbean, Central America and South America, and in the southern parts of USA (Biosecurity Queensland 2021).

In WA it has been listed as a garden escape that has been naturalised on creek banks and around waterholes throughout the Kimberley; also around coastal settlements in the Pilbara and Gascoyne (Hussey et al. 2007). Florabase (Western Australia Herbarium 1988) gives the current distribution in WA as IBRA regions: Carnarvon, Central Kimberley, Dampierland, Indian Tropical Islands, Murchison, Northern Kimberley, Ord Victoria Plain, Pilbara, Victoria Bonaparte.

Figure 1. The distribution of *Clitoria ternatea* in Australia from the Australian 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

Butterfly pea is regarded as an environmental weed in WA and the Northern Territory (NT), and also as a potential environmental weed in northern Queensland. It is actively managed by community groups in the NT, particularly where it has invaded riparian zones within conservation areas near Darwin. It has also been listed as a priority environmental weed in one Natural Resource Management region in northern Australia (Biosecurity Queensland 2021). Lonsdale (1994) noted its presence in one of the four weed lists that were examined. Butterfly pea is listed as an agricultural weed, cultivation escape, environmental weed, garden thug, naturalised, weed on the 'Global Compendium of Weeds' (Randall 2017).

Not listed in environmental weeds of Western Australia (Keighery 1991). Not listed in invasive naturalised plants in south-east Queensland (Batianoff and Butler 2002). Swarbrick (1990) reported *C. ternatea* a minor to medium weed of gardens, lawns, parks and amenity areas, a medium weed of irrigated crops, grown with supplementary irrigation and a minor weed of disturbed situations in which no crop or pasture is grown in coastal Queensland and the top end of NT.

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

In WA butterfly pea has been listed as a garden escape that has been naturalised on creek banks and around waterholes throughout the Kimberley; also around coastal settlements in the Pilbara and Gascoyne (Hussey et al. 2007).

The traits of drought tolerance and adaptation to heavy clay soils have helped butterfly pea to escape from cultivation and become an invasive species in river banks, creek lines, the margins of waterholes, irrigation channels, disturbed sites, waste areas, roadsides and disturbed open woodlands and grasslands in northern Australia (Biosecurity Queensland 2021). It is naturalised in Hawaii, the Galapagos Islands, Fiji, and on many islands in the Pacific region (Rojas-Sandoval 2016).

According to Cook et al. (2005), natural spread of butterfly pea is unlikely as the plants are very palatable and seedlings do not compete well with existing vegetation. In a study by Lawrence et al. (2012), they concluded butterfly pea is ideal for short term ley pastures as this species does not have any risk of future weed problems because the hard-seed softens within 2 years. In central Queensland, butterfly pea has persisted as a companion legume with competitive perennial grasses like buffel grass in rotationally grazed pastures (Collins and Grundy 2005).

3. Grazing tolerance and palatability

a) Very high - Unpalatable (or toxic), rarely grazed

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

c) Moderate - 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) Low - Readily grazed during the wet season with some preferential grazing, during the dry season some plants are grazed while others are left ungrazed

e) Very low - 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

Butterfly pea is highly palatable and as such is better managed as a short-term pasture under rotational grazing (Cook et al. 2005).

> "In the first season, delay grazing until plants have set seed. This will provide seed for future regeneration and also enable the plant to develop a woody frame that is more tolerant of grazing. ….If the plants are moisture stressed from drought or competition, grazing should be delayed as long as possible. Young butterfly pea subjected to high grazing pressure under these conditions will not persist.
>
> Butterfly pea seedlings are selectively grazed and will die if grazed early. Seedlings will only establish amongst mature plants after good rain, when there is lenient grazing pressure and low weed / grass competition" (Collins and Grundy 2005).

Butterfly pea is tolerant of heavy rotational grazing, but not constant heavy defoliation. Frequent trampling by cattle will damage the stems and the growing tips and axils of stems must be left to develop new leaves (Cook et al. 2005).

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

Commonly *C. ternatea* pastures are sown as pure legume pastures and are progressively invaded by vigorous pasture grasses as soil-N levels build up (Cook et al. 2005). In an agricultural context, with good management, butterfly pea will persist indefinitely on fertile soils with high plant available water capacity. However, on soils with minor limitations or where grazing places continual pressure on butterfly pea plants, stand life can be reduced to three to four years, while on soils with significant limitations to plant available water capacity (such as sodic and/or saline subsoils) or that are relatively infertile, effective stand life can be one to three years depending on the severity of the limitations (Collins and Grundy 2005).

Given the inherent very low phosphorus levels in the soils in northern WA (Smolinski 2021) and without grazing management – then stands of butterfly pea are likely to decline to a minor component of the vegetation.

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 10m outside the planted area within 5 years for herbaceous perennials or 10 years for woody perennials

e) Don't know

The persistence of butterfly pea was assessed in four replicated legume field nursery experiments in the west Kimberley and Pilbara. At the site in the Fitzroy Valley on a cracking clay soil where initially butterfly pea established and grew strongly, after 4 years persistence had declined to 20-50% on the control and on the plus Rhizobia–plus fertiliser treatments and was less than 20% on the plus Rhizobia with no added fertiliser treatment. At the other three sites there was similar or lower persistence. There was no movement of butterfly pea outside the trial area at any of the sites (G. Moore unpublished data).

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

a) Establishment, growth and seed production uninhibited in low-nutrient soils

b) Establishment, growth and seed production reduced in low-nutrient soils

c) Establishment, growth and seed production severely diminished in low-nutrient soils

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

e) Don't know

Butterfly pea grows on a wide range of soil types (from sands to heavy clays) of at least moderate fertility but is best adapted to fertile, heavy clay, alkaline soils. It will grow with pH_w from 5.5 to 8.9 but is best adapted in the pH_w range of 6.5–8.0 (Collins and Grundy 2005; Cook et al. 2005). For maximum production high plant available water capacity and reasonably high fertility are the most important soil characteristics. In central Queensland the recommendation is to apply phosphorous fertiliser at rates similar to those used for dryland crops on low P soils (Collins and Grundy 2005).

To ensure efficient nitrogen fixation butterfly pea requires inoculation with a broad-spectrum rhizobium such as Tropical Group M (CB 756-Siratro), however can nodulate with the native Rhizobia in the soil, although many of these strains are slower and result in less effective nitrogen fixation (Collins and Grundy 2005; Cook et al. 2005).

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

a) Common

b) Occasional

c) Unlikely

d) Don't know

No information found that described dispersal by birds or bats.

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

Dispersal by grazing animals is one of the main dispersal mechanisms (Staples 1992). There have been no experiments specifically evaluating passage of butterfly pea seed through the rumen, but there is no reason why it would not behave similarly to other hard-seed legumes.

Butterfly pea has a proportion of hard seed which survives ingestion and passage through the rumen as with other hard-seeded legumes. As a result seeds can be dispersed in cattle dung (Gardener et al. 1993; Rojas-Sandoval 2016). The proportion of hard-seed can vary from <10% to >65% in commercial seed lots (Collins and Grundy 2005) and in hard-seed experiments the proportion of hard-seed varied from 19% to 30% (McDonald 2000; Lawrence et al. 2008, 2012).

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

a) Common

b) Occasional

c) Unlikely

d) Don't know

Butterfly pea grows well in humid and sub-humid habitats (average annual rainfall 500-900mm) and is drought tolerant. However, it does not tolerate waterlogging or flooding, and the seeds do not have any specific adaptations for dispersal by water. In northern Australia, the butterfly pea grows on riverbanks, creek lines, margins of water holes irrigation channels. Butterfly peas living in these places can produce hard seed which could remain viable after water dispersal (Rojas-Sandoval 2016; Weeds of Australia, 2016).

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

a) Common

b) Occasional

c) Unlikely

d) Don't know

Butterfly pea seeds are 4.5-7mm long and 3-4 mm wide and are held in pods. When the pods are mature, they shatter and can spread seeds a short distance, however the seeds have no adaptation for wind dispersal (Rojas-Sandoval 2016).

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

a) Common

b) Occasional

c) Unlikely

d) Don't know

This may happen occasionally but no evidence that a significant factor.

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

a) Common

b) Occasional

c) Unlikely

d) Don't know

Butterfly pea is widely planted as an ornamental (Cook et al. 2005), however in an agricultural context *C.ternatea* is planted for forage, hay and silage. Butterfly pea produces a high-quality (crude protein 12–15%), highly digestible hay, which is best cut when the leaves and branches are still soft and succulent and before mature pods form (Collins and Grundy 2005).

To date, there has been very limited use of butterfly pea as a forage in northern WA and no fodder production, but if more widely grown it could be cut for hay and then moved around the region. However, this would only present a weed risk if it was cut well past the optimum cutting time.

9.1 What is the species' minimum generation time?

a) ≤1 year

b) 2-3 years

c) >3 years or never

d) Don't know

Under good growing conditions butterfly pea plants can flower within 7-11 weeks from germination, however butterfly pea is a hard seeded plant, and this is the main restriction to its minimum generation time. Commercial seed lots of butterfly pea can have hard-seed levels varying from <10% to >65% (Collins and Grundy 2005). However, Nagar and Meena (2015) report that for seed 3 months old the germination was only 6.5% without being treated (scarified, heat treatment). Therefore, in a tropical wet-dry season environment the minimum generation time is more than one year as the seed will not have softened before the onset of the dry season.

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

a) Prolific seed production high (e.g. >1000 m^{-2}/year for woody species, >5000 m^{-2}/year for herbaceous species)

b) Moderate – low seed production

c) None (or seed is sterile)

d) Don't know

Mature plants flower in summer and continue through to autumn. Butterfly pea is predominantly self-fertile but there is some out-crossing (Cook et al. 2005).

Seeds are oblong, flattened, and dark brown to almost black in colour. They are 4.5-7mm long and 3-4 mm wide. The seeds form in pods and each pod has 6-10 seeds inside. The average seed number is 20,000–30,000 seeds/kg (Cook et al. 2005).

Butterfly pea seed crops have yielded over 900kg/ha but 200–500 kg/ha is a realistic target in well-managed seed crops. Opportunity crops that have some grass or weeds present and/or lower plant populations are likely to yield 50-200 kg/ha (Collins and Grundy 2005). When unmanaged the seed yield is likely to be in the range of 100-600 seeds/m^2.

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

Lawrence et al. (2012) report the hard-seed content after 12 months was only 19% (s.e. 2.9%), while in Lawrence et al. (2008) and McDonald (2000) there was 30% hard-seed. Under a controlled field experiment with one year-old seed, after 100 days in the field from the start of the experiment, 90% of the hard seeds of *C. ternatea* had softened (Lawrence et al. 2012).

9.4 Can the species' reproduce vegetatively?

a) Yes – rapid vegetative reproduction

b) Yes – slow

c) No

d) Don't know

Butterfly pea can be grown from cuttings in a nursery setting but cannot reproduce vegetatively under field conditions.

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

Where ungrazed or lax grazing, butterfly pea could potentially be visually obvious in a rangeland environment in northern WA where in general perennial and annual grasses rather than herbs provide a ubiquitous lower stratum. However, as a highly palatable species in an environment where there is essentially uncontrolled grazing by feral and native animals this is likely to be uncommon.

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 can 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

Butterfly pea is quite competitive once established providing it is not subject to continuous heavy grazing. However, as a short-lived perennial it requires regeneration from the soil seedbank to persist in the medium-term. Butterfly pea seedlings are preferentially grazed and grazing at this stage will kill the plants (Collins and Grundy 2005) and the hard-seed is short-lived, softening within two years (Lawrence et al. 2012).

> "Butterfly pea will coexist with aggressive grasses such as buffel grass with good management. Mature plants are tolerant of periodic heavy grazing but prolonged periods of continuous heavy grazing may reduce plant numbers. Grazing using a rotational system is more likely to maintain a higher plant population and maximise dry matter production" (Collins and Grundy 2005).

Khan et al. (2014) demonstrated that butterfly pea is one of several desirable fodder plants which can be used to suppress the growth of the invasive alien weed, parthenium (*Parthenium hysterophorus*) under field conditions in Australia.

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

As an herbaceous, short-lived perennial legume which ungrazed grows to a height of ~1m, butterfly pea is unlikely to provide a new stratum within the rangelands of northern WA.

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

As a low growing herbaceous legume butterfly pea is unlikely to restrict the movement of people, animals or water in the rangeland environment.

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

The dry matter production of butterfly pea is moderate when compared with many other tropical species and highly palatable, so well grazed (Cook et al. 2005; Collins and Grundy 2005). As a result, the species is unlikely to have an impact on fire regimes in terms of increasing the fuel load (biomass).

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

While the seeds and roots of butterfly pea contain chemically active substances, there have been no reports of toxicity to animals grazing the top material (Cook et al. 2005).

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

There is no specific evidence that butterfly pea provides more shelter than the native vegetation. However, as a highly palatable legume that can nodulate to some extent with the background rhizobia (Collins and Grundy 2005) the feed quality and especially the crude protein is higher than many native shrubs and grasses.

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

Butterfly pea is a palatable legume with high digestibility and protein content that does not cause bloat. In an agricultural context butterfly pea requires inoculation with a broad-spectrum rhizobium such as Tropical Group M (CB 756-Siratro), to ensure efficient nitrogen fixation (Cook et al. 2005). However, butterfly pea can nodulate with the native Rhizobia in the soil, although many of these strains are slower and result in less effective nitrogen fixation (Collins and Grundy 2005). Overall, butterfly pea has the potential to increase the nitrogen content of the soil in a rangeland environment.

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 some ecosystems

c) Minor or no effect on water quality

d) Don't know

Butterfly pea has been listed as a garden escape that has been naturalised on creek banks and around waterholes throughout the Kimberley (Hussey et al. 2007) but as it only has tolerance of short-term flooding and not prolonged inundation or waterlogging (Cook et al. 2005), it is unlikely to reduce water quality or cause silting of waterways.

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

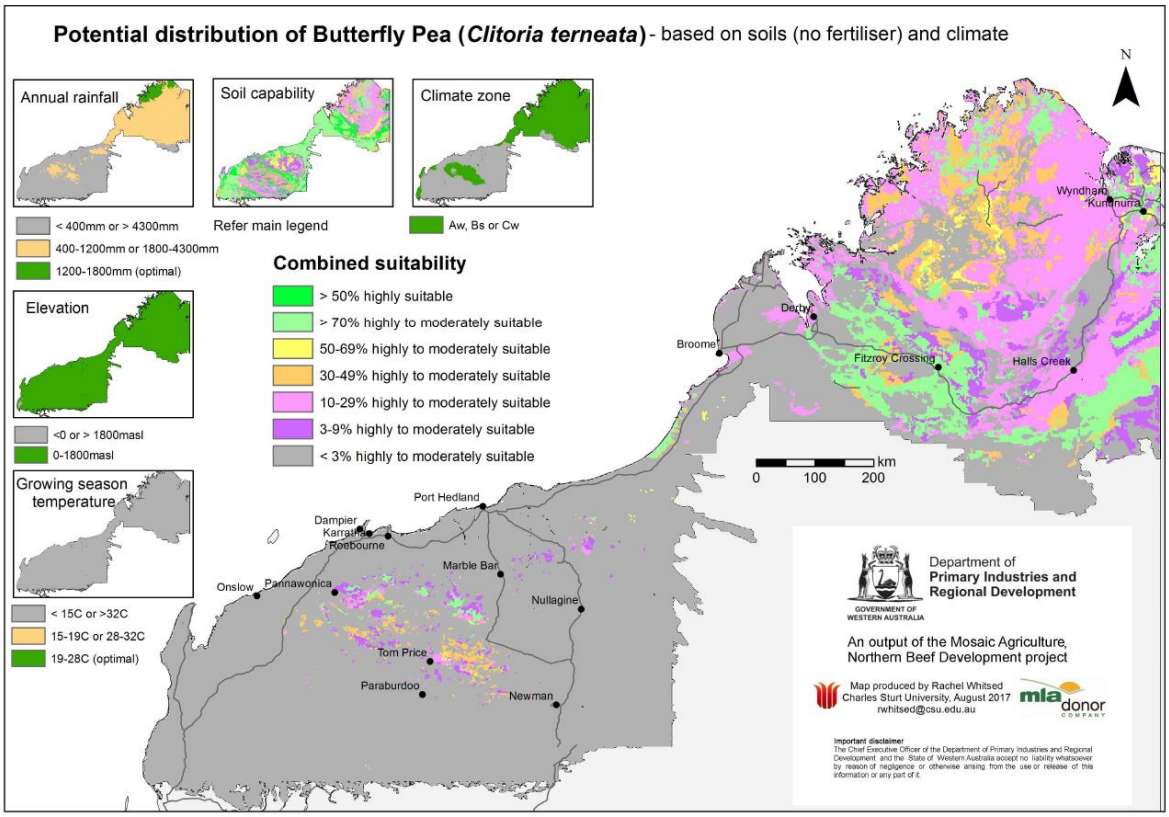
a) Will significantly lower the water table and/or reduce groundwater recharge to the water table.

b) Will have little or no impact on hydrology

c) Don't know

As a herbaceous legume, butterfly pea is unlikely to affect the hydrology in a landscape where woody vegetation is largely ubiquitous.

Potential distribution



Region	Area of suitable soils and climate	Potential distribution score
Kimberley (>400mm AAR)	7.7 Mha	7.0
Kimberley (<400mm AAR)	0	0.5
Pilbara (>400mm AAR)	0.38 Mha	2.0
Pilbara (<400mm AAR)	0	0.5
Gascoyne – Goldfields	0	0.5

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 (>400mm AAR)	4.6 x 2.0 x 7.0	**64.4**	**Medium**
Kimberley (<400mm AAR)	4.6 x 2.0 x 0.5	**4.6**	**Negligible-low**
Pilbara (>400mm AAR)	4.6 x 2.0 x 2.0	**18.2**	**Negligible-low**
Pilbara (<400mm AAR)	4.6 x 2.0 x 0.5	**4.6**	**Negligible-low**
Gascoyne – Goldfields	4.6 x 2.0 x 0.5	**4.6**	**Negligible-low**

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

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Important disclaimer