Department of
Primary Industries and Regional Development

GOVERNMENT OF WESTERN AUSTRALIA

Environmental weed risk assessment

Caribbean stylo (*Stylosanthes hamata*)

Family: *Fabaceae*

Common names: Caribbean stylo, Verano

Cultivars: Verano, Amiga

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Species summary:

Caribbean stylo (*Stylosanthes hamata*) is an annual or short-lived perennial herbaceous legume. Individual plants behave as self-regenerating annuals or biennials. In the Northern Territory up to 40% of plants persist from one wet season to the next (Cameron 2010), but this varies depending on the length of the dry season. It has a semi-erect or sometimes prostrate growth habit with many fine stems and is generally 25-40cm in height (up to 75cm), and may develop a low crown under grazing.

Stylosanthes is primarily a genus of self-pollinating species and *S. hamata* shows a low level of cross-pollination. There are two types: diploids and tetraploids. The diploid forms originate from Florida, Central and South America and the Caribbean Islands, while the tetraploids only come from Central and South America (Edye and Topark-Ngarm 1992; Cook et al. 2005).

The two commercial cultivars in Australia; 'Verano' and 'Amiga', are both tetraploids from Venezuela. They are morphologically similar, but cv. Amiga produces more seed, has a higher proportion of plants that persist through to a second year and may be better adapted to high altitude environments (Cameron 2010; Edye and Topark-Ngarm 1992). This assessment will focus on the tetraploid varieties. They are intolerant of frosts and restricted to tropical environments.

In Australia Caribbean stylo is usually planted for grazing, but it can be used for cut and carry or hay production before leaf fall in the dry season. Caribbean stylo is widely naturalised across northern Australia including northern WA (Figure 1), where it is commonly found in highly disturbed sites like parking bays and along the main roads where the roadsides are regularly mowed. The tetraploid varieties nodulate effectively with native Rhizobia (Date 1984). Caribbean stylo bears a close resemblance to Townsville stylo (*S. humilis*) which was widely sown in the north and west Kimberley in the 1970s before it succumbed to Anthracnose. The cvv Verano and Amiga are reasonably resistant to Anthracnose. There are few if any sown Caribbean stylo pastures in northern WA, while it has been widely sown as a companion legume in Queensland and to a lesser extent in the Northern Territory.

Figure 1. The distribution of Caribbean stylo (*Stylosanthes hamata*) 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

The genus *Stylosanthes* is recorded in the FloraBase weed list (Western Australian Herbarium 1998). The five *Stylosanthes* species introduced to Australia as pasture plants are vigorous, highly persistent legumes that may out compete native species and reduce biodiversity without careful grazing and fire management (Smith 2002). The 'Global Compendium of Weeds' (Randall 2017) notes that *Stylosanthes hamata* has been reported as naturalised, a weed of agriculture and a weed of the natural environment in Australia. It is widely naturalised in northern Australia and is regarded as an environmental weed in northern Queensland, the Northern Territory (NT) and northern Western Australia (Anon 2021). In WA, *S. hamata* is reported to be naturalised throughout the Kimberley and near Port Hedland and Karratha in the Pilbara (Hussey et al. 2007). Keighery and Longman (2004) report *S. hamata* as an environmental weed and naturalised in the north Kimberley, Victoria Bonaparte, Ord-Victoria Plains, central Kimberley, Dampierland and Pilbara IBRA regions.

In Groves *et al*. (2003) *S. hamata* was given a weed rating of 3+ and 5 for agricultural systems in WA and the NT respectively and a weed rating of 5 for natural ecosystems in Australia, but was listed as primarily an agricultural or ruderal weed. Tropical Forages Database (Cook *et al.* 2005) states "*S. hamata* is not considered a serious weed".

Swarbrick (1983) report *S. hamata* as a medium weed of gardens, lawns, parks and amenity areas and as a medium weed of dryland crops grown without supplementary irrigation in coastal and north Queensland and the top end of the NT. Lonsdale (1994) noted 17 accessions of Caribbean stylo in Australia and its presence on two of the four weed lists examined.

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

Caribbean stylo can establish among intact native vegetation in the Kimberley, but usually at a low density with small widely spaced plants**.** However, in highly disturbed areas, like off-road parking areas and along roadsides it is relatively common**.** Individual plants behave as annuals or week biennials, but can set seed in most seasons and regenerate from the soil seedbank.

In Lansdale, north Queensland, Gardener (1982) found that in grazed pasture, over a 9 year period, Caribbean stylo plants proved short-lived, but was persistent in the long-term, by re-establishing from seed. High levels of hard-seed and good seed production can result in a large soil seedbank for re-establishment.

3. Palatability and grazing tolerance

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

Caribbean stylo is usually sown as a companion legume in native grass pastures. In these systems stock preferentially graze the grasses early in the wet season, but the intake of Caribbean stylo increases towards the end of the wet season as the grasses mature and hay-off. It is then preferentially grazed as either green-leaf and stem at the end of the wet season or as seed, dry leaves and stem over the dry season (Gardener 1980). However, rain over the dry season or heavy dews can cause the fallen leaves to go mouldy and become unpalatable (Gardener 1980; McCartney 1991).

Caribbean stylo tolerates heavy grazing with grazed plants more likely to persist through to the next wet season than ungrazed plants (Humphries 1980; Cook et al. 2005). In sown pastures this grazing tolerance can be used to control the surrounding perennial grasses which might otherwise shade out the stylo. Seedlings regenerate satisfactorily in most grazing situations (Humphries 1980).

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

Caribbean stylo is preferentially grazed by native animals and naturalised plants in the Kimberley are usually small and a minor component of the vegetation. Without some grazing management Caribbean stylo is likely to be preferentially grazed and be a minor component of the vegetation. It persists well along roadsides where it receives additional runoff from the road and is often protected from grazing.

The commercial cultivars are promiscuous in their rhizobial requirements, nodulating freely with a wide spectrum of native rhizobia (Date 1984). In managed systems grazed plants persist as perennials better than ungrazed plants (Cook *et al.* 2005). Under grazing the number of plants may slowly decline after planting. However if seed set occurs the recruitment and establishment of new plants from the soil seed bank, once conditions improve, may support the population.

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

Seed can be spread by animals or machinery to colonise new areas and together with large seed production under favourable conditions, with a high level of hardseed provide a soil seed bank for regeneration and spread. The commercial cultivars are promiscuous in their rhizobial requirements, nodulating freely with a wide spectrum of native rhizobia (Date 1984).

No volunteer plants were found spreading outside the trial boundaries after 4-5 years across four experimental sites in the Pilbara and west Kimberley (G. Moore unpublished data, 2021).

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

Caribbean stylo can grow and persist on infertile soils, but is responsive to phosphorus and sulphur and on some soils potassium, molybdenum or zinc (Cameron 2010; Holm and D'Antuono 1990). Fertiliser trials over 4 years with cv. Verano stylo on three soils in the north Kimberley showed a marked decline in herbage mass to low levels (<1T DM/ha) without regular phosphorus applications (Holm and D'Antuono 1990). In relation to the Kimberley, McCartney (1991) states that sown pastures of Caribbean stylos can yield ~3T DM/ha with applied phosphorus, while production will be about 1.5T DM/ha without fertiliser.

The Caribbean stylo varieties are promiscuous in their rhizobial requirements, nodulating freely with a wide spectrum of native rhizobia (Date 1984; Cook *et al.* 2005). They grow on a wide range of soils, except heavy clay soils and are well suited to well-drained sandy soils of low fertility (Humphries 1980).

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

a) Common

b) Occasional

c) Unlikely

d) Don't know

The flowering spike of Verano produces double seed. The upper seed has a hook 3-5mm long, which can adhere to the fur or feathers, while the lower seed develops later and has no hook (Humphreys 1980). Seed may also be eaten and pass through the digestive system although no information was found about the viability of such seed.

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

Seed is spread through ingestion and defecation by cattle, native and feral animals and by stock movement with the hook on the upper pod segment adhering to the coat (Smith 2002, Cook *et al.* 2005).

In a controlled experiment 36% of Caribbean stylo seed placed directly into the rumens of cattle was excreted in faeces, 30% of the excreted seed was germinable, while 61% was hard-seeded and 10% was rotten (Gardener *et al*. 1993).

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

a) Common

b) Occasional

c) Unlikely

d) Don't know

Seed does not appear specially adapted for spread by water, but dispersal by water movement has been reported (Smith 2002; Cook *et al.* 2005). With large seed production under favourable conditions and a high proportion of hardseed there is the potential for seed dispersal with the overland flow associated with extreme rainfall events. On sandy soils with high infiltration the movement of organic matter and seed is often less than 100m.

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

a) Common

b) Occasional

c) Unlikely

d) Don't know

Seed has no special adaptations for spread by wind and >90% of seedlings recruit within 1 m of the parent plants (G. Moore unpublished data).

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

a) Common

b) Occasional

c) Unlikely

d) Don't know

Smith (2002) reports that the hairy hooked seed can be dispersed attached to vehicles and machinery such as slashers and graders. The hooked hairy seed could also potentially be carried on clothing or in soil on footwear, but this is unlikely.

The occurrence of *S. hamata* along roadsides and parking bays in the Kimberley and northern Pilbara suggests that this is roadside slashing is a means of dispersal.

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

a) Common

b) Occasional

c) Unlikely

d) Don't know

Caribbean stylo is usually grown as a companion legume for native perennial or introduced pasture grasses. It can be used for hay-making but this is unusual in WA. The hay currently used in northern WA is made from irrigated sorghum or Rhodes grass or transported from south-west WA.

With reference to the Northern Territory Smith (2002) notes that the copious seed can be dispersed as a contaminant of hay and more recently, the species has been observed to have

spread into the Pilbara via stock transportation and hay and has also been noted around transportation hubs much further south (G Keighery personal communication).

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

Caribbean stylo essentially behaves as an annual plant and can flower 9-10 weeks after germination and seed takes 15-16 days to ripen after flowering (Cook *et al.* 2005).

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

Well grown seed crops can produce one tonne per ha and total seed set may be as high as 1,750-2,000kg/ha (Humphreys 1980; Cook *et al.* 2005). There are about 270 seeds with pods/g and 450 seeds without pods/g (Edye and Topark-Ngarm 1992). Flowering is in response to short days and seed can be produced over an extended period. This ensures that some seed can be produced in most years with high seed production in favourable years.

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

At St Lucia in Queensland, Argel and Humphreys (1983) found that the longevity, regeneration and seed reserves of *Stylosanthes hamata* cv. Verano were positively and linearly related to temperature during seed formation. In experiments hardseed continued after 180 days of storage. At Katherine, Northern Territory McKeon and Mott (1982) found soil-surface temperatures greater than 50-55^{o}C were required to produce softening of some hard seed. In established pastures only 35% of seed softened in one year.

McIvor and Howden (2000) found Caribbean stylo to be in a group with high dormancy in both wet and dry seasons, which as an important sown legume they consider an important adaptation to the variable climate in semi-arid tropical areas.

9.4 Can the species' reproduce vegetatively?

a) Yes – rapid vegetative reproduction

b) Yes - slow

c) No

d) Don't know

Caribbean stylo shows no 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

Caribbean stylo is widely naturalised in northern WA, but usually occurs at a low density and the plants are generally small (<30cm in height). As a result, they are unlikely to be visually obvious within a grassland ecosystem in the rangelands where there are numerous small to medium-sized herbaceous tall grasses and woody sub-shrubs.

Caribbean stylo is an annual to short-lived herbaceous perennial. Smith (2002) suggests that stylos may out-compete native species and reduce biodiversity, unless managed, but this refers to high rainfall areas in the NT. *S. hamata* is widely naturalised in northern Australia and regarded as an environmental weed in northern Queensland, the Northern Territory and northern Western Australia (Anon 2021).

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

No significant evidence was found in the scientific literature for major impact on the establishment of other plants in natural environments although the widespread naturalisation of the species does suggest that there could be some minor displacement of other plant species.

There are numerous records of the presence of Caribbean stylo from the Devonian Reef Complex Rainforest (Nimbings, Ocar and Napier ranges) which are drier sections of the Kimberley, suggesting that it can invade relatively undisturbed sites. However, at this time it is

suggested that not enough is known or documented about the effect of the presence of Caribbean stylo in the rangeland environments of WA (G. Keighery personal communication).

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

Caribbean stylo is an annual or short-lived herbaceous perennial with many fine stems. When ungrazed it is usually 25-40cm in height, but it will often be much shorter under grazing. In native grasslands in northern WA it will not add a new strata as there is already an almost ubiquitous strata of herbs and perennial grasses.

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

Caribbean stylo is a herbaceous, prostrate legume usually <30-40cm, without spines or thorns and will not affect physical movement through the 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

Field trials in the Kimberley region have shown sown Caribbean stylo pastures without added phosphorus fertiliser have annual dry matter production of <1 to 1.5 T/ha (Holm and D'Antuono 1990; McCartney 1991). Naturalised plants are usually small and occur at a low density, so their overall contribution to the overall biomass would consequently be low. Nitrogen fixation is strongly correlated with biomass production, so low biomass will correspond to low N fixation.

The commercial cultivars do not tolerate dry season fires, and plants fail to recover following fire, relying on regeneration from the soil seed bank in the following wet season. However, fire increases the softening of hard seed in the soil, which assists with the persistence of the stand (Cook et al. 2005). Fire can be used to manage or control stylo in rangeland systems.

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

Caribbean stylo has no spines or thorns and is non-toxic (Cook *et al.* 2005). However, it has some acaricidal effect on cattle tick, *Boophilus microplus* (Fernandez-Ruvalcaba *et al.*1999).

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

Naturalised plants are usually small and occur at a low density, so their overall contribution to the biomass and food for pest animals would be similar to the native vegetation.

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

Caribbean stylo has been used as a ley in cropping systems with nitrogen benefits of up to 90 kg/ha recorded in West Africa and northern Australia under experimental conditions. It can extract phosphorus (P) from soils low in available soil P, but also responds strongly to applied P (Holm and D'Antuono 1990; Cook *et al.* 2008).

In the north Kimberley Caribbean stylo sown without added phosphorus had low productivity (Holm and D'Antuono 1990), so isolated plants would be unlikely to affect soil nutrient levels. Caribbean stylo is widely naturalised in northern WA and in uncleared native vegetation but may be present at a low density. However, studies in low nutrient soils in the Australian bushland have also shown that nodulating legumes effect nutrient levels and can aid weed invasion by other species (G Keighery personal communication).

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

Caribbean stylo has a low tolerance of flooding (Cameron 2010) and is poorly adapted to the cracking clay soils which are the dominant soils on the river frontages and areas subject to regular flooding in the west Kimberley. It has some waterlogging tolerance, but as a small herbaceous plant is unlikely to reduce water quality or cause silting.

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

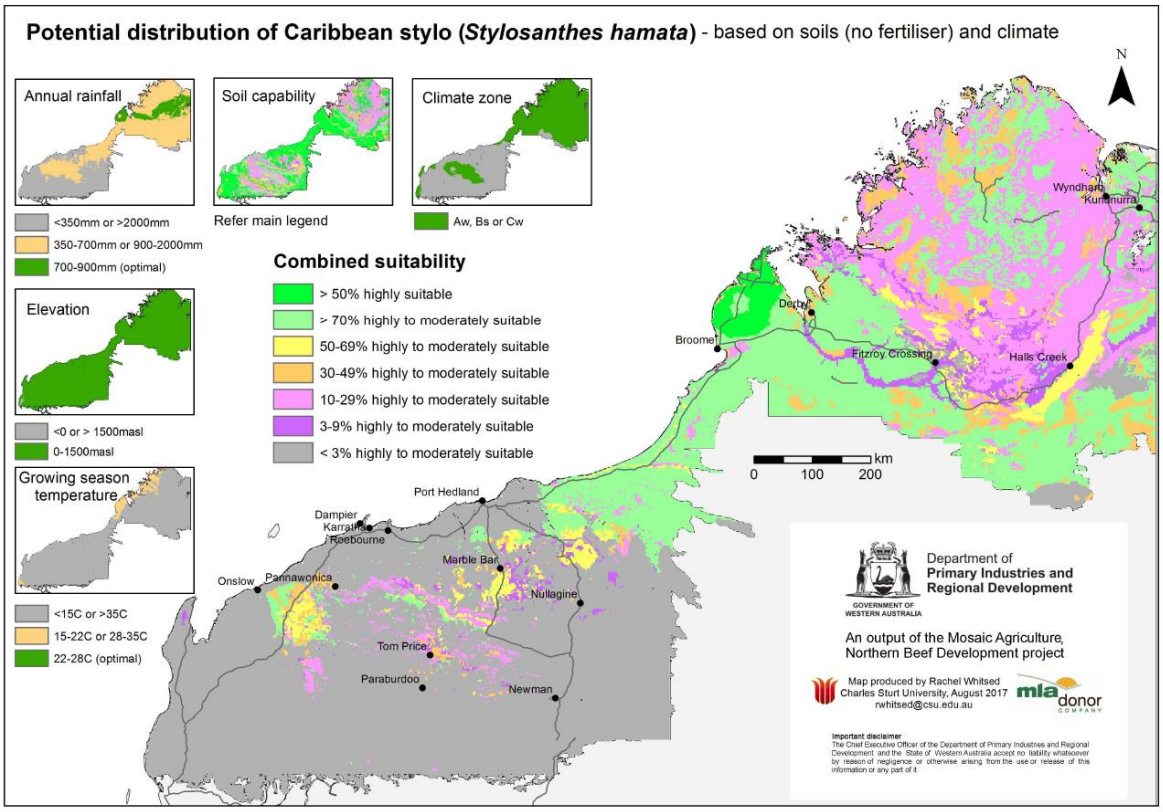
a) Will significantly lower the water table and/or reduce groundwater recharge to the water table.

b) Will have little or no impact on hydrology

c) Don't know

No information found to suggest Caribbean stylo has a major effect on the ground-watertable.

Potential distribution



Region	Area of suitable soils and climate (Mha)	Potential distribution score
Kimberley	16.5Mha	8.0
Pilbara (>350m AAR)	3.3Mha	6.0
Pilbara (<350mm 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)

Adjusted Invasiveness score = 6.1, Adjusted Impacts score = 1.5

Region	WRA calculation*	Overall score	WRA rating
Kimberley	6.1 x 1.5 x 8.0	**73.2**	**Medium**
Pilbara (>350mm AAR)	6.1 x 1.5 x 6.0	**54.9**	**Medium**
Pilbara (<350mm AAR)	6.1 x 1.5 x 0.5	**4.6**	**Negligible to low**
Gascoyne – Goldfields	6.1 x 1.5 x 0.5	**4.6**	**Negligible to low**
South-west land division	6.1 x 1.5 x 0.5	**4.6**	**Negligible to low**

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

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